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Frank Stuart Dethridge Memorial Address

FROM AUTOMATION TO AUTONOMY – CAN THE LAW KEEP UP?

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1 Introduction

I am delighted and honoured to give this address dedicated to the memory of Frank Stewart Dethridge. Frank Dethridge was the senior partner at Mallesons, Sydney, who had the foresight to recognise the importance of maritime law for our countries and take steps to establish this Association. In 1974 he called the first meeting of those interested and an Australian association was formed. The development was noted in New Zealand and, with Ian Mackay from P and I Services Wellington to the fore, New Zealand joined the Association a year later.

My involvement does not go that far back, but it does now seem a long time since I was persuaded by Brad Giles to attend my first MLAANZ meeting in 1990 - Brad could be very persuasive! I would never have thought it likely then, that, nearly 30 years later, I would give this address. Over the years the address has been given by a number of leading lawyers on a wide range of topics of interest, and I feel very honoured that MLAANZ has asked me to follow them.

Time does flow by quickly (and seems to accelerate) and I was surprised when I reflected on the subject I eventually chose; this produced some sobering thoughts - those who attended the early meetings of MLAANZ in the mid-1970s might have regarded some of the technological developments which are the starting point for this address as pure science fiction, and I may not have to address the issues which I will talk about today in practice.

In keeping with the theme of this Conference my topic concerns developments in technology which many consider are destined to change the face of maritime commerce and shipping operations most profoundly. Shipping and trade, like other areas of human activity, are going through an ongoing revolution driven by the development of digital technology, artificial intelligence or learning computers and robotics, which allows the creation of global inter-connected computer systems. These systems exchange and analyse data and make decisions operating physical things. This has been described as the fourth digital industrial revolution which is changing, and will change society, more fundamentally than the earlier industrial revolutions which involved the invention of steam engines and electricity. Against this background of broad general change, the address will examine the issues arising from the likely development of ships which are capable of operating without direct human intervention by persons on board, whether as a result of remote control by on shore controllers, or by autonomous direction by "intelligent" computer systems on board the ship (or a combination of those two systems). It is, however, important to bear in mind that the change to ships (which fundamentally disturbs one's general idea of a 'ship') is part of much broader transformation in which highly integrated digital systems are being developed to organise commercial activities, such as the carriage and transfer of goods.

The extract from Tennyson's poem *Locksley Hall*, which is on your conference programme, was written in 1835. It contains an extraordinary piece of romantic poetry and prophecy about international trade, in which the poet anticipates the development of the carriage of goods by air.

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For I dip't into the future far as the human eye could see
Saw the vision of the world and all the wonder that would be
Saw the heavens fill with commerce, argosies of magic sails,
Pilots of the purple twilight, dropping down with costly bales.

While this address starts from technological developments which, on my layman's understanding, are already with us, and are being developed and applied rapidly, it does dip into the future and contain some speculation about what it will bring for maritime commerce. I suspect that the predictions will not be as startling (or as accurate) as Tennyson's, but I hope to provide you as commercial parties, regulators and lawyers with some food for thought as the maritime industry starts to undergo significant change. Before I cast off, I should say that I am not an expert in computers or logistics or in matters nautical, and that the general description of actual and potential technological developments and my rough estimate of the current state of play is derived from various materials I have read.

2 Getting Started – My Changing Bike Ride

Most days I cycle to and from my office in Auckland along the beautiful, but dangerous – for cyclists at least – Tamaki Drive. I have taken this route to my desk for nearly thirty years; as a way of beginning and ending the working day this method of travel is refreshing and I strongly recommend it. (My efforts have also allowed me to say to my children, when they tell me about my generation's failures in managing the planet, that I have some personal credit in my account).

As I leave and enter the city, I ride past the Auckland port where the activity on the wharves provides a daily reminder of how the flow of trade sustains New Zealand. At night I enjoy – and I know that views in Auckland are much divided on this - the sight of the port, busy and brightly lit – a bustling, vibrant reminder of the commerce which underpins our daily lives and around which maritime law has developed. Something like 90 percent of the world's trade is seaborne and the recent growth in the global economy has led to growth in that trade. In 2017 the volume of trade carried by ships was estimated at 10.7 billion tons.[1] It has been estimated that the volume of containerised trade has tripled in the past 10 years and that growth is forecast to continue.[2] As an island nation New Zealand has been populated by people who came by sea, and it is dependent on commercial shipping with over 99 percent of our imports and exports arriving and leaving on ships. By contrast, where goods move within New Zealand, before or after international sea carriage, they are generally transported by road or rail and not by sea.[3]

At the end of the working day as I come out of the city, I share the road with trucks and trailers carrying containers and bulk cargoes in and out of the port, before I continue along Tamaki Drive next to the Waitematā Harbour. The traffic on the harbour is varied – the ferries going in and out of the city, container ships under pilot sailing in and out of the port in the shipping channel, fishing and pleasure craft, kayakers and, even the occasional swimmer. Although I have to keep my eyes on the road, my ride provides a varied stimulating maritime scene, and I do quite a bit of thinking as I pedal along.

When I accepted the invitation to give this address, I was initially very keen to keep to the areas where I was more comfortable, to hug the coast and keep close to shore – "wrinkles" or possible developments in familiar existing areas of admiralty or maritime law (usually of ancient origin) which I had come across over the years in applying legal principles to resolve problems. I had, like many of you, no doubt, read about the development of unmanned ships, and of computer based digitised systems for the movement and transfer of goods, brought about by the developments in the communication of data, robotics and "artificial intelligence" in computers, and the increased connection of things in systems linked together by the internet. I had read a number of interesting papers and articles and had attended various presentations, but a combination of nervousness about my lack of understanding of the technology, and, perhaps, a related sense that everything might somehow prove to be make–believe, held me back. It was the way in which my bike ride changed which brought me back to this challenging topic.

[1] United Nations Conference on Trade and Development (UNCTAD), *Review of Maritime Transport 2018.*

[2] See for example the summary in United Kingdom Department for Transport, *Maritime 2050: Navigating the Future* (Policy Paper, January 2019).

[3] New Zealand Ministry of Transport, *A Strategy for Domestic Sea Freight – Sea Change Transforming Coastal Shipping* (Policy Report, May 2008). The report emphasised the advantages of coastal trading from an environmental perspective and the expressed goal was to revitalise coastal shipping and lift the percentage of goods carried by sea on the New Zealand coast from about 15% to 30% by 2040. Part of the initiative involved the establishment of a special unit to promote the visibility of coastal shipping. Although there has been some increase in coastal shipping since the report, the report and its goals appear to have been largely forgotten. The current government established a working group to undertake the review of the North Island Supply Chain Strategy and its final report was due to go to Cabinet this month.

My mode of transport is old technology – a bicycle with a well-made Italian frame by Ernesto Colnago. As a form of transport, the bicycle has a comforting familiarity, particularly when you have used one most of your life. However, recently on my ride the usual hazards – trucks and cars – were increased with the arrival of new technology – e-scooters and e-bikes. They arrived suddenly, almost overnight, and now they are everywhere. The e-scooters, in particular, seemed to take those responsible for regulation in our city by surprise. I suspect that this is just a small part of the transformation in land transport which will be part of a wider revolution brought about by the rapid development in technology. As this was happening on the paths and roads, the port began to trial automated, unmanned, straddle carriers which will pick up, load, and unload containers under remote direction.[4] I read that this movement towards fully automated loading and discharging can also be seen in other ports around the world.

If I could see such changes on my ride might technology work much greater change on the maritime world? Eventually, I decided to cast off from the safe anchorage in established law with its comforting history – Charles Dickens described the old Admiralty Court as 'a lazy old nook…that has an ancient monopoly in disputes among ships and boats'[5] – and try to sail into uncharted waters looking towards the horizon and the uncertain future.

So I began to ask whether, if I keep pushing the pedals on the Colnago for a few more years, I would see container ships arriving in Auckland without master, crew or pilot on board, either remotely operated by on-shore controllers located in Asia or Europe, or functioning completely autonomously operated by on-board systems monitored from afar? Would the ferries in our harbour be unmanned and autonomous? Would there be fewer trucks coming in and out of the port because cargo was being distributed around the New Zealand coast by electric powered autonomous feeder ships? Would the port be fully automated for loading and unloading ships, perhaps using a system with autonomous ships? And, what were the issues for maritime commerce and law and society with the possible developments? Would Australia and New Zealand be able to address the issues and take any advantage offered by the developments?

These questions could provide material for a very long address or a book, but I will try to speak to you for about the time it takes me to ride home – 30 minutes with, hopefully, a strong finish to get home for tea and biscuits. After outlining my (layperson's) understanding of the nature of the technology, which is applied to design and build autonomous and remote-controlled ships and the state of some of the development, I will outline some of the regulatory issues which will arise at international and national level, then discuss some of the possible legal issues in relation to liability. This leads to a consideration of the benefits and the disruption which the changes may bring and some suggestions on what we might do about them in Australia and New Zealand. Given the breadth of the topic I can only offer an overview of the issues which seem likely to arise.

3 Summary – Opportunity and Disruption

My main point is that these developments in technology appear likely to provide both significant opportunity and significant disruption to existing shipping operations and their regulation, and that Australia and New Zealand should be taking steps both to assess the opportunities and to address the regulatory issues. Maritime law in New Zealand and Australia, as in most jurisdictions, covers a wide field of case law principles relating to civil liability, and statutory regulation, which has the general aim of ensuring the safety of shipping operations, and is largely derived from international conventions made to achieve that purpose on a global basis. The "system" of maritime law which has been developed over hundreds of years provides a stable, established foundation for maritime commerce. Initially, the law developed in admiralty to provide common principles governing the rights and obligations of those involved in maritime ventures. Gradually, maritime parties came to regulate their relationships by their agreements in an environment in which states or authorities regulated sparsely. In more recent history, starting really from the early 20th century, regulation by international conventions and agreements agreed between States has been developed to ensure the safe construction and operation of ships. In addition, international agreements have sought to standardise important aspects of the legal obligations owed by maritime parties, most notably in the area of the carriage of goods by sea.

To judge from the various projects which are being conducted around the world, the new technology aims to produce ships which do not operate in the way ships have functioned since the beginnings of maritime commerce and the development of legal principles governing it. The challenge presented by such innovation is to develop

[4] This is part of the port's broader strategy of reaching zero carbon emissions by 2040.
[5] This is the description of the old Admiralty Court in *Great Expectations*. That Court which was the home of the civil lawyers who practised admiralty law is now no more.

legal and regulatory principles which will minimise disruption and allow the new ships to operate effectively and safely. That is a major task because the new "ships", like the driverless trucks and cars which are being developed on land, are, by their different characteristics, profoundly disruptive of existing ways of operating and the legal regulation of those operations.

3.1 It May Not Happen?

At this point I note that that there are those who say that we will, in fact, never see fully autonomous ships[6] (or cars or trucks on the roads), whether because computer learning has reached, or will reach a "plateau," and will, as a result of its limits, not be able to provide the necessary assurance of safe, autonomous, operation at the required cost, or because humans will choose not to use this technology for psychological or other reasons, even if it is available, and autonomous vehicles can be built. However, from the reports I have read on the state of current developments, and the statements from bodies such as CMI and IMO accompanying their work in the area,[7] it seems a fair bet that fundamental changes to ships, as we have known them for thousands of year, involving unmanned operation with remote control, and varying degrees of autonomous operation, will be one aspect of the general change in the system by which goods are shipped and carried by sea and transferred between parties. The main uncertainty would seem to be the timing and pace of change which will see radically different commercial ships in operation. I am going to assume that this is on the way, and quicker than we might think.

3.2 The Changing World – The Technological Developments

Maritime commerce has evolved and developed from its early beginnings with the ingenuity of commercial parties using the technology at their disposal. The law has generally lagged behind. Some major developments in the regulation of shipping were a reaction to catastrophe although the system is now more developed in anticipating the need for regulation. At present major technological change in the digital revolution is taking place rapidly. Systems which automate processes and connect machines running those processes proliferate. To a significant extent, this is based on the rapid development of machines which have the ability to learn ever more complicated tasks involving analysis and assessment, which we would generally regard as exercises in thinking and decision making for human actors to undertake. This technology is producing exponential change and it is predicted that the coming years will see learning machines transform all aspects of how we live and work.

As I have said the development of ships which will be able to operate without direct human control is linked to broader change which is being produced by the same technological developments. Change is more likely to be widespread where the technology provides a general common foundation for change across a range of activities. In transport the same technological developments are involved in producing driverless cars and trucks, their operation in fleets, the development of unassisted airborne vehicles and autonomous ships. While the application of this technology in developing autonomous ships can be described as in its infancy and ships have relatively long financial and physical lives, the pace of change may surprise.

3.3 Towards Automated Ships – Some Examples of Current Projects

I am not aware of any government or private projects or public/private partnerships in New Zealand or Australia which are examining the potential to develop autonomous ships for commercial use on our coasts or internationally. Around the world the picture is different. In many countries in Europe and Asia, perhaps most notably in Scandinavia, companies have been working for some time to apply the required technology to develop and construct ships which will operate with varying degrees of autonomy. While the trial prototypes in operation are small ships, the aim of some of the projects is to design and build autonomous or remote-controlled commercial cargo vessels which will operate internationally. These projects have prompted a good deal of legal writing on the issues which arise,[8] reviews of national law to determine how it might apply or be amended to accommodate the

[6] Commander David Dubay, 'Why We Will Never See Fully Autonomous Commercial Ships', *Centre for International Maritime Security* (Web Article) <http://cimsec.org/why-we-will-never-see-fully-autonomous-commercial-ships/40652>

[7] Both organisations consider that the introduction of unmanned commercial ships operating with varying degrees of autonomy is likely in the near future.

[8] See for an early example, Professor Dr Eric van Hooydonk, 'The Law of Unmanned Merchant Shipping – An Exploration' (2014) 20 *Journal of International Maritime Law* 403; Robert Veal and Michael Tsimplis, 'The Integration of Unmanned Ships in the Lex Mercatoria' [2017] *Lloyd's Maritime & Commercial Law Quarterly* 303; Sir Bernard Eder, 'Unmanned Vessels: Challenged Ahead [2019] *Lloyd's Maritime & Commercial Law Quarterly*. For a recent study of the issues and challenges arising in relation to the regulation of autonomous ships in relation to the three main IMO Conventions of particular relevance (STCW Convention, SOLAS and COLREGS) see Henrik Ringbom, 'Regulating Autonomous Ships – Concepts Challenges and Precedents' (2019) 50 *Ocean Developments and International Law* 141.

operation of autonomous ships[9] and the work by international bodies considering the issues at national and international level (largely by reference to the international Conventions and agreements concerning the safe operation of ships) by the Comité Maritime General ("CMI") and the International Maritime Organisation ("IMO").[10] IMO is currently undertaking a regulatory scoping exercise reviewing existing international conventions and agreements which it is responsible for, in order to determine, 'how safe, secure and environmentally sound MASS (maritime autonomous surface ships) might be addressed in IMO instruments.' The exercise will involve reviewing the conventions to assess the scope of the regulatory challenge, then working out the best regulatory solution whether that involves amendment to existing agreements or new rules.

In Norway, a large chemical company which produces fertiliser approached a ship building company and commissioned the design and construction of an electric powered ship which would operate autonomously and carry cargoes of fertiliser on the Norwegian coast. The navigation equipment will be made by Kongsberg Maritime. The Norwegian government gave a grant to the project of about a third of the total construction cost of about $25 million. The result will be the *Yara Birkland* which will be the world's first autonomous container ship. The ship will be powered by electric motors and will, as a result, produce zero emissions. It will carry 120 TEU and is intended to operate between the company's factory and two ports on Norway's coast on short sea voyages.

The *Yara Birkland* is, I understand, currently scheduled to enter into service next year, and is planned to transition gradually from partially manned operation to remote operation, then fully autonomous operation in 2022. One of the underlying reasons for this project (which is consistent with Norway's general transport policy) is for the carriage of cargo by truck to be replaced by movement around the coast by ship. The company estimates that the use of the ship will remove about 40,000 truck journeys per annum from Norway's roads.

In June 2017, Rolls Royce and global towage company Svitzer demonstrated the first remotely operated commercial vessel in Copenhagen harbour. The 28m tug *Svitzer Helmond* conducted various manoeuvres under remote control from the quay.

Rolls Royce launched its first autonomous ship development project in 2012. It is part of a research and development group called Advanced Autonomous Waterborne Applications (AAWA) established with funding by the Finnish Funding Agency for Technology and Innovation, to develop and use the current technology to prove the concept and bring a remote-controlled ship into commercial use. This project brings together designers, equipment makers and universities to consider the development of autonomous ships. As part of this project an autonomous ships research and development centre was opened in Turku Finland in 2018.

Fin Ferries, the Finnish national ferry company, has worked with Rolls Royce to develop an autonomous ferry. At the end of 2018, a 53 metre ferry with 80 VIP guests on board operated by remote control and autonomously on a voyage in the port of Turku. According to Rolls Royce, the vessel detected objects and conducted collision avoidance in accordance with the Collision Regulations by using its sensors and programmed artificial intelligence. It docked automatically using an autonomous navigation system.

In May 2017, the ship operator, Mitsui O.S.K Lines, agreed to be part of a consortium with the shipbuilder Mitsui Engineering and Shipbuilding. The consortium brings together various parties including the NKK classification society, an academic institution and a technology assessment company in order to develop a technological concept for autonomous ocean transport. This is an ambitious research project which aims to develop autonomous technologies to create integrated systems for the transport of goods.

In the port of Rotterdam a start-up company called Captain AI aims to develop for commercial use the world's first software system for autonomous shipping. The system is being tested and refined on a floating laboratory in various operating conditions in the port.

Quite recently, in May 2019, the USV *Maxlimer* made the first crossing of the North Sea by an autonomous ship. This 12 metre vessel carried a cargo of 5 kg of oysters on its voyage. The voyage demonstrated the technological capability of the vessel's systems in a busy shipping route.

[9] See for example Danish Maritime Authority, *Analysis of Regulatory Barriers to the Use of Autonomous Ships* (Final Report, December 2017).

[10] Comité Maritime International, 'CMI International Working Group Position Paper on Unmanned ships and the International Regulatory Framework'(Position Paper, 2018) – this is a discussion paper covering both the potential regulatory and liability issues arising from autonomous ships. The scheduled IMO work is to be completed by 2021 but this does not involve actually developing any new rules or making amendments to existing agreements – that would take place later.

Classification societies and insurers are also involved. DNV– GL, which is the Norwegian based classification society, used then current technology (in 2016) to produce a concept design for an unmanned, zero emission short sea vessel. The project was intended to provide a model for the development of such vessels and the testing of sensor and collision avoidance systems. DNV–GL has published formal guidelines for the construction of remote controlled and autonomous ships as well as an informative paper on the operation of such ships and the issues which arise.[11] The Ship Owners' P and I Club has developed a liability cover for autonomous ships.[12]

Several States – for example Norway, Finland, Denmark and the United Kingdom – have established testing areas in coastal waters under national law where trials of autonomous ships can be carried out. Maritime UK has produced a voluntary Code of Practice for the Maritime Autonomous Surface ships of less than 24 metres covering design and manufacture and all aspects of operation.[13] It is perhaps most likely that autonomous ships will first be seen operating commercially in coastal voyages and as ferries.

4 How Does This Technology Work?

The technology is under constant development and the nature of work in commercial and military projects of this kind means that it is hard to fix the state of play with accuracy. Overall, the new systems make use of the technological advances in information and communications technology which allow for data collection by a range of sensors which is communicated in real time to computer systems which analyse the data received, make decisions and command the ship's operating systems or, in the case of remote control, the effective communication of data to a remote control station which then gives the required commands to the ship's operating systems. The operational effectiveness of the technology is based on the development of machines which have the ability to learn ever more complicated analytical and decision making tasks. Effective hardware and software which allows for both accurate real time status reports of the vessel's condition and responses which carry out the necessary navigation manoeuvres are, of course, essential to these systems, and the trial and approval of the early autonomous vessels by classification societies and regulators is likely to be an arduous process.

Elements of the technology required to construct autonomous vehicles and cars have been available for many years,[14] but it is only more recently with the rapid developments in sensors, robotics and artificial intelligence and the increased capacity to integrate the operation of these technologies, that work on autonomous transport on land and sea has accelerated. We are all more familiar with discussion and debate about autonomous vehicles in the context of the development of driverless cars and trucks and unmanned aircraft systems (or drones). The changes have already been quite startling. A few years ago, we might have said that operating a ship coming into harbour, or driving a car in traffic, were the kind of tasks which illustrated why computers would never take over our lives – humans would surely always have to do these things. And yet, this seems no longer to hold true.

Many of the projects involving automation in ships, like similar projects involving cars on land, are pursuing the goal of the construction of a "ship" which needs no master and crew on board to operate and navigate, (and no bridge and accommodation for them) and which will operate, either under remote control from shore or under its own computer system which has learnt to operate the ship to the standards applicable to a manned vessel (and will continue to develop its skills). Such a ship is also likely to be linked to a monitoring or control station on shore. It might form part of a fleet of similar autonomous vessels carrying goods around the world which is supervised to the extent required by a dedicated team of experts in the control centre. Those involved in the projects underline that autonomous ships will be less expensive to run than conventional ships, will produce lower levels or zero emissions and will reduce accidents by removing the potential for human error by master or crew on board (on the assumption that the technology on board is effective).[15]

As I have said, exactly, when we might see the general commercial employment of the larger autonomous ships is uncertain. The technology would appear to be already available but its development and implementation in ships might be described as being in its infancy. Although the developments in ships are likely to be incremental,

[11] See DNV GL, *Class Guidelines: Autonomous and Remotely Operated Ships* (Edition September 2018). Lloyds Register, *LR Code for Unmanned Marine Systems* (February 2017) has been developed to certify the safe design and build of unmanned marine systems.
[12] See Ship Owners web site: <https://www.shipownersclub.com/insurance/autonomous/>.
[13] Maritime UK, *Being a Responsible Industry: Maritime Autonomous Surface Ships UK Code of Practice* (Voluntary Code, Version 2, November 2018). The code aims to establish principles for the design, construction and operation of autonomous ships which are less than 24 metres operating in UK waters to standards which are equivalent to those applicable under IMO conventions. The idea is that the Code may inform the consideration of the regulation of bigger ships.
[14] For example, see United States Patent Office, 'Letter of Patent no 613809 - Method of and Apparatus for Controlling Mechanism of Moving Vehicle or Vehicles' (Nicholas Tesla, November 8, 1898).
[15] At a time when sulphur emissions have to be reduced under MARPOL Annex VI and States are committed under the Paris Agreement to reduce carbon emissions to zero, this form of propulsion has obvious environmental advantages.

the pace of development might surprise. Rolls Royce, which has invested significantly in developing the technology required, in particular the computer systems which will make the decisions necessary to operate the ship in accordance with the standards imposed by the Collision Regulations, says that this stage of the general commercial deployment of large cargo carrying ships might be reached by 2035. A Japanese consortium is working towards developing an autonomous ocean-going container ship by 2025.

Currently, the earliest autonomous vessel in service seems likely to be the *Yara Birkland*, which is scheduled to carry cargo on a coastal route in Norway operating autonomously by 2022. CMI simply records in its position paper on autonomous shipping that prototypes are being developed by various parties to develop unmanned container ships and passenger liners which are comparable in size to manned ships. Both CMI and IMO say that the autonomous ships are likely to be operating in the near future.

Of course, as with everything in maritime commerce, the uptake on new design and technology will depend on the business case for it. It seems likely be that the design and construction of ships may evolve towards the fully autonomous ship with technology assisting the master and crew more and more in existing larger vessels, but the nature of current projects around the world indicates that we are likely to see smaller autonomous cargo and other working vessels operating in the coastal and internal waters of some States in the near future. And, if the smaller ships support the business case, and the technology proves effective and safe in operation, larger autonomous ships are likely to be constructed to carry cargo internationally. As with the operation of ships in the earliest times it will take some time before the technology takes to the open ocean.

5 Degrees of Autonomy

Varying degrees of autonomy have been identified by those who are considering the regulatory issues which will arise. For its review IMO identified four different conditions for a ship – a ship with automated processes to assist decision making with seafarers on board, a ship which is remotely controlled from a distant location but has seafarers on board, ships which are remotely controlled from a distant location with no seafarers on board, and a fully autonomous ship where the ship's systems make decisions and take actions. The Code of Practice for autonomous ships of up to 24 metres in length made by Maritime UK has a range of operational conditions from full control and operation of an unmanned ship by a remote human operator, to full autonomy. Lloyds Register 2016 identifies 6 levels from manual through to full autonomous unsupervised operation.

The essential point is that the vessels will be designed to operate without a master and crew on board; the degree of operation which the vessel will carry out itself under the direction of its onboard computer systems is the main variable. Full autonomy involves the ship sensing its state and condition, making operational decisions and carrying them out within the limits of its own computer systems without notice to any external operator. Such a ship would be intended to operate with minimal supervision only communicating with the on-shore control in particular circumstances designated by the operating systems on the ship. It seems likely that new automated ships may be designed to function at different levels of autonomy and remote control at different stages of a voyage. From the regulatory and legal perspective the central challenge arises from the fact that a ship is unmanned with no master and crew on board, whether it is operated remotely by a controller ashore, or it is unmanned and operating and navigating autonomously using on board computer systems with minimal communication and direction from shore.

6 How Do Autonomous Ships Fit with Current Law and Regulation?

As many have pointed out, the technology which can produce autonomous vehicles (whether they operate on land, in the air or sea) is disruptive in both the social and regulatory sense. This is unsurprising because the technology aims to produce a radically changed method of transporting goods and people. This means that existing principles developed for the current circumstances are unlikely to fit well. A short consideration of the law and regulation of ships confirms this.

The principles of maritime law have developed over thousands of years since the beginning of maritime commerce. They centred on the interests of the parties – ship owners, charterers, merchants and cargo owners - involved in the perilous adventure of a voyage to carry goods or passengers by sea. Legal principles developed to protect interests in the maritime adventure and, over time, the parties protected themselves by agreements including contracts of insurance by which the risks of the adventure were spread. Today, the scope of maritime law in the private sphere remains founded on these principles. In legal systems like ours the legal principles involve applying the common law of bailment, tort, contract and specific principles which owe their origins to the admiralty jurisdiction over ships (general average, salvage, rights of arrest for maritime claims).

The concept of the maritime adventure conducted by a ship under the command of a master with a crew on board has been central to the development of maritime law and informs its content. In the context of carriage of goods, while the master's role as the ship owner's representative has been reduced by modern communications, the law relating to such matters as the issue of bills of lading, the stowing and carriage of goods and the conduct of the voyage centres on the actions of the master and crew. Agreements for the hire of a ship to carry goods have always had the same focus.

Where International conventions and agreements such as the Hague/Hague Visby Rules were adopted and implemented to produce standard terms for contracts for the carriage of goods by sea, the content of the rules relating to the vessel and cargo and the exceptions from liability (see, for example, the exclusion for 'act neglect or default of the master, mariner, pilot or servants of the carrier' in the navigation and management of the ship) reflected the fact that the master and crew were the agents of the ship owner on board responsible for the ship's management and operation and the care of cargo.

In the same vein, the principles which underpin admiralty law (which initially may have been more concerned with keeping order in the sovereign's fleet than with private rights) were linked to the maritime adventure and the actions of those who were operating on board the ship on behalf of the owner. Maritime liens and rights to bring claims in the admiralty jurisdiction, while they gave rise to claims against ships and maritime property, arose as a result of the actions of those operating the ship, or to protect the interest of parties which had provided services on, or to, the ship. Ship owners were liable for loss and damage caused to the property of third parties because they were responsible for the fault of those on board – master and crew. The principle of limitation of liability was developed in a wide range of jurisdictions to limit the liability of ship owners to claims and arose, in part at least, because the owner was liable for the faults of its master and crew on-board. Where the ship owner would be liable for the actions of those operating the ship on its behalf in distant seas, the policy was to limit that liability to the value of the ship and freight to encourage the pursuit of maritime trade. The principle is now, of course, given global effect by international convention – the LLMC. It is also used in specific pollution compensation regimes where the owner is strictly liable for pollution damage caused by those operating its ship but is entitled to limitation.

Similarly, the principles of general average which required all those interested in the voyage to contribute proportionately to loss or expense suffered for the common safety of ship or cargo in time of peril arose from the need for the person in charge of the ship – the master - to take steps to save the maritime adventure and protect the interests of all interested in it, usually, in ancient times, by jettisoning cargo to keep the ship afloat. Those principles are, of course, now given their developed international force by contracts incorporating the York Antwerp Rules.

6.1 Regulatory Provisions – Safe Operation

We can see the same focus in the development of the regulation of shipping which sought to improve the safety of the maritime adventure. Over centuries the regulation of shipping operations by authorities developed gradually, starting with regulations made by major ports and developing to regulation at the national level in the more advanced seafaring nations. While the process started in the Middle Ages, it was only in the nineteenth century with the passing of legislation like the UK Merchant Shipping Act (and similar legislation in many other countries) that detailed regulation of the design, construction, manning and operation of ships developed in order to ensure the safety of people and property at sea. Much of the focus of these conventions was on the proper operation of ships by properly qualified seafarers on board.

In the twentieth century international conventions and agreements between States to ensure the safe operation of ships became more common. Ultimately, IMO was established to be responsible for the international conventions and agreements which are primarily concerned with maritime safety and the prevention of pollution which State parties have to implement into their national law. In this way, a common regulatory basis for shipping operations worldwide has been established.

6.2 Overall

The result of the development of specific principles of maritime law and the regulation of shipping by internationally applicable rules is a well-developed system which provides certainty across international shipping and trade for the parties involved and their insurers. This legal order has developed in the context of the maritime adventure involving a ship operated by a crew under the command of a master.

No party contracting to ship goods, to charter a ship to carry goods, or bailing its goods to a ship owner, no regulator considering rules at the international or national level to provide for the safe conduct of shipping operations has, until recently perhaps, contemplated entering into a contract with a ship owner or the making of regulations, with an unmanned ship in mind. This produces the unsurprising result that the legal principles relating to liability and the substance of regulations do not fit with the operation of unmanned ships.

6.3 Ships – Definition Application to Autonomous Ships

As the responses to the CMI questionnaire sent to national maritime law associations in its work on autonomous ships show, the definitions of "ship" used in national law and in international conventions are generally broad and non-exclusive; they cast the net wide, and can be interpreted to encompass a ship which has no master or crew on board operating it because their terms refer to a vessel which is capable of navigating the seas; an autonomous ship will be a vessel or craft capable of navigating the seas, and the definitions do not refer to manning as a requirement for a vessel or craft to be a ship. No doubt, this was unintended by those making the legislation, but the terms of the definition mean that some regulations applicable to manned ships are capable of being interpreted so as to apply to autonomous ships. The position does depend on the particular provisions of national law and, in some jurisdictions, the position on the definition alone will be far from clear cut, particularly, I suspect, if the legislation in question is considered as a whole.

Cases involving the interpretation of definition of "ship" at national level, in differing statutory contexts, tend to concern the limits of jurisdiction in civil or criminal law, and may involve such questions as whether a person operating the vessel is liable to punishment under criminal law for a breach of applicable rules, or whether a claim is available in relation to the particular vessel in the admiralty jurisdiction. Disputes of this kind should be avoided by clear terms delimiting the application of regulation, if a legal regime is to provide certainty. The definitions used, are not, however, the main problem with the possible regulation of autonomous ships; it is rather the substance of statutory regulation and the principles of maritime law, which is unlikely to fit readily with the operation of an unmanned ship.

6.4 The Problem is the Substance of Regulations

If you go further than definitions and review the substance of legal principles or regulation applicable to ships, the simple point emerges fairly quickly that a good deal of the substantive content of international and national regulation about the manning and operation of ships is hard or impossible to apply to a ship which does not have a master or crew on board because it is directed at ships which are manned.

The burgeoning academic literature discussing the legal issues in relation to autonomous ships contains many examples of the uncertainty which will arise where existing legal principles and regulation are considered in the context of an unmanned ship operating without a master or crew. The CMI national questionnaires produced answers in the specific areas covered which confirm this uncertainty in relation to the application of national law applying the key IMO conventions which provide for the safety of property and people at sea.

If the substance of important international conventions and rules implemented by States in national law such as the International Convention on the International Regulations for Preventing Collision at Sea 1972 (COLREGS),the International Convention for the Safety of Life at Sea 1974 (SOLAS) and the International Convention on Standards or Training, Certification and Watch- keeping for Seafarers 1978 (STCW) is examined, key elements such as the obligations to keep watch, exercise good seamanship, qualification and manning requirements, are either difficult to apply or inapplicable where a ship is navigating with no crew or master on board, but under the control of a shore based controller or by the direction of a computer system on board. Again, there is a simple reason for this – the conventions (and national legislation founded on them) were not formulated with such a ship in mind.

7 New Zealand Regulation

New Zealand maritime law has the same sources of legal principles and regulation outlined above. A short review of the principal New Zealand statutes regulating shipping and navigation and the delegated legislation made under them illustrates the incompatibility of a ship operating without master and crew on board with the current substantive law. If the various statutory definitions of "ship" in our statutes are considered in isolation, you might well conclude that an autonomous ship would fall within the statutory definitions of "ship." However, if you go further and look at the substance of New Zealand legislation regulating shipping operations (which adopts relevant

international conventions), and legislation imposing criminal liability on owners or masters, it is clear that it was made to regulate the operation and conduct of ships operated by a master and crew and so is likely not to work with the operation of an autonomous ship.

The definitions of "ship" in the Maritime Transport Act 1993, the Ship Registration 1992 Act and the Admiralty Act 1973 are of the broad non-exclusive kind and refer to any vessel which is capable of navigation. An autonomous ship would appear to fall within this definition. As a result, such a ship could be registered under the Ship Registration Act.[16] It might be the subject of an admiralty claim, and would be a ship under the Maritime Transport Act.

The difficulty arises with the substantive content of the legislation and delegated legislation (in the form of maritime rules made under the MTA) which regulates shipping operations and implements the principal IMO Conventions designated under the Act – collision, operating procedures and training rules, carriage of cargo, crewing and watch keeping, seafarer certification, design construction and equipment, health and safety of crew on ships, keeping log books on board and pilotage. While some provisions cannot apply in their terms and some might possibly be interpreted to work in the context of an unmanned vessel on a purposive approach, the basic point is that much of the legislation does not work with an autonomous vessel and is obviously not intended to apply to such a craft. Some definitions like those of "master" – 'any person (except a pilot) having command or charge of a ship' – and "operation" which refers to causing a ship to sail 'whether or not the person operating is with the ship' – might be relied on to support a purposive approach to provisions relating to dangerous operation of ships so as to possibly allow the provisions to be applied to those who operated an autonomous ship remotely. That is, however, a doubtful and uncertain approach because the substance of the legislation is directed at manned operations.[17] "Crew" is defined as 'persons employed on board a ship' and the employers duties as regards seafarers plainly contemplate seafarers as those who work on board. Although the definition of master does not specifically refer to the master in charge on board, the master's general duties such as the duty to assist persons in danger, the duty to report dangers in navigation and the obligation to take a pilot on board where required under maritime rules, all point to the legislation being concerned with ships with master and crew on board. The Act and delegated legislation in the environmental field (marine protection rules implementing designated marine protection conventions, including MARPOL) – is directed at the responsibility of owners and masters for discharges in New Zealand waters. The same applies to the provisions of the Resource Management Act 1993, which applies to discharges in the costal marine area. The responsibility for reporting shipping accidents and incidents, and discharges, which is central to the prevention of pollution, rests with the master of the ship and the master is criminally liable for failures to report and for the discharge and dumping offences (along with the owner). The idea is to make the person in charge (and present in the jurisdiction) responsible and liable for breach. Again, the legislative regime contemplates the presence of a master on board the ship and is not workable without that presence.

If shipping operations were to be carried out by a vessel without master or crew, the regulatory framework under New Zealand law would be affected in a fundamental way, which no purposive approach to interpretation could properly address. Many important statutory provisions could not be applied and/or would not work in the case of a ship operating without master and crew. Significant amendment to provide certainty as to the obligations and operation of such a ship would appear to be the only solution and, given the fundamental change in operations which will be presented by autonomous ships, the range of substantive provisions affected and the range of possible autonomy, "quick fixes" like extending or amending definitions, such as those of 'master' and 'crew,' will not work if regulation is to be clear.

7.1 Rule Making Under the MTA

The fact that an autonomous ship would fall within the definition of ship under the MTA would mean that the general powers of the Director of Maritime New Zealand would be potentially available in relation to the ship (for example, inspection, audit and detention) if such a ship became operational. The power to make rules under the Act would also be available, and this would permit the making of specific rules for the certification and operation of an autonomous ship. That course would appear to be preferable where the various marine protection rules are

[16] UNCLOS Article 94 imposes conditions for the right of a Flag State to sail ships under its flag which are expressed generally and are, in part, concerned with the manning, qualification and training of master and crew. While some of the general requirements in the Article do not work with an unmanned ship, this general jurisdictional provision would not prevent New Zealand exercising its right as a Flag State to allow an autonomous ship to be registered under its legislation. Under New Zealand law the general requirements for registration under UNCLOS could likely be met by requiring appropriate safety measures for the particular autonomous ship which was to be registered.

[17] The many references to the master in the MTA and delegated legislation under it like the references to crew and seafarers is always in the context of operations on board a ship.

generally concerned with the design, construction and operation of manned ships. However, under the current rules the requirements for a person to carry out a maritime transport operation in New Zealand waters and /or the power to approve the construction of a novel ship not covered by other rules on construction and design might be applied to an autonomous ship. For an autonomous ship to be certified to operate under the current rules, documents would have to be submitted to show the safety management system for the ship complied with the ISM Code (for SOLAS ships) and with the NZ Code for smaller ships or to have a particular ship safety case approved for a novel ship. This system or safety case would have to show a standard for safe operation which would ensure safety at sea, prevention of injury and loss of life, and avoidance of damage to environment and property. The safety management system under the NZ Code would have to be managed by an organisation approved by the Director and compliance would be subject to annual audit. In short, a framework for considering the approval of the operation of an autonomous ship and its certification is available under the MTA although there are, as yet, no developed rules or standards which specify what is required for the construction and operation of such a ship. Where any process for approval will need to develop the substance for consideration from scratch for a new form of shipping operation it would seem preferable to have a specific maritime rule for this rather than seeking to use existing rules for the job.

8 New Rules Will Be Needed

As I have said, IMO is carrying out the important work of reviewing the application of the fifty conventions and agreements for which it is responsible to see what amendments or new provisions might be needed to ensure the safe operation of autonomous ships. My impression, after a relatively short review of the Conventions, and a consideration of New Zealand law on shipping and navigation, is that the uncertainty in the regulatory position at the international and national level will leave the certainty that new regulation will be required at both levels, if the operation of autonomous ships is to be carried out on a clear basis in coastal and international waters. The incompatibility of the substance of much national and international regulation means that a quick solution by say expanding definitions in statutes is unlikely to address the issues in a satisfactory way. The registration of an autonomous ship is likely to be available under many national registration provisions, and such ships have already been registered in some States. While an autonomous ship might be approved for operation by a Flag State in its coastal waters, it would inevitably interact with other manned ships in those waters; this underlines the need for clear rules from the outset.

If there are no specific rules, disputes as to the application of the law imposing civil and criminal liability regarding the operation of ships are likely should accidents occur. Flag States which register and approve the operation of unmanned autonomous ships will no doubt seek to impose appropriate standards under their laws, and the work of IMO is directed at providing a clear framework for international regulation, but the fact that an autonomous ship could be developed, registered and approved to operate in a particular State in the near future does raise the possibility that such a ship could commence operations without a clear framework for those operations in the waters of other States. The uncertainties could lead another State to take measures in relation to an autonomous ship under its national laws, where it had a different view about the safety of the ship from that of the regulators of the ship's Flag State.

As IMO and CMI and various States have recognised by their current commitment to work out what is required to regulate autonomous ships, it is best to consider the issues and develop regulatory responses, before autonomous ships are ready to operate commercially, and owners seek registration and certification from Flag States. If the development of autonomous ships proves to be of commercial benefit, those States which have taken the lead in developing the technology, and in considering the required regulation, seem likely to have the best chance of gaining the benefits of early adoption.

I would suggest that reviews should be conducted now at national level in Australia and New Zealand to assess the technology and the regulations and standards by which an autonomous ship might be approved to operate, and where national law may need amendment if the operation of an autonomous ship is to be addressed effectively. It would be best to work out the basis on which an autonomous ship might be certified and the requirements for a safe ship management system for such a ship under the NZ Code and develop a specific rule which can be applied generally. The process by which such a vessel might be tested and subsequently approved and certified for operation might be published (New Zealand Transport has published the requirements for the testing and approval of autonomous cars in New Zealand.) As yet, I am not aware of any preliminary work in this area in New Zealand in connection with shipping, in particular in relation to the regulation of smaller non-SOLAS autonomous ships. While IMO will address regulation from the international perspective in the areas covered by the international conventions, it is important to conduct a review of New Zealand legislation to identify where it will have to

change, whether in those areas where changes are likely to come through the IMO process, or in other areas where national law is likely to be required to regulate autonomous ships, because their operation is outside the scope of IMO Conventions.

A recent review of the position under New Zealand law addressing the possible impact of driverless vehicles is of interest.[18] The study recognises the way in which driverless cars will have the capacity to disrupt the existing national regulatory and liability regime for motor vehicles. The study examined the potential advantages of this technology and the regulatory barriers to its implementation, and identified the need to amend relevant national legislation if New Zealand was to be best placed to accept the technology. A number of points for amendment to New Zealand legislation were made including the need to make it clear that a driverless car was still a car for the purposes of the road traffic legislation, to provide for appropriate criminal legislation for offences committed by such cars and to consider creating strict civil liability for property damage. Cars on land are different and the focus can be solely on national law, but the scope of the study is instructive.

9 Civil Liability Issues – If Something Goes Wrong

If the regulatory requirements for the safe operation of autonomous ships can be addressed, a wide range of questions involving the potential civil liability arising from the operation of an autonomous ship will remain. As I have outlined those issues may well have to be addressed in the context of broader change to the organisation of shipping, the sale and transfer of goods and the carriage of goods by sea brought about by increased digitisation. This is likely to change the nature of the transactions involved and the parties responsible for the various stages of the physical and digital operations from those currently involved to the providers of various automated services. Some issues are likely to be addressed by commercial parties in the contracts they enter into for the use of autonomous ships or the carriage of goods on them. Some might be addressed by amendment to existing international agreements and conventions relating to the carriage of goods which have effect in private law (such as the Hague Visby Rules) or, more likely, the formulation of new international agreements specifically providing for the carriage of goods by autonomous ship.

As with regulatory provisions, a ship which operates autonomously without a master and crew, whether in a condition of remote control from shore, or in a state of full autonomy, presents a fundamentally changed liability picture from the one which is presented by ships which operate under the direction of master and crew. The development of autonomous ships will be incremental, but, as it occurs, it seems likely that the courts may have to address some of the issues and consider commercial agreements which seek to do this. By way of example, the examination of a factual concept such as the seaworthiness of a ship which arises in various legal contexts – carriage of goods, insurance cover - will have to be examined very differently where the vessel supplied is operated by computer systems with no master and crew on board.

As I have outlined, maritime law has developed in relation to the operation of ships by the master and crew on board. If that form of operation comes to an end in some ships at least, the application of many established principles may have to be reconsidered. By way of example, the law has developed on the basis that the owner of a ship is liable for loss and damage to third parties as a result of neglect or fault of those on board operating the vessel. That approach does not seem to be capable of application where the ship owner provides an autonomous ship, and any fault causing loss and damage to third parties may result from fault in the ship or its systems which might be attributable to companies supplying components. Similarly, whether established principles relating to the carriage of goods, which require proof of a failure to exercise reasonable care for the goods subject to various exceptions (including the fault in navigation or management exception) can be applied in any even modified form to carriage by an autonomous ship will need to be considered by the commercial parties in their arrangements, or in relation to the formulation of international standards for this form of carriage.[19]

As noted above, the principle of limitation was closely linked to the potential liability of the ship owner for the faults of those on board acting on its behalf, and provided for the right to limit in order to prevent the prospect of indeterminate liability arising from the actions and fault of a master or crew members, stifling commercial enterprise. This principle is internationally applicable through the relevant conventions – mainly now the 1976 Convention which provides for a right to limit which is very difficult to break and, that a servant or agent for

[18] Michael Cameron, *Realising the Potential of Driverless Vehicles: Recommendations for Law Reform* (New Zealand Law Foundation, 2018).
[19] The carriage of goods by sea within New Zealand would be subject to New Zealand domestic carriage of goods legislation which imposes a form of strict liability with limits of liability per unit of goods. Again, whether that regime which has relatively low package limits should be applied to carriage of goods by an autonomous ship would no doubt be debated. The broader problem is of course the appropriate regime for the carriage of goods internationally by autonomous ships.

whose acts or defaults a ship owner is responsible, can claim limitation, if claims which are subject to limitation are brought against them. An autonomous ship might fail, and cause loss and damage causing claims, not as a result of the acts of those on board operating the ship, but as a result of a failure by a remote operator or, perhaps, as a result of the failure of a computer system on board or ashore or a mixture of both – quite a different scenario. Given the origins and nature of the right to limit, the change in the manner of operation may lead to consideration whether it remains appropriate as a matter of policy to allow the operator of an autonomous ship to have the right to limit. Whether the concept of limitation in shipping can survive and apply to autonomous ships, where operative fault for an incident cannot lie with the fault of master or crew on board, but perhaps, in computer hardware or software which is part of the ship provided by the owner, must be open to some doubt. That is particularly so where the special nature of the concept of limitation as applied to ships, has been criticised as being out of line with general principles of liability which apply on land. While the owner of an autonomous ship will send its ship to sea to face the same perils as the owner of a manned ship, the manner of operation of the ship differs and, as a matter of principle, the owner may not be able to justify having the right to limit where it has supplied the ship/product which fails, and the fault is likely to be that of a shore-based operator or a system installed in the ship. It may be that the liability regime governing liability for loss and damage caused to third parties by the operation of an autonomous ship will involve a form of strict liability which is subject to a particular limitation regime.

If an autonomous ship was involved in a significant incident as a result of faulty design or manufacture, it is perhaps more likely that claims for losses by third parties would be determined by the law of a particular forum applicable to the liability of a manufacturer or designer (or, possibly, the party certifying the system responsible for the failure) because those would be the more likely responsible parties, and they would not be able to limit liability on a claim. This would produce uncertainty because the requirements for establishing liability against a party responsible for the design, manufacture or, indeed, certification of an autonomous ship, and the extent of financial liability, will differ from one legal system to another.[20] That is, of course, already the case with such claims but they have been very rare with manned ships. But, if ships do become autonomous, and are seen more in the nature of a sea-going computerised product, the focus of liability when something does go wrong, may switch from the owner or operator (with limitation rights) to manufacturers and designers which are seen as responsible for the failure of the product and who have no such right to limit the claim.

While manufacturers and designers will, no doubt, seek to limit their liabilities by contract, their potential liability to third parties could not be so limited, and I can see little prospect of the concept of limitation being extended to them by international agreement. Although one of the main aims and promises of the technology is to reduce the number of accidents by removing human error, the potential for liability in the event that something does go wrong, may give manufacturers, designers and certifiers (and their insurers) some concern. The potential liability is, however, present with many of the innovations produced by digitisation and automation and, to judge from some of the initial interest being expressed by insurance markets in the possible new commercial operations and new risks, it seems that the commercial opportunity in the developments and in providing the insurance of the risks, will outweigh any chilling effect.

10 Australia and New Zealand – What To Do?

Although I have recently seen that AMSA is holding a forum on autonomous vessels shortly after this conference, MNZ held two meetings on this topic in 2018, and both countries will attend on the IMO convention review process, I have not yet seen much published consideration of the opportunities and regulatory issues arising from the development of autonomous ships in Australia or New Zealand (apart from the answer to the CMI questionnaire setting out the position under Australian law).

As I have outlined, regulatory systems at the national level in many countries including New Zealand and Australia reflect international conventions and agreements, and IMO is working to determine how best to regulate Maritime Autonomous Surface Ships under the international conventions and agreements for which it has responsibility. We could opt to wait and see what happens in this international process then implement any changes to national law in accordance with the approach taken after the IMO review. Those changes would however, not cover all provisions of national law relevant to New Zealand ships, where change might be required, or produce regulation for the operation and certification of smaller autonomous ships operating in New Zealand coastal waters (non-SOLAS ships).

[20] There is strict liability in the US and EU for defective products and fault based negligence liability in many other jurisdictions like NZ. In Australia there is potential for strict liability under defective product legislation, but this is not present in New Zealand.

10.1 A Proactive Approach

It would seem preferable to take a more proactive approach to the potential developments. Where the technology is seen by many private companies and countries as offering significant potential for commercial development (particularly, perhaps, when seen as part of a transport strategy aiming to reduce road transport and emissions), New Zealand and Australia should probably consider the possible benefits and the barriers to its use. Where ships are being developed which may be available in the near future, States should be as ready as possible to assess any vessel which a party proposes to operate in its waters. Readiness involves having the necessary expertise in the standards applicable to design and construction of such vessels in order to consider an application for certification, and having the necessary regulatory framework for approval and operation in place. While the IMO process is likely to produce a considered view on how to regulate autonomous ships which operate on international voyages, whether by amending relevant existing conventions, or by creating a new regime imposing standards for operation, that process might not move fast enough to keep pace with technological developments and is unlikely to cover smaller autonomous ships which may operate in coastal waters. In the circumstances, I suggest that there is scope for the formation of a broad multi-disciplinary expert group in New Zealand and Australia to consider the state of technological development, the possible benefit of entering into development and application, and the regulation of it.

Where the developments may represent an opportunity to States which adopt them early, an approach similar to that taken in the Scandinavian countries or the UK where standards and codes have been produced for the design, construction and operation of autonomous vessels which will operate in coastal waters, and reviews of national law undertaken, has much to commend it. At the very least, New Zealand should review its existing primary and delegated legislation and work out where it will need amendment if smaller autonomous ships are to be permitted to operate in New Zealand waters and be the subject of effective regulation as regards safe operation and protection of the environment.

The risk with waiting to see what happens internationally is that New Zealand might have to prevent or delay the operation of an effective autonomous ship in its waters – perhaps a ferry or a coastal trading ship like the *Yara Birkland* – because of concerns about regulation and/or lack of knowledge in assessing the standards of its design and construction, or New Zealand has to regulate in haste to allow to craft to operate.

11 Concluding Comment

The rise of automation which is producing the development of modes of carriage and transport which do not require human operators tends to be portrayed in either utopian or dystopian terms. The rise of automation and learning machines certainly affects the way in which we operate as human beings in a fundamental way. In shipping, the trend towards increased automation is likely to be gradual but, if some ships are to be unmanned, the role of master and seafarer which has been central to the maritime adventure for thousands of years will be replaced in those ships by technical roles on – shore in operating and monitoring computer systems. That kind of change is disruptive, both in societal terms and in terms of the regulation of shipping operations by the law, but I suspect that the outcome of the technological revolution will be neither utopian nor dystopian, but somewhere in between; and, as ever, dependent on how we choose to make use of it.

Coming back to the implementation and application of legal rules, the best way to approach new methods of commercial operation is to be as prepared as possible to make and apply new rules to ensure that those who are engaged in commerce have as much certainty as possible. While wide- ranging change might take decades, the first changes are almost with us and setting the framework for legal regulation early is all important. We have work to do if we are to keep up. Thank you for your attention.