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MASTER THESIS

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Regulations and Their Effects on the Implementation of Innovation and Technology: A Case Study on Autonomous Passenger Vessels

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Preface and Acknowledgements

The idea for this master thesis came from the work I performed on behalf of a Norwegian company, Zeabuz. Zeabuz is presently developing and intends to implement autonomous inland waterway passenger vessels to help facilitate transportation in urban centers where crossing a river would be much faster than following traffic across a bridge. The primary focus of my work for them was to map out the existing regulations with respect to passenger vessels within the EU to determine how they would be applicable to the prototype vessel they are developing to bring to market. As a U.S. licensed and practicing attorney, I jumped at this opportunity because delving into the minutiae hidden within the law is something I enjoy. For this thesis I expanded my research to include international, regional, and national regulations within the European Union and extended it to include, to the extent they exist, regulations dealing with or attempting to touch upon unmanned or autonomous vehicles, whether land-based or water-borne.

Although the primary focus of this research was directed at unmanned / autonomous passenger vessels conducting operations in inland European waterways, the issues studied and deficits identified when it comes to technology and governance directed at said technology abound. The recent governmental attempts to stop and regulate the growth of AI-based ChatGPTs serve as an example of how technology can advance and grow in ways that the institutions that form the basis of human governance are not always adept to timely or properly regulate. I would like to thank my advisor, Reidar Staupe-Delgado for helping me to stay focused on the task at hand and for his guidance in channeling and expanding my ideas in a way that permitted me to transfer them into written form. I would also like to thank all my classmates at UiS, who were my social support system in the midst of a pandemic while in a foreign land. Lastly, I would like to thank my wife and children for their support, patience, and help in pushing me to the finish line.

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I. INTRODUCTION

Gordon Moore posited that the number of transistors in an integrated circuit doubles approximately every two years.[1] Better known as "Moore's Law," the idea is that the growth of technology is expected to be exponential. As technology continues to expand and grow, so too does humankind's attempts to harness technology towards efforts to automate processes and arguably simplify the human existence.

Included in these efforts are attempts to create autonomous vehicles (i.e., driverless cars, self-operating water vessels, and other modes of transportation) that will ultimately be able to operate on their own without the need for any active human interaction through the increasing use of what some have termed an "intelligent system" or machine learning. The development and implementation of intelligent systems capable of autonomously operating land, air, and water-based vessels continues to grow. Not coincidentally, so too has the interest in this phenomenon - from private enterprises to government entities, and universities to start-ups – which are all helping to fuel the growth of intelligent and eco-friendlier technologies to address the existing and foreseeable transportation needs. Many of these same entities are working on developing and implementing unmanned vessels as a means to solve transportation-related issues that range from local, short-term routes, to routes that extend across oceans and borders throughout the world.

It is indisputable that the advances in this particular technology will touch upon vast aspects of modern life and bring with it a whole host of questions that continue to emerge - many of which remain to be answered. This includes, *inter alia,* ensuring that the technical specifications and equipment required to operate these autonomous vessels are consistent with best practices when it comes to safety and operations, determining how and whom will be responsible for the oversight

[1] https://www.britannica.com/technology/Moores-law (last accessed on June 13, 2023).

of the autonomous vessels, what kind of training and supervision will be required to operate these vessels, etc., and what will form the primary focus of this thesis, how these vessels will be regulated and treated by governmental entities. The list of areas and matters that will require a rethinking of how we presently organize society are way too many to be covered in this one writing.

However, other questions to ponder include issues surrounding insurance, liability, and culpability surrounding any potential accidents caused by an unmanned vessel. For example, will autonomous vessels be considered strict-liability[2] instruments, and if so, who will bear the risk? The manufacturer, the operator, the licensee, or all three? If not strict liability, then what will be the liability levels assigned to the respective entities involved in the construction, operation, and maintenance of these vessels? As this form of technology, and the vessels that will employ them, continue to advance, two growing questions also emerge:

- What are the current existing regulations, if any, with respect to these vessels? and,
- What role do they play in helping, or conversely, hindering the dissemination of innovation?

The answer to these questions will have differing implications for small and big businesses alike. The existence of applicable regulations permits a business to adopt and adapt their operations accordingly. The absence of applicable regulations can result in operations remaining in limbo for an unforeseeable amount of time, up and until regulations are enacted. Without regulations, can the emerging technology be disseminated for use by society? The aforementioned example of ChatGPTs serves as an example of what can happen when technology is disseminated before regulatory structures exist. As can be imagined, the aforementioned regulations cover a vast area

[2] Liability which does not depend on actual negligence or intent to harm.

of compliance and includes a vast number of areas and industries that are beyond the scope of this thesis. Accordingly, the focus of this thesis will be guided by the two questions below:

1. What governmental entities are responsible for enacting regulations that would be applicable to waterborne vessels operating on EU waterways, including those proposed by Zeabuz?

2. What are the existing EU and Norwegian regulations governing unmanned or autonomous in-land passenger vessels and how do they apply to the operations of Zeabuz's proposed autonomous passenger vessels?

After reviewing the applicable regulations, the author will determine whether said regulations take into consideration the use of autonomous vessels equipped to carry passengers. This particular focus and emphasis arose, as noted, from my prior work with a company at the forefront of this movement, Zeabuz. Based out of the Norwegian University of Science and Technology - Trondheim, Zeabuz intends to develop the world's first full-scale autonomous ferry – the "milliAmpere 2."


[3]

[3] *See,* https://www.zeabuz.com/join (last accessed on June 13, 2023).

It is designed to carry up to ten passengers on short, ferry connections among points in urban waterways. As the technology of their vessel advances and becomes more and more autonomous the questions surrounding regulations and their ability to place their product into commercial use remains. This thesis hopes to be able to provide answers to the questions noted above, and hopefully chart a course forward that will allow technology to flourish, and not be hindered by the absence of forward-thinking regulations.

A. Delimitations

As noted in the introduction, the areas that will be impacted by the increased use of unmanned and / or autonomous vessels, whether on land, sea, or inland waterways, are too vast to be covered in this one thesis. Each geographic area noted above operates under its own differing sets of rules and regulations that govern the vessels operating in each. To these geographic regulations, one must also add the differing geopolitical regulations that cities, states, nation-states, and supranational entities enact and enforce on vessels operating within their respective, and sometimes overlapping, jurisdictions.

Due to the breadth of overlapping laws and regulations, the primary emphasis of this thesis will be limited to scoping the existing regulations governing passenger vessels in inland waterways in Europe and Norway in order to determine whether current, existing regulations would be applicable to Zeabuz's innovative and increasingly autonomous passenger vessel. The author anticipates that such regulations still do not yet exist. As such, determining the role do regulations (or in this case, the absence of regulations) play in helping, or conversely, hindering the dissemination of innovation, becomes crucial. The answer to these questions, and the others, will be contrasted to the operations being undertaken by Zeabuz in its continuing efforts to place autonomous passenger vessels into commercial use.

My research into answering these questions was also limited by both access to resources and my basic knowledge and understanding of Norwegian language. Though I came across numerous secondary sources that discussed to some degree the legal implications of autonomous vehicles or vessels under the current-existing legal framework, access to many of these sources were restricted by paywalls or subscription services I was not privy to. As for the language barrier, though I was fortunate enough to have lived in Norway for two years, those years came in the midst of Covid where social interaction was minimal and my opportunities to expand my knowledge and understanding of Norwegian were scarce. As such, I was only able to reference regulations and proposals that also provided English translations of the originals.

B. Structure of Thesis: This Thesis will be Organized in the Following Chapters.

Chapter II provides a literature review of the current efforts to classify and define the increasing levels of autonomy for both land and water-based vehicles. This forms the starting point to determining what is the current landscape and status of existing legislation with respect to this emerging technology, and to the extent it exists, regulatory efforts directed at autonomous vehicles, and passenger vehicles. Differences in the uniformity, or lack thereof, in these approaches will be discussed. Though beyond the scope of this thesis, other issues that are highlighted include how referring to something as a “vessel” versus using the term “ship” has legal implications in how that particular vehicle will be regulated and the liabilities that come with each. This small distinction, carries with it immense legal implications that must be taken into account when legislative or regulatory bodies are drafting legislation, and the language chosen to describe or define terms.

In Chapter III, I discuss the methodology and research design I used when putting together this thesis. This includes an overview of the theoretical perspective and approach, the research strategy, and the method under which the data that was collected was analyzed.

In Chapter IV, I review the results of my research. The first part focuses primarily on the first research question and looks at regulations enacted by international and regional organizations affecting the use of waterborne vehicles, including the International Maritime Organization, the Central Commission for the Navigation of the Rhine, the United Nations Economic Commission for Europe, the European Parliament and European Council, and the Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation Intérieure. As part of this analysis, I applied, or attempted to apply, the current regulations to Zeabuz's proposed passenger vessel, often finding that in many occasions, there would be no easily defined application. The second part of Chapter IV, will focus on Norwegian regulations applicable to ships operating in Norwegian waters or registered as Norwegian fleet.

Chapter V provides a discussion of the results with a greater emphasis that highlights both the inconsistencies in the current regulations, as well as the general inapplicability to a vessel such as the one currently being developed for use in Zeabuz's operations. This includes regulations that simply do not yet contemplate the use of autonomous vessels, to regulations that have envisioned the use of such vessels, but appear to cling to existing regulations that require that these autonomous vessels also not be unmanned. An overview of Zeabuz's current operations is also discussed as provided to me by its CEO and Co-Founder, Eric Dyrkoren.

In Chapter VI, , the conclusion, I provide closing remarks as well as ideas for future research and calls to action in order to clear up the murky regulatory waters that currently exist with the classification and regulation of autonomous vessels in general, and autonomous passenger vessels in particular.

II. LITERATURE REVIEW

A. Attempts to Classify and Define the Differing Levels of Automation of Land-Based Vehicles

Although the focus of this thesis is ultimately inland water-based vessels, it is worth noting what regulatory attempts have been made in the areas of land-based autonomous vehicles, and the extent to which these classifications attempt to establish a uniform system for classifying the same. The Society of Automotive Engineers ("SAE") is a global association of more than 128,000 engineers and related technical experts in the aerospace, automotive and commercial vehicle industries whose mission is to advance mobility knowledge and solutions for the benefit of humanity.[4] In an effort to have uniformity and common understanding in the area of automation of land-based vehicles it released publication, SAE J3016™ Recommended Practice: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles[5] in 2014, which created the following six levels of automation:

Table 1: Levels of Automation for Road Vehicles (adapted from Blanke et. al, 2016).

Level 0: No Driving Automation	The driver performs all driving and navigation without any assistance.
Level 1: Driver Assistance	The car can keep a distance to other similar cars.
Level 2: Partial Driving Automation	The car can perform simple tasks on its own, such as driving in the road system where it is located.
Level 3: Conditional Driving Automation	The car can drive on its own specific situation. The driver does not need to control the car actively of keep a lookout, **but must be able to intervene on short notice.**
Level 4: High Driving Automation	The car can drive on its own in specific surroundings, but the driver does not need to be ready to take over control.
Level 5: Full Driving Automation	Driverless cars in all surroundings and in all potential situations.

4 https://www.sae.org (last accessed on June 13, 2023).

5 https://www.sae.org/standards/content/j3016_202104/ (last accessed on June 13, 2023).

In May 2017, The European Commission issued a communication to the EU Parliament, Council, the Economic and Social Committee, and the Committee of the Regions outlining a path forward for implementing automated mobility on a continent-wide basis.[6] The communication used SAE's levels of automation[7] and called for greater work with and among European Union ("EU") member states to establish guidelines to ensure harmonized approaches for national ad-hoc vehicle safety assessments of automated vehicles. It also as established new vehicle safety certification for automated vehicles (cars, trucks, public transport vehicles on defined routes). It pledged 450€ million Euros to accomplish these goals.

The European Commission recognized that vehicles corresponding to levels 1 and 2 on the SAE scale where already available on the EU market, and noted that levels 3 and 4 were being tested and should be available by 2020 (see Table 2, below). These expectations were later revised, such that levels 3 and 4 would be available on the market between 2020 and 2030, with the expectation that level 5 vehicles would be available in 2030, as noted in table 3, below.

Shortly after the release of the communication, Wim van de Camp issued a draft report on autonomous driving in European transport that argued for the extension of the communication to go beyond just road-based vehicles.[8] Van de Camp argued that continent-wide attempts to develop autonomous vehicles should also be extended to air-based transport, rail-based transport, and waterborne transport, including, and especially, inland waterways. The expectation was that autonomous vessels should and would become more diffuse throughout Europe, from roadways to railways and from wharfs to docks.

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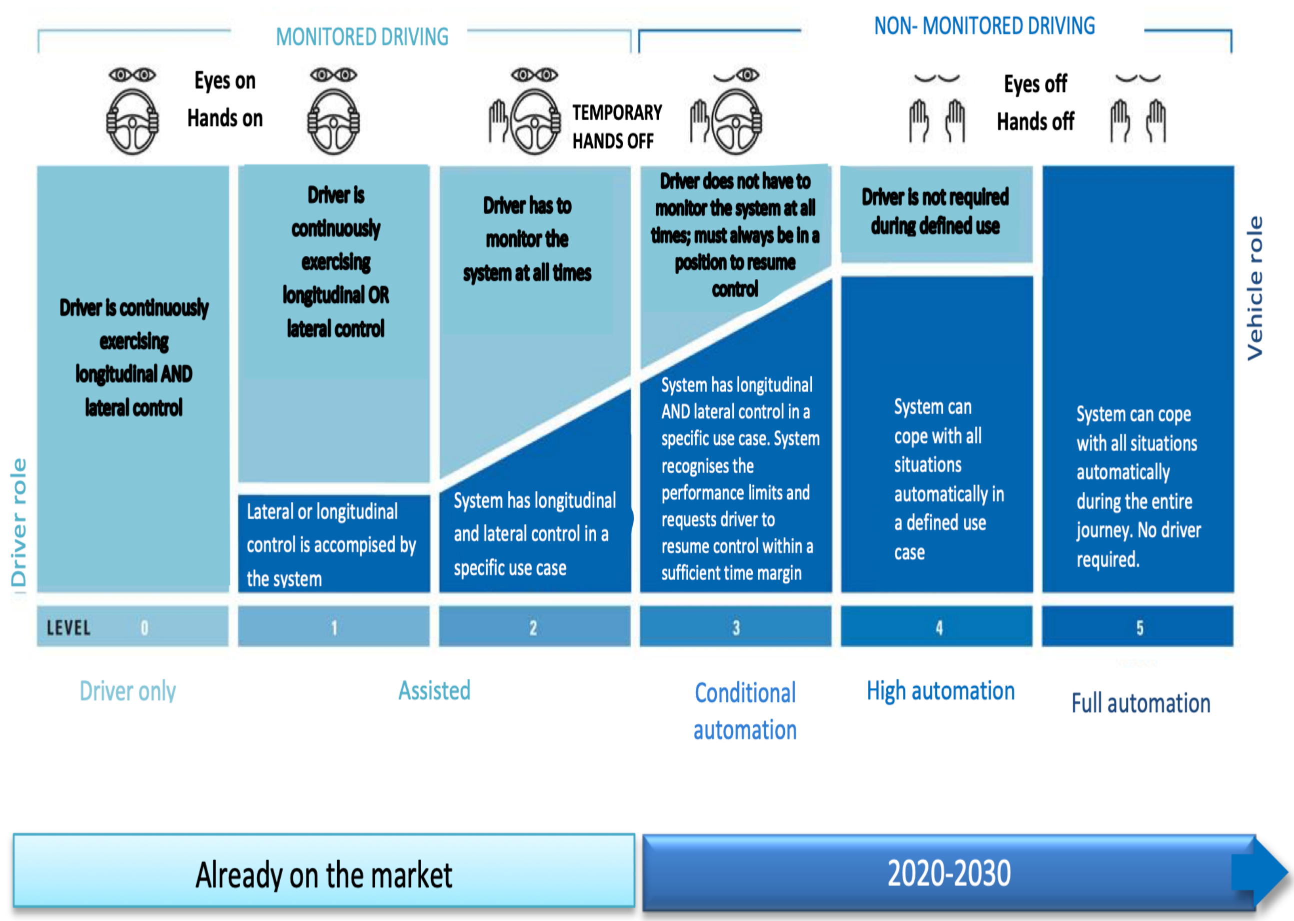
6 See, https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2018:0283:FIN:EN:PDF (last accessed on June 13, 2023).

7 (*Id*. at p. 3)

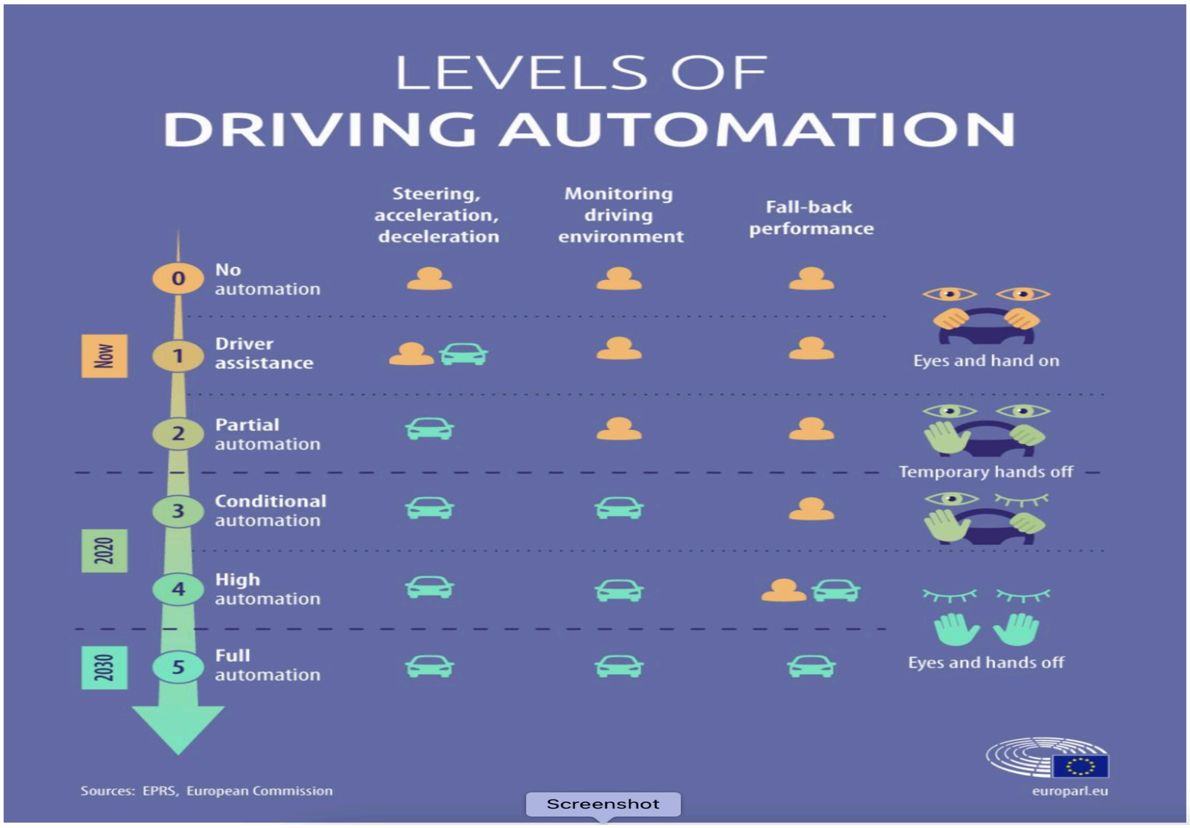
8 https://www.europarl.europa.eu/doceo/document/TRAN-PR-623787_EN.pdf

Table 2: Society of Automotive Engineers Levels of Automation Overlapped with EU's timeframe for implementation of autonomy levels[9]



9 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2018:0283:FIN:EN:PDF (last accessed on June 13, 2023.

Table 3: The European Union's adaptation of Society of Automotive Engineers levels of autonomous vessels.[10]



On May 3, 2021, SAE released an updated version of its defined levels of driving automation as shown on the chart below:

[10] See https://www.europarl.europa.eu/news/en/headlines/economy/20190110STO23102/self-driving-cars-in-the-eu-from-science-fiction-to-reality (last accessed on June 13, 2023).

Table 4: Society of Automotive Engineers' Updated Levels of Automation Chart (2021) [11]

	SAE LEVEL 0™	SAE LEVEL 1™	SAE LEVEL 2™	SAE LEVEL 3™	SAE LEVEL 4™	SAE LEVEL 5™
What does the human in the driver's seat have to do?	**You are driving** whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			**You are not driving** when these automated driving features are engaged – even if you are seated in "the driver's seat"		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			**These are automated driving features**		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering **OR** brake/ acceleration support to the driver	These features provide steering **AND** brake/ acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering **OR** • adaptive cruise control	• lane centering **AND** • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/ steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

In 2021, the United States Department of Transportation ("DOT")[12] also issued it Automated Vehicles Comprehensive Plan,[13] which has three objectives: (1)

1. **Promote Collaboration and Transparency** – Promote access to clear and reliable information to its partners and stakeholders, including the public, regarding the capabilities and limitations of ADS.

2. **Modernize the Regulatory Environment** – Modernize regulations to remove unintended and unnecessary barriers to innovative vehicle designs, features, and operational models, and will develop safety focused frameworks and tools to assess the safe performance of ADS technologies.

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[11] https://www.sae.org/blog/sae-j3016-update (last accessed on June 13, 2023).

[12] The United States DOT is a Department of the Executive branch of the U.S. federal government that is responsible for planning and coordinating federal transportation projects. It also sets safety regulations for all major modes of transportation at the federal level. https://www.transportation.gov (last accessed on June 13, 2023).

[13] https://www.transportation.gov/AV (last accessed on June 13, 2023).

3. **Prepare the Transportation System** – Conduct, in partnership with stakeholders, the foundational research and demonstration activities needed to safely evaluate and integrate ADS, while working to improve the safety, efficiency, and accessibility of the transportation system.

Similar to the EU initiative, the Automated Vehicles Comprehensive Plan purports to bring together numerous stakeholders, and organizations, including the SAE, to develop and facilitate the use of automated driving systems. Because it forms part of the U.S. Federal government, its regulations apply uniformly across all states and transportation sectors within the U.S. One would also anticipate that this would also be the case when it comes to the EU regulations envisioned by the European Commission, as noted above.

The aforementioned initiatives for autonomous land-based vehicles demonstrate an ongoing and arguably coordinated effort by varying entities to attempt to create uniform classification systems for the use and regulation of land-based transport vehicles. However, once we leave land-based regulations and turn our focus off-shore, the regulatory waters and definitions become murky, as discussed in greater detail, in the following sections.

B. "Autonomous" or "Unmanned" / "Ship" or "Vessel" – What's in a name?

"What's in a name? That which we call a rose by any other name would smell as sweet."[14] Though it rang true for Juliet, the first obstacle in determining what regulations will apply to what ship or vessel does indeed depend on the term used to describe its operations. Merriam-Webster's dictionary defines **unmanned** as "not carrying, staffed, or performed by people."[15] **Autonomous**, on the other hand can mean "undertaken or carried without outside control; existing or capable of existing independently; or responding, reacting, or developing independently of the whole."[16] One must be cognizant to use terms properly when speaking of "autonomy." (Blanke et al. 2017).

"**Autonomous ship**" has been understood to mean "a ship which, to a varying degree, can operate independent of human interaction." (Pietrzykiwski and Hajduk 2019). Another attempt at defining "autonomous ship" comes from Vojković and Milenković (2019), who used it to mean "ships capable of independent navigation without human presence on board, which can be divided to ships with no human presence on board and those without a navigation crew." The levels of autonomy increase from manual control, to automatic control, fully automatic control, and autonomous navigation. This spectrum, from fully manned vessel to fully autonomous ship, entails differing degrees of manning, remote control, and automation (Chircop 2018).

Other definitions that require our attention are **autonomous** versus **remote**. "**Autonomous**" "implies a capability to make a decision independently from human beings." (Dremliuga & bin Mohd Rusli 2020). It has been noted that "autonomy starts with a navigation, guidance, and control system together with a dynamic unmanned vessel algorithm." (Li & Fung 2019). "**Remote**" on the other hand, refers to human control from a distant, or as the term implies,

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[14] Shakespeare, William: Romeo & Juliet, Act II, Scene 2.

[15] https://www.merriam-webster.com/dictionary/unmanned (last accessed on June 13, 2023).

[16] https://www.merriam-webster.com/dictionary/autonomous (last accessed on June 13, 2023).

remote location, not on-board the vessel engaged in voyage. "Remote-controlled ships are ships operated by cameras and sound receptable for shore streaming from remote location but are not provided for independent navigation." Vojković and Milenković (2019). The differing proposed levels of automation (and corresponding definitions) by various organizations will be discussed further below.

Although beyond the scope of this thesis, another issue also worth noting, that one must consider when it comes to autonomous vessels, is whether they will also be considered "ships." Professor Suri provides an interesting analysis of the possible implications that would arise from referring to autonomous vessels also as ships. (Suri 2020). He notes that the maritime convention dealing with flag and port state rights and responsibilities does not define the term "ship" and uses it interchangeably with "vessel." This, as he points out, has varying consequences under private law on the duties, responsibilities, and liabilities that a particular craft could face under the laws of a domestic state.

C. The Current Landscape Governing Water-Based Vessels

My review of the literature yielded apparent consensus in the fact that current legislation and regulations are incompatible with attempts to create vessels that will require increasingly less and less interaction and direction from a human source to operate. Chircop (2018) points to the public law issues with the current governing legislation, as written, when it comes to regulating shipping vessels whose ultimate aim is to be completely autonomous. Chircop's analysis highlights the existing legal limitations underlying the use of remotely controlled, partially, or fully automated ships in international shipping. His review of applicable laws finds that while the terms "ship" and "vessel" tend to be used interchangeably under the United Nations Convention on the Law of the Seas (UNCLOS), the terms are not defined. As noted in the prior section, Suri (2020) has already noted the legal consequences that can occur depending on which particular term is used.

What constitutes a "ship" can vary from regulation to regulation, which has implications on where one would register a vessel, and under what classification. Furthermore, current regulations require that ships have a "flag state," which corresponds to the national location where the ship is registered, and under whose jurisdiction, laws, and rules its operations are governed. Ships are also subject to the jurisdiction of "coastal states" if they happen to enter the territorial water boundaries of these states while in transit. Upon reaching their destination, ships also become subject to the jurisdiction of the "port state." Chircop also points out that current regulations, as written, are largely human-centered when it comes to areas of maritime safety, the training, certification, and working conditions of crews. (Chircop 2017; Chircop 2018).

In addition to the areas identified by Chircop, most modern-day regulations have explicit rules governing the conduct of the shipmaster or captain of a vessel. Vojković and Milenković

(2019), note that these “rules have been ‘built’ for centuries, beginning with a ubiquitous fact: that the master must be on board during navigation.” The master, captain, or shipmaster is the person who holds the ultimate command and responsibility over a ship or vessel. The shipmaster has three main and general authorities aboard the ship: One, he or she is responsible for the safety of the ship (i.e., maintaining sea-worthiness), taking care of the ship’s supply or cargo, and crew and passengers. Two, he or she is also authorized to limit the freedom of movement of any person on board and responsible for administrative duties related to keeping appropriate records and reporting criminal activities that may have occurred. Third, he or she is also the legal representative of the shipowner and can bind the shipowner by entering into contracts, or be seized as part of a civil or criminal investigation concerning the ship or shipowner. Vojković and Milenković (2019).

D. Attempts to Classify and Define the Differing Levels of Automation of Waterborne Vessels

This section will provide an overview of the various organizations that have attempted to categorize and define the differing levels of automation that increasingly unmanned vessels are intended to achieve.

In 2018, the International Maritime Organization ("IMO") started a scoping exercise with the purpose of determining how Maritime Autonomous Surface Ships ("MASS") could be addressed within existing regulations governing their operations.[17] Their initial review described the following four levels of anticipated autonomy of a ship.

- **Ship with automated processes and decision support**: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated.

- **Remotely controlled ship with seafarers on board**: The ship is controlled and operated from another location, but seafarers are on board.

- **Remotely controlled ship without seafarers on board**: The ship is controlled and operated from another location. There are no seafarers on board.

- **Fully autonomous ship**: The operating system of the ship is able to make decisions and determine actions by itself.

Lloyd's Register's (2016) attempts to define differing levels of autonomy are captured in Table 5, below. (Blanke et al. 2017; Kazem and Hesham 2018).

[17] See: https://www.imo.org/en/MediaCentre/PressBriefings/Pages/08-MSC-99-MASS-scoping.aspx (last accessed on June 13, 2023).

Table 5: Lloyd's Register Autonomy Level as adapted by Blanke et al. 2017 and Kazem and Hesham 2018

Description	Operator role
AL 0: Manual steering. Steering controls or set points for course, etc. are operated manually.	The operator is on board or performs remote control via radio link.
AL 1: Decision-support on board. Automatic steering of course and speed in accordance with the references and route plan given. The course and speed are measured by sensors on board.	The operator inserts the route in the form of "waypoints" and the desired speed. The operator monitors and changes the course and speed, if necessary.
AL 2: On-board or shore-based decision support. Steering of route through a sequence of desired positions. The route is calculated so as to observe a wanted plan. An external system is capable of uploading a new route plan.	Monitoring operation and surroundings. Changing course and speed if a situation necessitates this. Proposals for interventions can be given by algorithms.
AL 3: Execution with human being who monitors and approves. Navigation decisions are proposed by the system based on sensor information from the vessel and its surroundings.	Monitoring the system's function and approving actions before they are executed.
AL 4: Execution with human being who monitors and can intervene. Decisions on navigation and operational actions are calculated by the system which executes what has been calculated according to the operator's approval.	An operator monitors the system's functioning and intervenes if considered necessary. Monitoring can be shore-based.
AL 5: Monitored autonomy. Overall decisions on navigation and operation are calculated by the system. The consequences and risks are countered insofar as possible. Sensors detect relevant elements in the surroundings and the system interprets the situation. The system calculates its own actions and performs these. The operator is contacted in case of uncertainty about the interpretation of the situation.	The system executes the actions calculated by itself. The operator is contacted unless the system is very certain of its interpretation of the surroundings and of its own condition and of the thus calculated actions. Overall goals have been determined by an operator. Monitoring may be shore-based.
AL 6: Full autonomy. Overall decisions on navigation and operation are calculated by the system. Consequences and risks are calculated. The system acts based on its analyses and calculations of its own capability and the surroundings' reaction. Knowledge about the surroundings and previous and typical events are included at a "machine intelligent" level.	The system makes its own decisions and decides on its own actions. Calculations of own capability and prediction of surrounding traffic's expected reaction. The operator is involved in decisions if the system is uncertain. Overall goals may have been established by the system. Shore-based monitoring.

In addition to the six autonomous levels, noted above, Blanke et al. (2017) also made note of the differing terminology used to describe the levels of human interaction involved in operating a vessel.

Table 6: Terminology Related to Automatic Steering, Remote Operation, Remote Monitoring and Autonomy. Source: Blanke et al. 2017

Terminology related to automatic steering, remote operation, remote monitoring and autonomy	
Manual navigation of merchant ships	The navigating officer gives the command for the wanted course and speed, either to a helmsman or as an autopilot setting and for bridge navigation of the ship's main engine. The navigating officer has electronic charts and own position and course. A radar system shows other ships' course and speed.
Automatic course steering	Course steering takes place between encoded positions; the ship's autopilot ensures that the ship goes from position A to B.
Decision-support	Decision-support consists in planning a route and speed profile in order to reach a port at a given time with a prediction of the sea and wind conditions underway. More extensive decision-support could consist in guidance for the navigating officer about the performance of an evasive action in narrow waters.
Remotely operated navigation	Remote operation is used about the possibility of remotely operating a point for the autopilot and the effect on the propulsion machinery.
Remote monitoring	Measured values from sensors in, for example machinery spaces, on course and speed are shown in real time in an operation centre ashore or on board another vessel. Full monitoring includes transmission of TV monitoring and radar picture so that the operation centre has sufficient information about the ship and its surroundings to be able to perform remotely-operated navigation.
Partial autonomy	The ship has systems for assessing the situation as well as the consequences and advising the navigating officer about how to react. The navigating officer is not necessarily present on the ship's bridge in person.
Full autonomy	The situation is perceived and assessed and a decision on which action to take is made without any intervention by human beings.

Veitch and Alsos' (2022) reviewed the pertinent literature that discusses the intersection of artificial intelligence and human interaction in the area of autonomous ship systems. They also identified roles humans are intended to have in the process into three categories: active, backup, and passive. They are defined as follows:

- ***Active*: Continuous monitoring and decision-making support:** the operator's role is active and engaged in all operational phases; the operator is in control of the ship, either through direct or indirect remote control. On-board roles were often specified, including emergency handling, active maintenance, lookout / watchkeeping, cargo loading and unloading.

- ***Backup:* Monitoring and control intervention:** the operator's role is characterized as "backup" to the AI system; control interventions, or takeovers, can occur when the operator takes over control from the AI system, either on their own initiative or from the prompting of the AI system itself. Monitoring is mostly continuous; the operator is never far from the control position if left unattended; emphasis placed on timely emergency or contingency response.

- ***Passive:*** **Supervision and assistance:** the operator's role is characterized mainly by passive supervision; the operator can leave the control position and is alerted by the AI system if they are needed. Instead of handling situations as they arise, the emphasis is on planning how to resolve situations before intervention is needed.

The above-referenced autonomous classifications identified by the IMO's MASS were expanded by Pietrzykiwski and Hajduk (2019) to include the involvement of personnel as the autonomy level of a vessel increases.

- **Degree One: Ship with automated processes and decision support**: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.

- **Degree Two: Remotely controlled ship with seafarers on board**: The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions, or there are no qualified seafarers on board able to take over ship control.

- **Remotely controlled ship without seafarers on board**: The ship is controlled and operated from another location. There are no seafarers on board.

- **Fully autonomous ship**: The operating system of the ship is able to make decisions and determine actions by itself.

In addition to the categories referenced above, Pietrzykiwski and Hajduk (2019) also identified other attempts to create and define differing levels of autonomy with a focus on the technical autonomy rather than the level of operational control denoted in the prior examples listed above.[18] These include the following (adapted from Pietrzykiwski and Hajduk (2019)):

- **A0 - Manual:** Manual operation and control of ship systems and functions, including basic individual system level automation for simple tasks and functions.

[18] MSC 99/5/5. Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships (MASS). Plan of approach for scoping exercise. Submitted by Australia, Canada, Denmark, Estonia, Finland, Japan, the Netherlands, Norway, Singapore, Sweden, the United Kingdom, the United States, IMarEST, and IMCA. 12 March 2018, and MSC 99/5/6. Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships (MASS). Considerations on definitions for levels and concepts of autonomy. Submitted by Finland. 12 March 2018.

- **A1 – Delegated:** Permission is required for the execution of functions, decisions, and actions; however, the operator can override the system at any stage.

- **A2 – Supervised:** The qualified operator is always informed of all decisions taken by the system. Permission of the qualified operator is not required for the ship to execute functions, decisions, and actions; However, the qualified operator can again override the system at any stage.

- **A3 – Autonomous:** The qualified operator is informed by the system in case of an emergency or when ship systems are outside of defined parameters. Permission of the qualified operator is not required for the ship system to execute functions, decisions and actions; the qualified operator can override the ship system when outside of defined parameters. So long as the boundaries of the ship system are not exceeded, then "human control" becomes "human supervision."

In the above referenced proposals by Pietrzykiwski and Hajduk (2019), the operational control assigned to the human element only has the following two levels:

- **B0 –** No qualified operators on board but qualified operators available at a remote location.

- **B1** – Qualified operators on board.

The foregoing review of the literature has hopefully highlighted the fact that there are various organizations, methods, and differing definitions and corresponding levels applicable to a vessel or ship depending on its degree of respective automation and input of human interaction with its navigation. Furthermore, and most important with respect to the emphasis of this thesis, all of these definitions and academic materials primarily focus on the issue of operating and regulating autonomous ships and shipping, that operated in and about international waters. The emphasis of those efforts are also centered on the potential implications that come with the mandatory ingress and egress of said vessel or ship into the national and judicial territory of the respective nation where its intended journey ends and/or begins.

It is also worth noting that Veitch and Alsos' (2022) expansive and comprehensive review of the literature discussing the intersection of artificial intelligence and human interaction in the area of autonomous ship systems yielded a total of 603 studies, which through their selection process were narrowed down to forty-two articles that the authors felt met their selection criteria. These forty-two articles were deemed to touch upon a governing theme of safety and control and were further classified into five broad disciplines: (1) marine policy; (2) ocean engineering; (3) human factors; (4) reliability engineering; and (5) risk science. Notably, Veitch and Alsos' (2022) review of the literature was conspicuously devoid of articles that discussed the issue of autonomous passenger vessels or the state of regulations surrounding the same.

In my own review of the literature, I was able to find just two publications touching upon the topic of autonomous passenger vessels in European inland waterways. The first, by Reddy et al. (2019), *Zero-emission Autonomous Ferries for Urban Water Transport,* provides and overview of existing and ongoing projects that are working on autonomous shipping, mostly in Norway and surrounding countries. The emphasis of Reddy et al.'s work, however, appeared to be more focused on attempts to create zero-emissions systems for autonomous ships, as well as the different power sources that would be needed to operate the ship's automated system depending on the level of autonomy that is being used at a given time. Reddy et al.'s article is mostly devoid of any discussion with respect to how or what regulations would be applicable to their intended ferries. They reference the IMO's efforts to create a code for autonomous maritime surface ships, while noting that "legislation could give answers." Quite the understatement indeed.

The other article by Rødseth et al., *Towards Approval of Autonomous Ship Systems by their Operational Envelope* (2021), is more on point when it comes to recognizing the shortcomings with the current guidelines for the approval of autonomous ship systems. Rødseth et al. propose an alternative method whereby the approval for the use of autonomous ship systems would not be dependent on the ships' concrete operations, nor tied to the particular geographic area where it intends to operate - which is how the current system is organized. Rather, Rødseth et al. propose using the current-existing operational design domain used for road vehicles and extending it to an operational envelope for autonomous ships systems that would also include the responsibility of humans within the operation. This, arguably, is in line with the approach highlighted by Pietrzykiwski and Hajduk (2019).

However, as was to be expected given the nascent state of this technology, and even more of any accompanying regulations, I did not find any articles or publications that discussed the topic of regulations of autonomous passenger vessels. To address that void, the aforementioned questions, repeated here for ease of reference, will be addressed as the main emphasis of this thesis:

1. What governmental entities are responsible for enacting regulations that would be applicable to waterborne vessels operating on EU waterways, including those proposed by Zeabuz?

2. What are the existing EU and Norwegian regulations governing unmanned or autonomous in-land passenger vessels and how do they apply to the operations of Zeabuz's proposed autonomous passenger vessels?

III. RESEARCH DESIGN

A. Methodology

In this thesis, I drew on a combination of retroductive and abductive logics to explore the answers to the questions posed. I also attempted to allude to possible solutions that could facilitate a more responsive approach to enacting regulations that keep up with the technological innovations being developed and implemented in ever-increasing autonomous vessels.

1. Retroductive Logic

"The aim in the use of Retroductive logic is to discover underlying structures or mechanisms that, in particular contexts, explain observed regularities" (Blaikie & Priest 2019, p. 96). Retroductive logic "involves working back from data to a possible explanation," and as such, a central problem in its use "is how to discover the structures and mechanisms that are proposed to explain observed regularities." (Blaikie & Priest 2019, p. 97).

The retroductive logic used in this thesis is clear from the way that I compiled, reviewed, and analyzed the existing regulations applicable to ships, passenger vessels, and, where applicable autonomous vessels. The current structures governing the operation of vessels are primarily focused on international voyages that carry goods. It is with this mind frame that these regulations have evolved for centuries. This is likely due to the collective effort to create standards that are applicable across oceans and nation states. As such, the advent of autonomous vessels can currently be described as an "irregularity" – as autonomous vessels in general, and autonomous passenger vessels, in particular, do not yet form part of the structures and mechanisms of the laws and regulations currently in use.

2. Abductive Logic

Abductive logic can be used to answer both "what" and "why" questions, however, "it answers 'why' questions by producing understanding rather than an explanation, providing reasons rather than causes." (Blaikie & Priest 2019, p. 99). "This logic of inquiry involved constructing theories that are derived from social actors' language, meanings and accounts in the context of everyday activities … that can form the basis of an understanding of the problem at hand." (*Id.*).

I used abductive logic to determine the meanings and actions ascribed to the language used by actors in drafting and implementing regulations and how this language can affect the behavior of the actors affected by such regulations, in this case, waterborne vessels in general, and unmanned vessels, in particular. As noted in the literature review above, the current mechanisms are just now beginning to address the advent of autonomous vessels and their increased use in both shipping and transportation routes. Thus, it should be clear as the analysis continues further below, that what is presently occurring results from the novelty of the technology that has heretofore simply not been present in the manner in which humans attempt to organize the world around them through laws and regulations.

3. Ontological and Epistemological Assumptions

Because the inquiries that went into conducting the underlying research consisted of retroductive and abductive logic, the ontological and epistemological assumptions I used were depth realist, idealist, and constructionism. Each of these terms are described in greater detail, as follows: Ontological assumptions are concerned with claims about what kind of social phenomena do, or can exist, the conditions of their existence, and the ways in which they are related. (Blaikie & Priest 2019, p. 102). This is evident in the manner in which we as a society have chosen to organize the social phenomena that forms part of our daily lives through institutions and laws whose aim is to govern conduct. The conditions of the existence of these phenomena are the laws and regulations themselves, and how the interrelation of how these laws will apply over a given thing will shape its conduct.

Epistemological assumptions, on the other hand, are concerned with the kinds of knowledge that are possible – how we can know – and what criteria can be used to decide when knowledge is both adequate and legitimate. (Blaikie & Priest 2019, p. 102). The data I acquired was also viewed through a neo-realist lens whereby the knowledge of the causes of the observed regularities are derived from the structures that produce them, which in this case was adherence to the established laws and regulations governing vessels. (*Id.*).

Under a Harré Depth Realist ontological assumption, social reality is viewed as social episodes that are the products of the cognitive resources of social actors, and unlike natural structures, social structures are less enduring and do not exist independently of the activities influenced by them or the social actors' conceptions of what is being done in these activities. (*Id.*). With respect to an Idealist ontological assumption, social reality is made up of shared interpretations that social actors produce and reproduce in their daily lives. (*Id.*). The Constructionism epistemological assumptions note that because access to any social worlds has to be through the language of the participants, social reality has to be discovered from the "inside" rather than being filtered through, or distorted by "experts'" concepts or theories. (Blaikie & Priest 2019, p. 104).

B. Research Strategy

The research strategy I chose consisted of a **case study**. The focus of the case study was Zeabuz and how its unmanned passenger vessel would be treated under current regulations were it to be put into commercial service today. I began by doing an overview of the regulations governing sea vessels in general and inland-waterway vessels in particular to determine approaches across the European Union and Norway, that governments (supranational, national, state, local) take towards regulation these crafts while flying their flag, or navigating their waters. After completing the initial overview, I narrowed my scope towards regulations governing inland-waterway vessels. Lastly, I analyzed all of these regulations to determine whether they took into account and addressed the ever-expanding autonomous technologies to determine whether this has had any impact on the growth (or non-growth) of industries working within this sector. The primary case study was focused on the aforementioned Zeabuz.

In conjunction with conducting a case study research strategy, I also interviewed Zeabuz's CEO to obtain his perspectives and concerns with current regulations and their effects on the implementation of innovation technologies. Again, the focus of the interview was with a member of Zeabuz given that the case study was primarily focused on their autonomous passenger vessel.

C. Method – How Was It Studied?

The data I used for the research underlying this master's thesis consisted of both quantitative and qualitative data, to the extent that dichotomy continues to be relevant. (Blaikie & Priest 2019, p. 201). Whereas "quantitative methods are generally concerned with counting and measuring aspects of social life," "qualitative methods are most concerned with producing discursive descriptions and exploring social actors' meanings and interpretations." (*Id.* at pp. 200-201).

The data that I collected and reviewed can be further divided into primary, secondary and tertiary forms of data. Secondary data generally refers to data that has previously been collected by someone else, whereas tertiary data has been analyzed by researchers who have generated the data or a user of secondary data. (Blaikie & Priest 2019, p. 156). Although primary data is generally considered to have been generated by the researcher, in this case, I also used primary data because the actual words and texts created at the source (i.e., regulations addressing vessels and unmanned vessels) are what were analyzed in order to determine their applicability to the type of passenger vessel that formed the basis of the case study. The source of the primary data used can be overwhelmingly classified as macro-social phenomena as it primarily deals with "social phenomena that transcend borders." (Blaikie & Priest 2019, p. 161). However, as I continued to gather and analyze the data, it also became evident that the data also involved micro-social due to the fact that some of the regulations do not transcend borders, or rather, could not transcend borders, as the activities being conducted were not yet approved in neighboring states.

The data gathered and reviewed consisted of over fifty scholarly articles, various legislative documents and intergovernmental accords, as well as national and industry-specific literature.

Because not all of the articles and materials reviewed were on topic, they were not included in my analysis and references.

Once the data was collected, I proceeded to perform a content analysis of the same. Content analysis is a technique used for examining information or content, in written or symbolic material. (Neuman 2014, p. 13). My content analysis was primarily focused on documents. The particular focus was on the respective language of the laws, regulations, and topic papers used in each, and the manner in which the language used affects actors over whom they exercise control. In this case, how the language of the respective regulations applied, if at all, to Zeabuz's proposed unmanned passenger vessel, and how this shaped the actions of Zeabuz in the continued development and use of their prototype.

Because of the nascent nature of the technology being studied and the still-emerging attempts to define and regulate its use, I would also argue that I also engaged in what has been termed a prospective longitudinal study (Blaikie & Priest 2019, p. 198), as this review begins at a time when the regulations that will eventually exist, are only beginning to be conceptualized.

IV. RESULTS

Part I:

The following section provides a brief overview of the organizations and governmental entities that have some form of regulatory control over the classification and use of vessels originating in and/or traversing European waterways. This includes those that are capable of enacting regulations applicable to waterborne vessels carrying passengers within EU waterways. I have also proceeded to conduct an overview and description of the most pertinent regulations and their application, or not, to the planned unmanned passenger vessel envisioned by Zeabuz.

A. The International Maritime Organization

The International Maritime Organization ("IMO") is the United Nations' specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. The IMO's work supports the UN sustainable development goals.[19] The IMO is the global standard-setting authority for the safety, security and environmental performance of international shipping. Its main role is to create a regulatory framework for the shipping industry that is fair and effective, universally adopted and universally implemented.

Although the breadth of the regulations, publications, and agreements that fall under the auspices of the IMO are immense one in particular must be mentioned. Regarded as the "most important of all international treaties concerning the safety of merchant ships,"[20] the International Convention for the Safety of Life at Sea ("SOLAS Convention") was initially adopted in 1914 as a response to the tragic incident that claimed the infamous *RMS Titanic*. The SOLAS Convention

[19] https://unosd.un.org/content/sustainable-development-goals-sdgs (last accessed on June 13, 2023).

[20] IMO, History of SOLAS, available at: https://www.imo.org/en/KnowledgeCentre/ConferencesMeetings/Pages/SOLAS.aspx (last accessed on June 13, 2023).

sets the minimum safety standards for the construction, equipment, and operation of merchant ships.[21] The SOLAS Convention has been subsequently renewed and updated in 1929, 1948, 1960, and 1974. The most recent version was adopted in 1974 and came to force in 1980. The current SOLAS Convention signatories include one-hundred-sixty-seven contracting states that account for about 99% of the world's gross shipping tonnage.

During the 1960 SOLAS Convention, the IMO also established the 1960 Convention on the International Regulation for Preventing Collisions at Sea ("COLREGs").[22] COLREGs were established to create international navigation rules for ships and vessels. COLREGs consist of forty-one rules, divided into six parts, that create international standards that govern the conduct, lighting, and signaling that vessels and their crew must adhere to in order to prevent collisions between two or more vessels. A review of the most current consolidated edition of COLREGs, makes clear that liability for neglecting to comply with COLREGs regulations continues to fall on the owner, master, crew, or seamen of the vessel.[23]

Because the IMO's primary focus is international shipping and regulations surrounding operations of that scope, its regulations generally will not apply to domestic EU inland waterway or vessels that operate exclusively in those waters. Nonetheless, certain definitions and policies are worth noting, including the following initiatives dealing with Maritime Autonomous Surface Ships ("MASS"). From May 5 to 14, 2021 the Maritime Safety Committee ("MSC") of the IMO

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[21] IMO, Status of Conventions, available at: https://www.imo.org/en/About/Conventions/Pages/StatusOfConventions.aspx (last accessed on June 13, 2023).

[22] IMO, Convention on the International Regulations for Preventing Collisions at Sea, available at: https://www.imo.org/en/About/Conventions/Pages/COLREG.aspx (last accessed on June 13, 2023).

[23] Rule 2 Responsibility: (a) Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case. Available at: https://www.samgongustofa.is/media/log-og-reglur/COLREG-Consolidated-2018.pdf last accessed on June 13, 2023).

approved the Outcome of the Regulatory Scoping Exercise ("RSE") for the use of Maritime Autonomous Surface Ships.[24] The RSE adopted the following definitions pertinent to small passenger vessels.

> 3.3 For the purpose of the RSE, "MASS" was defined as a **ship** which, to a varying degree, can operate independent of human interaction.
>
> 3.4 To facilitate the process of the RSE, the degrees of autonomy were organized as follows:
>
> > **Degree One**: Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.
> >
> > **Degree Two:** Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.
> >
> > **Degree Three:** Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
> >
> > **Degree Four**: Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.

The RSE concluded, however, that *passenger transports without seafarers on board* **cannot be performed** under current applicable regulations. (Table 1, of MSC.1/ Circ. 1638) (emphasis added).

In particular, the RSE explicitly highlighted the current shortcomings that exist between the regulations *as written*, and the need to actualize them when it comes to having a fully autonomous ship. Some regulatory areas to be considered, were a fully autonomous ship be

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[24] MSC.1/Circ.1638, OUTCOME OF THE REGULATORY SCOPING EXERCISE FOR THE USE OF MARITIME AUTONOMOUS SURFACE SHIPS (MASS) (3 June 2021), available at: https://wwwcdn.imo.org/localresources/en/MediaCentre/HotTopics/Documents/MSC.1-Circ.1638%20-%20Outcome%20Of%20The%20Regulatory%20Scoping%20ExerciseFor%20The%20Use%20Of%20Maritime%20Autonomous%20Surface%20Ships...%20(Secretariat).pdf (last accessed on June 13, 2023).

permitted to carry passengers included; updating current regulations that require a minimum number of crew member(s) on board; the requirement that seafarers be on board in order to be permitted to transport passengers; determining the role of the *master* as the degree of autonomy of the vessels increases; and, whether a "remote operator" should be considered a seafarer, among others.

With respect to liability, COLREGs seem to leave open the possibility that liability for the operation of an unmanned vessel can attach to the owner in the absence of a crew. For example, questions still remain as to how the lookout requirement under COLREG, and compliance with the same, will be carried out in the absence of a master or crew being aboard the vessel. Another thing to consider when determining liability, which was previously noted (Suri 2020), is the legal implications of defining the unmanned vessel as a "ship." As they are currently written, these overlapping regulations make it difficult to determine just what and how an unmanned passenger vessel is intended to be regulated and operated.

B. The Central Commission for the Navigation of the Rhine

Another organization responsible for regulating waterborne vessels within parts of the European continent is the Central Commission for the Navigation of the Rhine ("CCNR"). The origins of the CCNR date back to the Congress of Vienna (1815). The CCNR is the oldest international organization in modern history.[25] Its legal foundation is the Revised Convention for Navigation on the Rhine - referred to as the Mannheim Document - of 17 October 1868. The CCNR promotes the development of close cooperation with the other international organizations working in the field of European transport policy and with non-governmental organizations active in the field of inland navigation. It has five member states: Germany, Belgium, France, the Netherlands, and Switzerland.

The CCNR is vested with authority to create regulations or provide exemptions from the same where warranted. As part of this authority, it is presently creating a framework for the authorization of pilot projects which require temporary derogations from CCNR regulations.[26] In order to address the specific challenges posed by automated navigation, the CCNR has revived its Small Navigation Committee ("RN"), originally established to tackle and coordinate innovative and cross-sectoral developments in Rhine navigation. The Small Navigation Committee has been permitted to process applications for the approval of pilot projects and, in close collaboration with the other committees concerned, will direct and coordinate all work related to automated navigation.

During its plenary session in December 2018, the CCNR adopted the first international definition of the various levels of automation in inland navigation. Table 7 below notes the

[25] CCNR, about accessed from https://www.ccr-zkr.org/11000000-en.html (last accessed on June 13, 2023).

[26] CCNR, Press Release, Strasbourg (17 November 2021), available at https://www.ccr-zkr.org/files/documents/cpresse/cp20211117en.pdf (last accessed on June 13, 2023).

preliminary definitions for varying degrees of automation for the navigation of inland vessels adopted by the CCNR.[27] As can be noted, these six degrees differ from the aforementioned attempts at classifying varying degrees of automation discussed above. Other areas that merit consideration when it comes to unmanned vessels as defined in the CCNR regulations, include regulations dealing with the personnel who will be navigating on the Rhine.[28] These include requirements for the qualification of crew members, minimum crew member on-board requirements, boatmaster certification requirements, and a set of additional requirements targeted specifically as vessels that intend to carry passengers.[29]

27 Central Commission for the Navigation of the Rhine (CCNR) (2018) Definitions on various forms of automated navigation, available at: https://www.ccr-zkr.org/files/documents/AutomatisationNav/DefinitionAutomatisation_en.pdf (last accessed on June 13, 2023).

28 CCNR, Regulations for Rhine Navigation Personnel (RPN), available at https://www.ccr-zkr.org/files/documents/reglementSTF/stf1_072016_en.pdf (last accessed on June 13, 2023).

29 *Id.*

Table 7: CCNR Definitions of Varying Automation Levels[30]

	Level	Designation	Vessel command (steering, propulsion, wheelhouse, ...)	Monitoring of and responding to navigational environment	Fallback performance of dynamic navigation tasks	Remote control
BOATMASTER PERFORMS PART OR ALL OF THE DYNAMIC NAVIGATION TASKS	0	**NO AUTOMATION** the full-time performance by the human boatmaster of all aspects of the dynamic navigation tasks, even when supported by warning or intervention systems *E.g. navigation with support of radar installation*				No
	1	**STEERING ASSISTANCE** the context-specific performance by a steering automation system using certain information about the navigational environment and with the expectation that the human boatmaster performs all remaining aspects of the dynamic navigation tasks *E.g. rate-of-turn regulator* *E.g. trackpilot (track-keeping system for inland vessels along pre-defined guiding lines)*				
	2	**PARTIAL AUTOMATION** the context-specific performance by a navigation automation system of both steering and propulsion using certain information about the navigational environment and with the expectation that the human boatmaster performs all remaining aspects of the dynamic navigation tasks				
SYSTEM PERFORMS THE ENTIRE DYNAMIC NAVIGATION TASKS (WHEN ENGAGED)	3	**CONDITIONAL AUTOMATION** the sustained context-specific performance by a navigation automation system of all dynamic navigation tasks, including collision avoidance, with the expectation that the human boatmaster will be receptive to requests to intervene and to system failures and will respond appropriately				Subject to context specific execution, remote control is possible (vessel command, monitoring of and responding to navigational environment and fallback performance). It may have an influence on crew requirements (number or qualification).
	4	**HIGH AUTOMATION** the sustained context-specific performance by a navigation automation system of all dynamic navigation tasks and fallback performance, without expecting a human boatmaster responding to a request to intervene[1] *E.g. vessel operating on a canal section between two successive locks (environment well known), but the automation system is not able to manage alone the passage through the lock (requiring human intervention)*				
	5	**AUTONOMOUS = FULL AUTOMATION** the sustained and unconditional performance by a navigation automation system of all dynamic navigation tasks and fallback performance, without expecting a human boatmaster responding to a request to intervene				

[1] This level introduces two different functionalities: the ability of "normal" operation without expecting human intervention and the exhaustive fallback performance. Two sub-levels could be envisaged.

Additionally, the CCNR regulations define "*vessel*" to include inland waterway vessels, ferries, a seagoing ship, or a floating equipment.[31] "*Inland waterway vessel*" is further defined as a vessel intended solely or mainly for navigation on inland waterways.[32] In contrast a "*passenger*

30 https://ccr-zkr.org/files/documents/cpresse/cp20181219en.pdf (last accessed on June 13, 2023).

31 CCNR, Regulations for Rhine Navigation Personnel. (Art. 1.01 (1)).

32 *Id.* at Art. 1.01 (2).

vessel" is defined as a craft constructed and **equipped to carry more than 12 passengers**,[33] and a "*day-trip vessel*" as a passenger vessel *without overnight passenger cabins*, where the vessel's certificate bears the appropriate entry.[34] A "*recreational craft*" is defined as a "vessel other than a passenger vessel, intended for sport or pleasure."[35]

Passenger vessels and other vessels to which these regulations apply must also meet requirements with respect to crew member qualifications (Chapter 3), minimum crews on board (Chapter 3), mandatory resting time (Chapter 3), requirement for security personnel to be aboard passenger vessels (Chapter 5), as well as certification of the boat skipper (Chapter 7), and radar equipment (Chapter 8). Additional requirements under the CCNR include police regulations for the navigation of the Rhine, however, these also define "small craft" ("*menue embarkation*") as a boat authorized to transport more than 12 passengers.[36]

Although the CCNR has set out definitions to classify the automation levels for vessels, as the foregoing section makes clear, the existing regulations continue to demand the presence of a human crew and master on-board. This is something that must be addressed for the regulations to make sense. Additionally, and more pertinent to the case study that forms the basis of this thesis, the question arises as to whether the current regulations would be applicable a "passenger vessel" anticipated to carry only up to 10 people, much less one that is intended to be fully autonomous.

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[33] CCNR, Regulations for Rhine Navigation Personnel at Art. 1.01 (12) (emphasis added).

[34] *Id.* at Art. 1.01 (13).

[35] *Id.* at Art. 1.01 (16).

[36] CCNR, Règlement de Police pour la Navigation du Rhin (RPNR), available at https://www.ccr-zkr.org/files/documents/reglementRP/rp1fr_012022.pdf (last accessed on June 13, 2023).

C. The United Nations Economic Commission for Europe

The United Nations Economic Commission for Europe (UNECE) was set up in 1947 with the major aim of promoting pan-European economic integration. It includes fifty-six (56) member states in Europe, North America, and Asia, as well as over seventy (70) international professional organizations and non-governmental organizations that contribute to UNECE's activities and goals. UNECE has been a prominent player in helping to enact legislation, including the European Agreement on Main Inland Waterways, and maintains the maps of inland waterway for both commercial and recreational purposes.[37] It has the widest geographical coverage since all European countries involved in inland navigation are members, and maintains fifty-nine (59) international transport conventions that provide the legal framework and technical regulations for the development of international road, rail, and inland navigation.[38]

One pertinent legislative document enacted by UNECE that bears mention in connection with this thesis is the European Code for Inland Waterways (CEVNI). The 6th Edition of CEVNI, issued in December 2021, provides for the following definitions.[39] "**Vessel**" is defined as "any inland waterway craft, **including small craft** and ferry-boats, as well as floating equipment and seagoing vessels."[40] Similarly, "**passenger vessel,**" is again defined as a "day-trip or cabin vessel constructed and equipped to carry more than 12 passengers."[41]

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37 https://unece.org/where-navigate-network-inland-waterways-europe-and-its-parameters (last accessed on June 13, 2023).

38 UNECE, ECE / Trans / 279, White Paper on the Progress, Accomplishment and Future of Sustainable Inland Water Transport, (Geneva 2020), available at https://unece.org/DAM/trans/main/sc3/publications/IWW_WhitePaper_ECE_TRANS_279.pdf (last accessed on June 13, 2023).

39 https://unece.org/sites/default/files/2021-12/2109540_E_pdf_web%2BCorr1.pdf (last accessed on June 13, 2023).

40 *Id.* at Chapter 1, Article 1.01 I. 1.

41 *Id.* at Chapter 1, Article 1.01 I. 6.

However, and in contrast to other inland waterway regulations, CEVNI proceeds to introduce the concept of a "**small craft**," which is defined as "**any vessel with a hull less than 20m long** without rudder or bowsprit, except vessels built or equipped to tow, push or propel vessels other than small craft in side-by-side formation **and except craft authorized to carry more than 12 passengers**, ferry- boats and pushed barges."[42] CEVNI also defined "sport or pleasure craft" as "any vessel used for purposes of sport and recreation and not financial gain." [43] This latter part, discussing financial gain, is absent from other definitions as further discussed, below.

Despite the inclusion of a definition ("small craft") that could be applicable to a vessel that only intends to carry up to ten passengers, as currently written, the regulation would not encompass what CEVNI considers to be a "passenger vessel" as this definition explicitly says the vessel is "equipped to carry *more than* 12 passengers." As such the intended unmanned passenger vessel envisioned by Zeabuz would arguably be excluded. As if this were not confusing enough, the CEVNI regulations also still continue to require the following:

> Article 1.02 – Boatmaster
>
> 1. **Every vessel** or assembly of floating material, except vessels in a pushed convoy other than the pusher, shall be placed under the authority of a person having the necessary qualifications. This person is hereinafter referred to as the boatmaster.[44]
>
> **…**

[42] *Id.* at Chapter 1, Article 1.01 I. 10.

[43] *Id.* at Chapter 1, Article 1.01 I. 12.

[44] *Id.* at Art. 1.02 (1).

As previously noted, "vessel," as defined under CEVNI, includes both small-crafts and inland water way crafts. Additionally, the regulations state that "when a vessel is under way the boatmaster shall be on board."[45]

With respect to the applicable "Rules of the Road" governing "small craft," the CEVNI regulations require that "small craft in relation to vessels other than small craft, including high-speed craft, shall leave them enough room to hold their course and to maneuver. They may not require that such vessels give them way."[46] This regulation is silent on whether the small craft to which applies are intended to be manned or autonomous. Given the existing regulations requiring a boatmaster to be on-board, one would argue that autonomous vessels would be excluded. Once again, the existing regulations reveal that Zeabuz's intended autonomous passenger (ten) passenger vessels simply does not register on the radar of the existing regulations.

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[45] *Id.* at Art. 1.02(3).

[46] *Id.* at Art. 6.02.

D. Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation Intérieure[47]

The Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation Intérieure ("CESNI") was created by the Central Commission for the Navigation of the Rhine (CCNR) and the European Union in June 2015 with the purpose of drawing up standards in the field of inland navigation with the following missions in particular:

- adopting technical standards in various fields, in particular as regards vessels, information technology and crew to which the respective regulations at the European and international level, including the European Union and the CCNR, will refer with a view to their application;
- deliberating on the uniform interpretation and application of the said standards, on the method for applying and implementing the corresponding procedures, on procedures for exchanging information, and on the supervisory mechanisms among the Member States;
- deliberating on derogations and equivalences of technical requirements for a specific craft; and,
- deliberating on priority topics regarding safety of navigation, protection of the environment, and other areas of inland navigation.

CESNI is comprised of the following countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and Switzerland. In 2021, it issued updated regulations governing inland navigation vessels in Europe.

CESNI's most recent definition of what constitutes a "*Vessel,*" includes *"*an inland waterway vessel or sea-going ship."[48] This approach differs slightly from both CCNR's and CEVNI's definitions, as noted in Table 8. CESNI proceeds to define an "*Inland waterway vessel*"

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47 https://www.cesni.eu/en (last accessed on June 13, 2023).

48 *CESNI - 2021/1 – European Standard Laying Down Technical Requirements for Inland Navigation Vessels*, at Art. 1.01 (1.2). Available at: https://www.cesni.eu/wp-content/uploads/2020/10/ES_TRIN_2021_en.pdf (last accessed on June 13, 2023).

as "a vessel intended solely or mainly for navigation on inland waterways."[49] This is the same definition used by CCNR, and as noted in Table 8 below, is one that would be subsumed by the definition of "vessel" adopted by CEVNI. Another definition that adopts the same language as the CCNR, is the one used for "recreational craft," which is again defined as "a vessel other than a passenger vessel, intended for sport or pleasure."[50] The last definition that concerns the potential application of these regulations to Zeabuz's proposed autonomous ten-person passenger vessel would be that of "*passenger vessel*," which is defined as "a day trip or cabin vessel constructed and equipped to carry more than 12 passengers."[51] I note now that *this* is the same definition used by the CEVNI regulations, and it is now the CCNR definition that is at odds.

The CESNI regulations also create special provisions when it comes to "passenger vessels," that are beyond the scope of this paper, but which would have to be adhered to in the event that the definition of "passenger vessel" were modified to include a vessel equipped to carry only ten passengers. Additionally, it is worth noting that the term "small craft" is notably absent from the CESNI standards, which was included in the CEVNI definitions discussed above. Once again, the language of the CESNI regulations, as currently written, do not appear to leave any room for a passenger vessel that is expected to carry ten passengers only, much less one that is intended to be autonomous.

49 *Id.* at Art. 1.01 (1.3).

50 *Id.* at Art. 1.01 (1.24).

51 *Id.* at Art. 1.01 (1.17).

E. The European Parliament and European Council

The European Parliament is one of the legislative bodies and one of the seven principal decision-making bodies of the European Union, along with the European Council, the Council of the European Union, the European Commission, the Court of Justice of the European Union, the European Central Bank, and the European Court of Auditors. The European Parliament is composed of 705 members (MEPs) who are elected every five years by citizens of the European Union. The European Council on the other hand, has no legislative powers, but forms part of the executive of the European Union, and is composed of heads of State of Government of the EU member states, the President of the European Council, and the President of the European Commission. Its primary objective is to provide the European Union with general political directions and priorities to address issues facing the European Union.

The European Parliament acts as a co-legislator, sharing with the European Council, the power to adopt and amend legislative proposals. It also supervises the work of the Commission and other EU bodies and cooperates with national parliaments of EU countries to get their input. As it pertains to the use of inland waterways, the following legislative instruments have been passed which I determined could be relevant to Zeabuz's proposed operations.

On July 6, 2021, the European Parliament issued its updated report discussing inland waterway transport in Europe.[52] With respect to passenger transport, urban mobility and waterborne city logistics, the Parliament has made the following calls for action:

- For Member States and cities to include, where possible, waterborne public transport, city logistics and local freight distribution as a safe, sustainable and effective mode of transport in their sustainable urban mobility planning and to enhance their urban mobility data

[52] European Parliament, Report Towards Future-proof Inland Waterway Transport in Europe, A9-231/2021 (6 July 2021), available at: thttps://www.europarl.europa.eu/doceo/document/A-9-2021-0231_EN.pdf (last accessed on June 13, 2023).

collection; stresses the need, furthermore, to include waterborne public transport means in digital mobility platforms such as mobility as a service…

- Calls on the Commission to include waterborne transport in the Sustainable and Smart Mobility Strategy goal of making better use of inland waterways in cities and to come up with concrete proposals that aim to boost logistics over our inland waterways …;

- Calls on the Commission, in this regard, to enhance its collection of urban mobility data for waterborne passenger transport and freight and highlights the potential of inland waterway transport for the last mile in urban sustainable logistics.

As mentioned in the above-referenced report, the Sustainable and Smart Mobility Strategy ("SSMS") was enacted by the European Commission in 2020.[53] It calls for the following objectives within the European Transport System.

- **Sustainable mobility:** involving an irreversible shift to zero-emission mobility by making all transport modes more sustainable, ensuring wide availability of the most sustainable options and giving users incentives to make sustainable choices;

- **Smart mobility:** supporting sustainable choices by taking advantage of digitalization and automation to achieve seamless, safe and efficient connectivity; and

- **Resilient mobility:** bouncing back from the COVID-19 pandemic by creating a Single European Transport Area that is affordable and accessible for all citizens and businesses and resilient against future crises and safety and security challenges.

The SSMS references the increased use of intelligent transport systems ("ITS") and connected, automated mobility as part of the overall objectives and goals. However, although discussing it in the context of *land* vehicles, the Commission noted the following:

> For the time being, the legal and policy framework defining links between vehicles and traffic management, between public and privately owned data, and between collective and individual transport, are not sufficiently developed. There is no coordination mechanism at the EU level that would help ensure consistency of the deployment and management of ITS and CCAM across Europe. There is no coherent way of implementing a type-approval

[53] European Commission, COM/2020/789 Final, *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions,* (9 December 2020), available at https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12438-Sustainable-and-Smart-Mobility-Strategy_en (last accessed on June 13, 2023).

for connected and automated vehicles and their emissions testing and roadworthiness inspection methods, for example.[54]

As discussed in Chapter 3 Part A, above, the automotive industry's attempts to create a universal and coordinated classification system for differing levels of automated vehicles is far more advanced than what can be said for waterborne vessels. Thus, the SSMS' observance that the current legal and policy framework is not yet ready for the use of automated vehicles applies to a greater extent when it comes to the area of waterborne vessels, in light of the lack of uniformity in the respective attempts to classify differing levels of automation of unmanned vessels.

Another legislative instrument that must be considered, which is applicable to inland waterway vessels at the EU level, is the *Council Directive 2014/112/EU of 19 December 2014, implementing the European Agreement concerning certain aspects of the organisation of working time in inland waterway transport, concluded by the European Barge Union (EBU), the European Skippers Organisation (ESO) and the European Transport Workers' Federation (ETF).*[55] The aim of this directive is to adopt homogenous EU-wide regulations concerning the organization of working time in inland waterway transport. It applies to "crafts" which are defined as "a vessel or item of floating equipment;" a "passenger vessel" is defined as a "day trip or cabin vessel constructed and equipped to carry *more than 12 passengers*."[56] "Working time" is defined as "the time during which a worker is scheduled to work or must be available to work (on-call time) on and for the **craft** on the instructions of the employer or the employer's representative."[57]

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[54] Id. at ¶ 618.

[55] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014L0112 (last accessed on June 13, 2023).

[56] *Council Directive 2014/112/EU of 19 December 2014, implementing the European Agreement concerning certain aspects of the organisation of working time in inland waterway transport, concluded by the European Barge Union (EBU), the European Skippers Organisation (ESO) and the European Transport Workers' Federation (ETF)* at ¶ 2 (a)&(b), respectively. (emphasis added). Available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0112 last accessed on June 13, 2023).

[57] *Id.* at ¶ 2 (c).

Although this regulation would arguably not apply to a water craft that is not intended to carry over 12 passengers, it is worth noting that the definition of "crafts" is much broader, such that any "worker" engaged in any operation would arguably be covered. Therefore, as applied to Zeabuz's operations, it would seem as though it would apply to all of their "workers," whether they be in a remote tower, or onboard in an assistive capacity, regardless of whether a vessel intending to carry up to ten passengers, would be classified as a "passenger vessel."

The *Directive (EU) 2016/1629 of the European Parliament and of the Council of 14 September 2016 – laying down technical requirements for inland waterway vessels, amending Directive 2009/100/EC and repealing Directive 2006/87/EC*[58] also merits a review for the ambiguity posed by its regulations as currently written and defined, and the prospective operations of Zeabuz. I will begin by noting that this directive explicitly excludes its application to the following countries, Denmark, Estonia, Ireland, Greece, Spain, Cyprus, Latvia, Malta, Portugal, Slovenia and Finland, due to the fact that there are no inland waterways, or inland navigation is not used to a significant extent. As such the EU Parliament and Counsel felt it would be a disproportionate and unnecessary obligation for those member states to transpose and implement this Directive.

The pertinent focus of my inquiry of this directive was its application to "passenger vessels" and how those are defined. The definitions used here mirror those used by CEVNI, and they are as follows: "vessel" means an inland waterway vessel or seagoing ship;[59] "inland waterway vessel" means a vessel intended solely or mainly for navigation on inland waterways;[60]

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[58] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016L1629 (last accessed on June 13, 2023).

[59] *Id.* at Art. 3(b).

[60] *Id.* at Art. 3(c).

and, "passenger vessel" means a day trip or cabin vessel constructed and equipped to carry more than 12 passengers. [61]

Again, it is interesting to note that also absent from the EU Directive is the inclusion of "small craft" previously identified in the CEVNI definitions. Thus, it again appears that the definition of "passenger vessel" both under EU directives and CESNI resolutions is vessels "equipped to carry more than 12 passengers." Hence, the question remains whether a proposed 10 passenger vessel would be covered under this current legislation. Furthermore, and as noted in the European Commission's most recent SSMS report, there is presently no legal or policy framework that covers the use of autonomous vessels, much less autonomous vessels intended to carry public passengers.

Both European and International private and governmental entities have identified the need to transition to cleaner, smarter, and eventually unmanned forms of transportation on the roads, seas, and for purposes of this analysis, inland waterways. Recent developments in this field include the passage of standardized regulations governing the use of various forms of vessels within European inland waterways, as well as the adoption of international definitions of various levels of automation when it comes to water-based vessels. Additionally, pilot programs for the use of unmanned shipping vessels are underway in certain localities.[62] Despite these encouraging developments and desire to achieve full automation of the transport section, there presently exist no clear or universal laws, regulations, or agreements with respect to unmanned passenger vessels.

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61 *Id.* at Art. 3 (f).

62 For example, see AUTOSHIP (https://www.autoship-project.eu); the Advanced Autonomous Waterborne Application (https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/%20customers/marine/ship-intel/rr-ship-intel-aawa-8pg.pdf); Yara Birkeland (https://www.yara.com/news-and-media/press-kits/yara-birkeland-press-kit/). last accessed on June 13, 2023).

Table 8: Comparison of Definitions used to Describe Different Vessels by Organizations

Term	**CCNR**	**UNECE (CEVNI)**	**CESNI**	**EU Council Directives**
Vessel	An inland waterway vessel, a ferry, a seagoing ship or a floating equipment.	Any inland waterway craft, including small craft and ferry-boats, as well as floating equipment and seagoing vessels.	An inland waterway vessel or sea-going ship.	An inland waterway vessel or seagoing ship.
Inland waterway vessel	A vessel intended solely or mainly for navigation on inland waterways.	*Arguably falls under the "vessel" definition.*	A vessel intended solely or mainly for navigation on inland waterways	A vessel intended solely or mainly for navigation on inland waterways.
Passenger vessel	A craft constructed and equipped to carry more than 12 passengers.	A day trip or cabin vessel constructed and equipped to carry more than 12 passengers.	A day trip or cabin vessel constructed and equipped to carry more than 12 passengers.	A day trip or cabin vessel constructed and equipped to carry more than 12 passengers.
Day-trip vessel	A passenger vessel without overnight passenger cabins.	*Arguably falls under the "passenger vessel" definition.*	*Arguably falls under the "passenger vessel" definition.*	*Arguably falls under the "passenger vessel" definition.*
Small Craft	*Not defined*	Any vessel with a hull less than 20m long without rudder or bowsprit, except vessels built or equipped to tow, push or propel vessels other than small craft in side-by-side formation and except craft authorized to carry more than 12 passengers,	*Not defined*	*Not defined*

		ferry- boats and pushed barges.		
Recreational (sport, or pleasure) craft	A vessel other than a passenger vessel, intended for sport or pleasure.	Any vessel used for purposes of sport and recreation and not financial gain	A vessel other than a passenger vessel, intended for sport or pleasure.	*Not defined*

To summarize, this section has provided an overview of the governmental bodies and entities that are responsible for enacting legislation and regulations that dictate what requirements must be met in order to operate a vessel. Although certain overlaps exist with respect to the definitions and corresponding legal responsibilities for the particular kind of vessel one intends to operate, the lack of uniformity among the various regulations can create an environment where a potential operator may be compliant with one set of regulations, while running afoul of another. As such, clarity and uniformity among the various regulatory bodies is needed.

Part II.

A. A Review of Regulations for Waterborne Craft in Norway

The following section provides a review of existing Norwegian regulations governing unmanned or autonomous in-land passenger vessels and how they would apply to the operations of Zeabuz's proposed autonomous passenger vessel.

The Act of 16 February 2007 No. 9 relating to ship safety and security (Ship Safety and Security Act)[63] has as its intended purpose to safeguard the life, health, property, and environment by creating regulations that provide for satisfactory working conditions, environmental safeguards, and public supervision of ships. It is intended to apply to all Norwegian and foreign ships operating within Norwegian territorial waters. The Ship Safety and Security Act, however, notes that it does not apply to ships of less than 24 meters in overall length nor ships that carry up to 12 passengers, or ships that are solely used on rivers and lakes.[64] Nonetheless it is worth noting as its relevance will become clearer further below.

In 2014, the Norwegian Maritime Authority (Sjøfartsdirektoratet) issued RSR 06-214, *Regulations of 1 July 2014, No. 1072 on the construction of ships*,[65] the relevance of which, for purposes of this thesis, is that it applies to "Norwegian ships required to have [a] Passenger Ship Safety Certificate engaged in foreign voyages [or] ships required to have [a] Passenger Certificate."[66] The RSR 06-214 Norwegian regulation adopted the SOLAS conventions definitions for "passenger ship," which is defined as a "*ship certified to carry more than 12 passengers or*

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[63] Available at https://www.ilo.org/dyn/natlex/docs/ELECTRONIC/79957/101037/F1526185700/NOR79957%20ENG.pdf (last accessed on June 13, 2023).

[64] *Id.* at Chapter 1, Section 2.

[65] Available at https://www.sdir.no/contentassets/22767390faa04f24bc027b2e31902e68/1-july-2014-no.-1072-construction-of-ships.pdf?t=1599815855611 (last accessed on June 13, 2023).

[66] *Id.* at Chapter 1, Section 1 (a) & (b), respectively.

required to have a Passenger Certificate."[67] Thus we are again faced with the legal conundrum of whether a passenger vessel intended to carry up to 10 passengers would even be covered by this regulation.

The answer to this question is extremely relevant as additional requirements under RSR 06-214, include ensuring that all (universal) "passenger ships" must be designed in such a way as to accommodate the ability of persons with reduced functional abilities to embark and disembark easily and safely.[68] It goes without saying that determining whether this regulation applies to Zeabuz's proposed operations has significant implications as to how their vessels are to be designed, before even taking into consideration how any regulation would apply to an unmanned passenger vessel.

In an apparent attempt to address the lack of regulations that would be applicable to vessels of less than 24 meters, which as noted above, are exempt from the Ship Safety and Security Act, in 2020, the Norwegian Maritime Authority issued RSR 01-2020 (14 January 2020), *Regulations on vessels of less than 24 metres carrying 12 passengers or less,*[69] which recognizes the need for regulations to cover vessels whose aim is to carry less than 12 passengers. The RSR 01-2020 Regulations explicitly apply to Norwegian and foreign vessels of less than 24 metres in overall length carrying 12 passengers or less in Norwegian territorial waters, rivers and lakes."[70] Section 2 lays out specific provisions that exempt certain vessels from additional regulations if the vessel operates in the territorial waters of Norway, is 10 or less meters in overall length, and has a

67 *Id.* at Chapter 1, Section 2 (2)(a).

68 *Id.* at Chapter 1, Section 7 (2)a).

69 Available at https://www.sdir.no/contentassets/6e5146f562b642eba04fe3c98749cdc3/14-january-2020-no.-63-vessels-of-less-than-24-metres-carrying-12-passengers-or-less.pdf (last accessed on June 13, 2023).

70 *Id.* at Chapter 1, Section 1 (1).

maximum propulsion power in relation to the vessel's overall length that does not exceed the following formula:

Table 9: Maximum Propulsion Power Table[71]

Overall length ≤	4 m	6 m	8 m	10 m
Max hp/kW	15/12	25/19	40/30	60/45

[72]

This regulation becomes important with respect to Zeabuz's proposed vessel, because if it were to exceed the propulsion power limits established above, then its vessels would also subject itself to additional regulations called for under the RSR 01-2020. These include the requirements that a qualified master and seafarers be present and aboard the vessel.[73] Even if Zeabuz's operations were to fall within the propulsion limits noted in this regulation, they would still be required to have both a vessel and a "master" that complies with the construction, equipment, and qualification requirements applicable to recreational craft."[74] However, as previously defined, a "recreational craft" cannot be engaged in operations "for financial gain," at least as defined under CEVNI's regulations. Thus, once again, Zeabuz's operations would fall into an unknown area with respect to what regulations govern their intended operations.

In an effort to possibly address this inconsistency in regulations and definitions, the Norwegian Maritime Authority, simultaneously issued Circular – Series R, RSR 01-2020 (14 January 2020), *New Regulations on vessels of less than 24 metres carrying 12 passengers or less*,[75]

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71 *Id.* at Chapter 1, Section 2 (1)c).

72 https://www.sdir.no/contentassets/6e5146f562b642eba04fe3c98749cdc3/14-january-2020-no.-63-vessels-of-less-than-24-metres-carrying-12-passengers-or-less.pdf

73 *Id.* at Chapter 2, Section 6.

74 *Id.* at Chapter 1, Section 2 (2).

75 Available at https://www.sdir.no/contentassets/6e5146f562b642eba04fe3c98749cdc3/eng12pax_rsr.docx_nb-no_en-gb.pdf?t=1682881172508 (last accessed on June 13, 2023).

("The Circular"), which, in part, attempted to clarify the terms used to define "passenger ship." In the Circular, the Norwegian Maritime Authority noted that although under the 12 Pax Regulations[76] "vessel" was defined as a ship carrying 12 *passengers or less*. In contrast, and as discussed above, the majority of other regulations, including the Ship Safety and Security Act, defined "passenger vessel" as a ship carrying *more than 12 passengers*. The result of this was that a ship carrying 12 passengers or less would fall under the definition of "cargo ship."[77]

In light of this, The Norwegian Maritime Authority recognized in the Circular that "if vessels carrying 12 passengers or less were to comply with the 12 Pax Regulations in addition to requirements for cargo ships set out in other regulations ... would undermine the idea of a user-friendly legislation where the minimum requirements for carrying 12 passengers or less would be consolidated."[78] In order to avoid what would amount to abiding to two different standards, the Norwegian Maritime Authority clarified that only the minimum requirements of the Regulations would be applicable to all transport of 12 passengers or less if the activity could not be characterized as a recreational activity. The Circular also highlights special provisions that are applicable to vessels of less than 10 meters which are also permitted to comply with regulations applicable to recreational craft.

However, the Norwegian Maritime Authority went on to recommend that recreational crafts operate at a speed of less than 10 knots, have a master that has a boating license, that all passengers wear suitable flotation equipment during the entire voyage, and that the vessel have a device on board that makes it possible to pick up a person from the water. Under the current regulations, it would appear that both vessels carrying 12 passengers or less, and recreational craft

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76 Regulations of 24 November 2009 No. 1400 on the operation of vessels carrying 12 passengers or less.

77 The Circular, at Section I. 5.

78 *Id.*

require that a master is required on board during operations. Thus, an argument could be made that Zeabuz's proposed unmanned automated 10-passenger vessel would not be permitted to operate as there would be no master on-board during operations.

On August 27, 2020, the Norwegian Maritime Authority issued RSV 12-2020, *Guidance in connection with the construction or installation of automated functionality aimed at performing unmanned or partially unmanned operations.*[79] ("Guidance RSV 12-2020). Guidance RVS 12-2020 begins by noting that autonomous or partially operated ship are required to hold the same level of safety as conventional ships in addition to the legislation already applying to the ship type. Guidance RSV 12-2020 also makes clear that it is intended to apply to all ships with a level of autonomy equal to levels 3 ("periodically unmanned") through 5 ("fully autonomous") as defined under the Norwegian Forum for Autonomous Ships[80] ("NFAS"), which are as follows:

[79] Available at https://www.sdir.no/contentassets/2b487e1b63cb47d39735953ed492888d/rsv-12-2020-guidance-in-connection-with-the-construction-or-installation-of-automated-functionality.pdf?t=1646784000030 (last accessed on June 13, 2023).

[80] The Norwegian Forum for Autonomous Ships refers to itself as an interest group for persons or organizations who are interested in the subject of autonomous ships. Its membership is limited to individuals and organizations established in Norway. *See* *https://nfas.autonomous-ship.org/about-us/* last accessed on June 13, 2023).

Table 10: Norwegian Forum for Autonomous Ships autonomy levels – adapted from Appendix 1 of RSV 12-2020

1. **Decision support**: Decision support and advice to crew, but the crew is in direct command of ship operations. Will normally involve various types of autonomous operation carried out by a computer, such as maintaining the course and speed (auto pilot). May also involve various types of alarms, e.g., when there is a risk of collision (ARPA – Automatic Radar Plotting Aid).
2. **Autonomous**: Autonomous under constant surveillance with the option to take control of the vessel (advanced or enhanced "track pilot"). May also involve alarms to operators on detection of dangers. This is a further developed stage where the entire or part of the voyage is automated, such as a fjord crossing by a car ferry or autonomous berthing and mooring.
3. **Periodically unmanned**: At night in good weather and with little traffic, or unmanned for days, **but with crew on board** or in an escort vessel to handle the berthing or more complex tasks. Here, the operator will be alerted or the crew be awakened if situations arise that the system is unable to handle.
4. **Unmanned:** Completely unmanned, but with an option of direct or indirect remote operation from a shore-based control center to handle complex operations. It is assumed that there is no crew on board for any part of the voyage and that **a continuously manned control room is monitoring the ship**. An alarm system is required to alert operators in situations that the system is unable to handle. 5. **Fully autonomous**: Completely unmanned and **without monitoring from shore**. This is of little or no relevance for ships, and particularly for ships engaged on international voyages. This is both due to complexity and safety, but also to meet the requirement that the ship must be under the control of a responsible person at all times, and that Coastal States must be able to call up the ship.

The NFAS are unique from any of the previously mentioned autonomy classifications systems discussed above in Part I. The NFAS levels of autonomy and degree to which human interaction is required, if at all, have previously not been defined. Pietrzykiwski and Hajduk (2019)'s expanded definitions of the IMO's *MASS* classifications are what come to mind as being the closest definitions from the ones discussed above in section III, D, above.

Guidance RSV 12-2020 also establishes additional requirements that all ships subject to the regulations must abide by, including: (1) obtaining proper certification (Section 4); (2) designing the ship and maintaining corresponding documentation, depending on the intended use of the ship (Section 7); (3) the use of a safety management system in the ship (Section 8); and (4) testing requirements in areas approved by the Norwegian Maritime Authority, *including compliance with COLREG* (Section 9). With respect to the use of a safety management system, Guidance RSV-12-2020 makes it explicitly clear that Chapter 2 of the Ship Safety and Security Act is intended to "play a central role in the assessment of autonomous systems and vessels."[81] Chapter 2 of the Ship Safety and Security Act lays out the duties that the company responsible for the vessel and the safety management system being installed must abide by. This includes designating a company or managing company that will be responsible for registering the ship.

Additionally, the entity in charge of the ship has a duty to ensure that the construction and operation of the ship are compliant with the regulations, "including that the master and other persons working on board comply with the legislation."[82] Section 8, titled *Duty to Cooperate for the master and other persons working on board,* not only explicitly reinforces this requirement, but it also makes clear that a master *must* be involved in the operation of these vessels. Thus, the following quandary arises - where is the master of an unmanned or fully automated ship, as proposed by Zeabuz, supposed to be physically located?

Another issue we must also consider, when considering Zeabuz's proposed vessel, is the requirement that testing be compliant with COLREG regulations, as called for under Section 9 of Circular RSV 12-2020. This requirement echoes that of the Ship Safety and Security Act with

81 RSV 12-2020 at Section 8, Safety management system.

82 Ship Safety and Security Act, Chapter 2, Section 6.

respect to the requirements that a master be involved in operations, and also seems to be at odds with the entire idea of an "Unmanned" or "Fully Autonomous" ship, as defined under the NFAS. The COLREG regulations make clear that liability for failing to abide by COLREG will fall on the owner, master, crew, or seamen of the vessel. Thus, if there is no master, crew, or seaman aboard the ship, does RSV 12-2020 implicitly imply that liability will fall upon the owner? Again, that is something that goes beyond the scope of this thesis, but it bears mentioning and pondering, as the answer will have all kinds of legal and regulatory implications.

To summarize, Norway's efforts to both recognize and attempt to legislate the use of increasingly autonomous vessels appears to be ahead of most other legislative and regulatory entities' efforts. Norwegian legislative and regulatory bodies have further noted some of the inconsistencies in the existing regulatory frameworks and have made efforts to clarify the same as noted in The Circular's clarification of how "passenger ship" is to be defined under Norwegian law. Guidance RSV 12-2020 takes this one step further by providing a preliminary road map as to what is required to operate autonomous or unmanned vessels within Norwegian waters.

As noted, though, because both The Circular and Guidance RSV 12-2020, rely on the language and requirements from older regulations, it does not appear that permitting the use of autonomous passenger vessels has yet been contemplated, nor addressed directly. Perhaps this is due to the nascent nature of the technology, or the unresolved legal questions that would accompany the commercial use of such a vessel. It remains to be seen whether regulations will help advance innovation – or hinder it.

V. DISCUSSION

A. Literature Review

The review of the literature made it clear that there are no clear nor uniformly defined classification levels to describe a water-based vessel as its level of autonomy increases. This stands in contrast to the efforts that have been developed primarily by the Society of Automotive Engineers with respect to land-based vehicles. In the maritime arena, the International Maritime Organization's *Maritime Autonomous Surface Ships* classifications serve as the starting point for these attempts. However, each respective organization discussed above, including the European Union's adaptation of the Society of Automotive Engineers levels of autonomous vessels, and Lloyds Register, have each adopted their own classification system.

In light of the lack of uniformity, scholars studying the topic of autonomous or unmanned vessels have also taken it upon themselves to clarify these levels by creating their own respective levels. These include Blanke et al.'s (2017), Veitch and Alsos' (2022), and Pietrzykiwski and Hajduk (2019). Although each of these approaches sought to create classification systems that included the roles humans are intended to have in the process, we are still left with three different classification systems, each attempting to define and classify arguably the same thing.

As if determining how to define a respective level of automation weren't confusing enough, to that we must also keep in mind the distinctions that the current existing regulations make with respect to whether something is called a "ship" or a "vessel." The legal implications attached to each one of these terms differ, and as such, one must be wary of what exactly is in a name when deciding which will be used.

Whether a ship or vessel will be classified as autonomous or unmanned also carries implications for the level and degree of technology and human presence that will be required on-board. As discussed, unmanned implies that no human activity will be involved or present. However, as defined by most of the classification systems discussed above, autonomous is also defined to mean the system will operate without the need for human input, but does not exclude the possibility of humans on board who could, if needed, exercise some form of control over the ship or vessel.

An additional possibility also exists whereby a ship or vessel can be controlled via a remote location. This last possibility is consistent with the increasing levels of automation contemplated by the IMO's *MASS* classifications, which call for a decreased level of human presence and interaction with the vessel or ship's systems as the level of autonomy of these systems increases. Under *MASS,* the increasing levels of autonomy begin with a ship where only some operations may be automated, but the ship is manned by seafarers on board who operate and control the shipboard's systems and functions (Ship with automated processes and decision support). From there, the operations begin to take into account the concept of control via a remote location.

The first stage under *MASS* for this, calls for the ship to be controlled and operated from a remote location, but with seafarers on board (Remotely controlled ship with seafarers on board). From there, the *MASS,* classifications continue to be remotely controlled, but now the seafarers have been removed (Remotely controlled ship without seafarers on board). Lastly, and as called for most of the classification systems discussed, *MASS's* level four calls for the operating system of the ship to be able to make decisions and determine actions by itself (fully autonomous ship). Though it could be inferred that this last level of ship also has no seafarers on board, it does not explicitly call for their exclusion altogether.

B. European Regulatory Entities and Regulations Governing In-land Waterborne Passenger Vessels

The foregoing Results section provided and overview of the entities that in some form or another, enact or issue regulations that govern the use of waterborne passenger vessels operating in European Union waterways and beyond. In so doing, the answers to the first question, posited above, and provided below for ease of reference, remains partly answered.

1. What governmental entities are responsible for enacting regulations that would be applicable to waterborne vessels operating on EU waterways, including those proposed by Zeabuz?

Although the role of the International Maritime Organization and the regulations enacted therefrom at first glance appear to be more directed at the international level, one cannot escape how they too can shape regulations at the national level. A prime example of this is how the SOLAS Convention and the subsequent COLREGs enacted under it, appear to have a direct relationship to how Norway intends to regulate ships intending to operate unmanned or partially unmanned operations, as those terms are defined under the Norwegian Forum for Autonomous Ships.

Other entities responsible for enacting regulations at the European continental level that were reviewed include the Central Commission for the Navigation of the Rhine, The United Nations Economic Commission, The Comité Européen pour L'Eboration de Standards dans le Domaine de Navigation Intêrieure, and the European Parliament and European Council. As I discussed above, although some of these entities do have mirroring regulations that define a type of ship in the same manner (for example, UNECE, CESNI, and the EU Council Directives define "passenger vessel" to mean "a day trip or cabin vessel constructed to and equipped to carry more than 12 passengers."), inconsistencies remain with respect to what falls under the definition of "vessel." The inclusion of "small craft" in the definition of "vessel" is unique to UNECE. Under

UNECE's definitions, a "small craft" refers to any vessel whose hull measures less than 20 meters, but does not include crafts authorized to carry more than 12 passengers.

When considering Zeabuz's proposed vessel that will carry 10 passengers, it becomes clear that any attempt to use the "passenger vessel" definition would not work, because in order to be classified as a "passenger vessel" requires that the vessel be equipped to carry more than 12 passengers. Thus, we are left with the possibility that it would fall under the classification of "small craft," but as noted, only UNECE includes this as a possible form of defined "vessel" at the European Union level. What is meant by "vessel" is also not clearly defined at the European Union level as the CCNR definition also includes a "ferry." This in itself, also brings additional regulations that must be taken into account, but which are beyond the scope of this paper.

As discussed further, below, Norway appears to also have noticed the existence of this gray area, and has taken legislative steps to address it. Thus, this brings us to the second question that formed the basis of this thesis, which is as follows:

2. What are the existing EU and Norwegian regulations governing unmanned or autonomous in-land passenger vessels and how do they apply to the operations of Zeabuz's proposed autonomous passenger vessels?

As noted, the EU regulations, with the exception of UNECE, do not appear to take into account how to define and regulate a 10-passenger vessel, as proposed by Zeabuz. Norway, in contrast recently enacted regulations that address not only what regulations will apply to such a vessel, but also to vessels that are intended to eventually be fully autonomous in their operations. The classifications covered by Circular RSV 12-2020 include, "periodically unmanned," "unmanned," and "fully autonomous" vessels, as those terms are defined under the NFAS. These regulations are both revolutionary and forward thinking, and take into account the speed at which automation in all types of craft is advancing, with one, not so slight, caveat. Circular RSV 12-2020 makes clear that all vessels subject to its regulations require that a master be involved in operations, and leaves the question of liability, in the case of an unmanned vessel, unanswered.

C. Zeabuz's Current Operations

In my conversations with Erik Dyrkoren, CEO and Co-Founder of Zeabuz, he informed me of their intent to launch commercial operations in Stockholm, Sweden. Their choice of Stockholm was based, in part, due to the large amount of available navigable waters and high-density population. Zeabuz has partnered with Torghatten, a major Norwegian ferry service provider that includes over 60 ferries in their fleet.[83] They intend on launching a ferry service to be operated by Zeabuz autonomy in the summer of 2023.

With respect to the level of autonomy of their intended vessel, Zeabuz's operations will begin with autonomous operations with an onboard operator who can take control in the event it is needed. This appears to be consistent with Lloyd's Register's AL 4 classification, *execution with human being who monitors and can intervene*. As the autonomous system's performance improves, Zeabuz intends to move the operator onshore, where the operations can be supervised remotely. Thus, arguably moving up to a combination of Lloyd's Register's AL-5 classification, *monitored autonomy.*

The reasoning for following this trajectory is two-fold. First, Zeabuz wants to work out all the regulatory issues that still surround its ability to commercially operate their autonomous, but currently manned, vessel, while demonstrating and building trust in their systems. Second, as the vessel goes from being manned and autonomous, to remotely monitored, and fully autonomous – the *hope* is that the regulatory issues will be resolved, such that Zeabuz will be in a position to scale up their urban mobility concept.

83 https://www.torghatten.no

Since my initial involvement with Zeabuz, their operations have expanded to include office locations in Oslo, Stockholm, and Brussels. They have also partnered with a Malaysian company and are co-funded by the European Union. This indeed is good news for both Zeabuz and its proposed passenger vessels. However, it also raises the same questions that, although I have endeavored to attempt to answer, remain unanswered at to what will be the regulations that will apply to their passenger vessels. Will the regulations be Norwegian, Swedish, or will the EU enact something uniform that would also be applicable and consistent with now-existing Swedish regulations? Because Norway is not part of the EU, to what extend would EU regulations be enforceable in Norway, and conversely, would Norwegian regulations called for under the Ship Safety and Security Act, be enforceable in EU waters?

Until these questions can be answered, it would appear that current regulations are functioning more as a hindrance to innovation. Or at the very least, increasing the time and cost that companies such as Zeabuz, must spend in navigating the murky regulatory waters in which they, and other similarly thinking entities wishing to commercialize the growth of autonomous technology, find themselves in.

VI. CONCLUSION

I hope that the legal review and analysis of the regulations discussed has not been too burdensome or confusing for the average reader. However, I would also hope that said review and analysis has made it clear of the work that remains to be done when it comes to naming, classifying, and eventually regulating vessels such as those being built and used by companies such as Zeabuz, and others wishing to harness the ever-evolving technology of autonomous vehicles.

As noted, whether something is called a "ship" or a "vessel" has legal implications that are not always contemplated by the regulations and the effect that this may have. Additionally, determining how to define a specific level of automation for waterborne crafts continues to be an exercise in redundancy and lack of uniformity. As the use of autonomous technology and vessels operating the same continues to grow, legislative bodies would be keen to adopt uniform definitions and regulations that create a system that potential entrants to this market can understand and abide by. Although attempts to create such a system by entities such as the IMO, CCNR, UNECE, and EU regulatory bodies were highlighted and discussed, there continue to be gaps and inconsistencies in their approaches and definitions, as highlighted by the Zeabuz example.

Due to time constraints, I was unable to review what the current regulatory framework for autonomous vessels is in Sweden, where Zeabuz's operations have already began, and are expected to commercially launch in May 2023. It would be interesting to know how and to what extent they may mirror that of Norway, or whether they are completely different. The existence of additional regulations at the national level adds yet an additional layer of bureaucracy that a ship owner or operator must contend with, and as previously discussed, not always in a way that is consistent or congruent with other regulations. As was evident, even Norway's revolutionary regulations specifically addressing the use of autonomous vessels, appear to need additional tweaking, since they continue to reference the need for the ship to have a master.

As noted in the delimitations section, the primary emphasis of this thesis was limited to the existing regulations governing passenger vessels in inland waterways in Europe and Norway. However, these geographic areas are but a drop in the bucket when compared to the vastness in which autonomous or unmanned vessels can and will operate. The increasing use of this technology and vessels that operate under it are also taking place in Asian nations, such as China, Singapore, and Japan, to name a few. (Rivkin 2021). Thus, this thesis barely scratches the surface as to what the current existing regulations are with respect to regulating autonomous vessels, and whether any of these nations not reviewed have made attempts to regulate autonomous passenger vessels.

This limitation, however, also presents and opportunity. As discussed above, within the EU there are conflicting regulations and definitions that cannot be squared away. Rather than continue down the path of piecemeal regulations limited by geographical location, I would argue that allowing an international organization, such as the IMO for example, to take charge in enacting regulations would be more practical. However, given the differing levels of development that exists among different geographical areas and their respective abilities to afford, much less use automated technology, one could foresee resistance and pushback from those who would be subject to said regulations without even being able to participate in their use.

Although the emphasis of this thesis was directed at the existing regulatory framework and its application, or lack thereof, to emerging autonomous vessels, another area that requires additional overview and updating should be centered on how the role of humans, in particular, the master of the vessel or boatmaster, will be defined and performed. As noted previously, most of the current existing regulations governing vessels have at their core the presence of a boatmaster, and the legal authorities confided in him or her when operating a vessel. This is something that is currently unresolved and must be addressed, especially as vessels continue to progress in their level of autonomy.

To conclude, future areas of research I would propose with respect to the central subject of this thesis include determining which stakeholders must be involved in order to facilitate the creation and adoption of regulations that can keep up with the diffusion of technological innovation. As noted, the IMO could serve as the central body by and through which all respective nations and regulatory bodies could help craft uniform regulations with respect to autonomous vessels, including vessels intended to carry passengers. Additionally, and in the same vein, what approaches to regulation would help promote the diffusion of innovative technology. The answers to these questions would certainly go a long way in helping Zeabuz and others navigate the proper course to ensure their autonomous vessels can operate commercially, and at the scale they envision.

VII. REFERENCES

Act of 16 February 2007 No. 9 relating to ship safety and security (Ship Safety and Security Act). Available at https://www.ilo.org/dyn/natlex/docs/ELECTRONIC/79957/101037/F1526185700/NOR79957%20ENG.pdf

Bačkalov, I. (2020). Safety of autonomous inland vessels: An analysis of regulatory barriers in the present technical standards in Europe. *Safety Science*, 128, 104763.

Blanke, M., Henriques, M., & Bang, J. 2017. A pre-analysis on autonomous ships. Kongens Lyngby: Technical University of Denmark. Last accessed on June 13, 2023, from https://maritimecyprus.files.wordpress.com/2017/03/autonomous-ships-pre-analysis-s.pdf.

Chircop, A. (2017). Maritime Autonomous Surface Ships in International Law: New Challenges for the Regulation of International Navigation and Shipping, in Nordquist, M.H., Moore, J.N., and Long, R. Eds. (2019). Cooperation and Engagement in the Asia-Pacific Region. Pages 18-32. Leiden, The Netherlands: Brill.

Chircop, A. (2018). Testing International Legal Regimes: The Advent of Automated Commercial Vessels. (2018) 60:2017 *German YB Int. L* 109.

Dremliuga, R., & bin Mohd Rusli, M. H. (2020). The development of the legal framework for autonomous shipping: Lessons learned from a regulation for a driverless car. *J. Pol. & L.,* 13, 295.

European Parliament (2014-2019). Committee on Transport and Tourism. Draft Report on autonomous driving in European transport 2018/2019 (INI). July 7, 2018.

International Maritime Organization. MSC 99/5/5. Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships (MASS). Plan of approach for scoping exercise. Submitted by Australia, Canada, Denmark, Estonia, Finland, Japan, the Netherlands, Norway, Singapore, Sweden, the United Kingdom, the United States, IMarEST, and IMCA. 12 March 2018.

International Maritime Organization. MSC 99/5/6. Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships (MASS). Considerations on definitions for levels and concepts of autonomy. Submitted by Finland. 12 March 2018.

Jokioinen E. *et al.* 2016. Remote and Autonomous Ship – The next steps. https://www.rollsroyce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aawawhitepaper-210616.pdf.

Kazem, A. and Hesham, H. (2018). Autonomous Surface Ships, in View of Existing Legislation, and the Need for a New Governance. The International Maritime Transport & Logistic Conference. Innovation in Ports "The Gateway to the Future." 18-20 March 2018.

Li, S., & Fung, K. S. (2019). Maritime autonomous surface ships (MASS): implementation and legal issues. *Maritime Business Review*, 4(4), 330-339.

Lloyd's Register (2016). Cyber-enabled ships: Deploying information and communications technology in shipping – Lloyd's Register's approach to assurance. Available at: https://www.lr.org/en/cyber-safe-for-marine/ Last accessed on June 13, 2023.

Mayank, S. 2020. Autonomous Vessels as Ships – the Definition Conundrum. 3rd International Conference on Maritime Autonomous Surface Ships. *IOP Conference Series: Materials Science Engineering*. 929 012005.

MiT, 2020. Roboat project [WWW Document]. roboat.org. URL http://www.roboat.org (Last accessed on June 13, 2023).

Neuman, W.L. (2014). *Understanding Research* (1st Ed.). Essex: Pearson Education Limited.

Nzengu, W., Faivre, J., Pauwelyn A.S., Bolbot, V., Wennersberg, L.A., & Theotokatos, G. (2021). Regulatory Framework Analysis for the Unmanned Inland Waterway Vessel. *WMU Journal of Maritime Affairs* 20 (pp. 357-376).

Pietrzykiwski, Z. and Hajduk, J. (2019). Operations of Maritime Autonomous Surface Ships. Transnav: *The International Journal on Marine Navigation and Safety of Sea Transportation*. Vol 13, Number 4 (December 2019).

Reddy, N.P, Zadeh, M.K., Thieme, C.A., Skjetne, R., Sørensen, A.J., Aanondsen, S.A., Breivik, M., Eide, E. (2019). Norwegian University of Science and Technology. Zero-emission autonomous ferries for urban water transport. IEEE Electrification Magazine, Vol. XX, No. X.

Rivkin, B.S. (2021). Unmanned Ships: Navigation and More. ISSN 2075-1087, *Gyroscopy and Navigation*. Vol. 12, No. 1, pp. 96–108.

Rødseth, O.J., Wennersberg, L.A., and Nordahl, H. (2021). Towards Approval of Autonomous Ship Systems by their Operational Envelope. *Journal of Marine Science and Technology*

Society of Automotive Engineers (SAE). https://www.sae.org

Suri, Mayank (2020). Autonomous vessels as ships – the definition conundrum. The 3rd International Conference on Maritime Autonomous Surface Ships (ICMASS 2020); IOP Conf. Series: Materials Science and Engineering 929 (2020) 012005.

United States Department of Transportation. Automated Vehicles Comprehensive Plan. (January 11, 2021).

Veitch, E., & Alsos, O. A. (2022). A systematic review of human-AI interaction in autonomous ship systems. *Safety Science*, 152, 105778.

Vojković, G. and Milenković, M. 2020. Autonomous ships and legal authorities of the ship master. *Case Studies on Transport Policy*, 8 (pp. 333-340).

Willumsen, T. A legal reality check for autonomous shipping in 2018. Last accessed on June 13, 2023, from Seatrade Maritime News: http://www.seatrade-maritime.com/news/asia/a-reality-check-for-autonomous-shipping-in-2018.html.

Yin., R.K. (2018). Case study research and applications: design and methods (6th Ed.). Los Angeles: SAGE.