Autonomous Robotic Inspection and Maintenance on Ship Hulls and Storage Tanks

Deliverable report D10.5

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DISCLAIMER

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EXECUTIVE SUMMARY

Following the formulation of the BUGWRIGHT2 policy blueprint, this work package deliverable progresses to contribute to the evolution of norms and regulations concerning maritime robotics and autonomous systems (RAS). In light of this, the primary focus of the World Maritime University (WMU), as outlined in section 2.1.3 of the Description of Actions (DoA), has been to furnish practical recommendations and formulate guidelines tailored for end-users --- specifically, targeting the core audience involved in the BUGWRIGHT2 project. The efforts undertaken within the scope of this deliverable align closely with the regulatory objective outlined in page 4 of the DoA, which aims to bolster the BUGWRIGHT2 mission: "[t]he objective of BUGWRIGHT2 will be to bridge the gap between the current and desired capabilities of ship inspection and service robots by developing and demonstrating an adaptable autonomous robotic solution for servicing ship outer hulls". According to the WMU Researchers, these gaps can be effectively addressed through regulatory guidance notes. These notes act as a compass for end-users navigating the intricate yet complicated policy landscape, offering direction, comprehension, and assistance to ensure adherence to legally permissible perimeters while striving for optimal performance.

Altogether, the current work package deliverable materializes through five distinct strands of research. The primary tasks focused on reviewing origins, types and status of international, European and national norms, regulations and standards. WMU Researchers note that artificial intelligence (AI) applications offer vast potential across industries but demand a nuanced approach to governance that harmonizes ethical considerations with industry-specific needs. A hybrid framework combining adaptable regulations and standards is pivotal in steering AI's trajectory within an ever-evolving technological landscape while addressing societal implications. Effective AI governance necessitates alignment with current global governance realities, acknowledging the burgeoning influence of transnational actors and the private sector. A synthesis of "soft" and "hard" law emerges as an optimal path to steer new technologies for broader societal good, ensuring responsible AI development and deployment. A "polycentric" governance model, involving diverse stakeholders like policymakers, software developers, academia, and industry, is imperative. This approach fosters inclusivity, ensuring equitable AI development, deployment, and usage while maintaining safety and ethical standards.

In the process of developing a methodology for evaluating existing norms and standards, WMU Researchers shed light on hazards posed by remote inspection techniques (RIT). Findings underscore the necessity of instituting ethical frameworks centered around human welfare and values. They also unveil regulatory sandboxes and living labs as crucial methodologies for guiding and regulating new innovations. Regulatory sandboxes offer controlled spaces for testing innovative solutions within relaxed regulatory frameworks, particularly beneficial in managing the challenges posed by rapidly advancing technologies. However, challenges such as equal access, risk management, and scaling successful innovations remain. In a different fashion, Living Labs provide user-centered ecosystems for evaluating autonomous systems, fostering collaborative innovation among users and producers. While these labs also offer opportunities for testing regulations, their primary focus lies in user-centric innovation and technology uptake. Notably, a crucial gap exists in a common platform for interactions among policymakers, standard organizations, manufacturers, and consumers in robot regulation. Living Labs have the potential to bridge this gap by creating an inclusive ecosystem involving all stakeholders. Although regulatory sandboxes emphasize regulatory understanding while Living Labs prioritize user-centric innovation, a potential convergence termed 'Regulatory Living Labs'

could amalgamate these approaches, blending regulatory focus with user-centric innovation for real-world experimentation of new technologies.

When advancing understanding whether new regulatory approaches or self-regulatory approach is best, WMU Researchers considering evidence at hand support co-regulation marked by cross-border, pliable, and dynamic approach to regulatory affairs, fostering international coordination and engaging a multitude of stakeholders. This approach, according to Researchers requires a thorough consideration of the distinct challenges and prospects inherent in each technology and sector, entailing a concerted collaboration among industry, government, and civil society. Within this paradigm, the techno-regulatory tools demand regular updates while fostering communication channels with industry or public oversight groups, aimed at facilitating the dissemination of best practices.

Finally, WMU Researchers revisit the regulatory blueprint initially formulated under the auspices of work package 1.4 report deliverable, collaborating with selected members of the Senior Advisory Group (SAG). The primary aim of this endeavor was to comprehensively review and synthesize all components of the regulatory blueprint, constituting an important phase within the "enhancement" process.

The concluding section encapsulates a synthesis of key recommendations comprised of strategic ways forward derived from insights provided by panelists of the WMU-GOI-BUGWRIGHT2 Forum.

Finally, annexed to this report are guidelines developed in accordance with the structure adhered to by international organizations. Similar to preceding segments, this part has been crafted through consultations with specific members of the SAG.

KEY SIGNIFICANT MILESTONES ACHIEVED

1. Developed two state-of-the art reports (ref: Report Deliverable under WP 1.4 and WP 10.5)

The World Maritime University (WMU) team successfully developed two comprehensive reports under Work Packages (WP) 1.4 and WP 10.5, showcasing state-of-the-art advancements in their respective domains. The reports delve into cutting-edge technologies, methodologies, and findings, providing a comprehensive overview of the latest developments. Each report incorporates detailed analyses, critical assessments, and recommendations, serving as valuable resources for professionals, researchers, and policymakers in the relevant fields.

2. Produced a BUGWRIGHT2 Regulatory Blueprint

The BUGWRIGHT2 Regulatory Blueprint stands as a pivotal milestone, outlining a comprehensive framework for regulatory considerations in the context of the project's goals. This blueprint serves as a guiding document for policymakers, regulatory bodies, and industry stakeholders, ensuring a harmonized and well-structured approach to the integration of autonomy, ports, and robotics. Its development marks a crucial step towards creating a standardized regulatory environment to foster innovation and deployment.

3. Published two peer-reviewed books on autonomy, ports and robotics and several articles and book chapters

The team achieved significant recognition by publishing two peer-reviewed books focused on autonomy, ports, and robotics. These publications contribute to the academic and professional literature, consolidating the project's research findings and insights. Additionally, the team disseminated knowledge through numerous articles and book chapters, further solidifying their presence in the scientific community and enhancing the project's impact on a global scale.

4. Facilitated international dialogue and discussions through WMU-GOI-BUGWRIGHT2 Forum

The establishment and successful operation of the WMU-GOI-BUGWRIGHT2 Forum created a dynamic platform for international dialogue and discussions. This collaborative space brought together experts, practitioners, and stakeholders from diverse backgrounds to exchange ideas, share experiences, and address challenges related to autonomy, ports, and robotics. The forum has become a hub for fostering cross-disciplinary collaboration and driving innovation within the maritime industry.

5. Disseminated and exploited results with over 3000 audiences from across the globe through participating in seminars, workshops, conferences and webinars

The project achieved widespread dissemination of its results, reaching a diverse audience of over 3000 individuals globally. This outreach was accomplished through active participation in seminars, workshops, conferences, and webinars. By engaging with professionals, academics, and industry leaders, the project maximized its impact, fostering knowledge transfer and creating awareness of the breakthroughs achieved.

6. Developed a WMU-GOI Senior Advisory Group with advisors from international, regional and national organizations and bodies

The establishment of the WMU-GOI Senior Advisory Group represents a strategic move to garner expertise and insights from key figures in international, regional, and national organizations and bodies. This advisory group plays a crucial role in guiding the project, offering valuable perspectives, and ensuring alignment with broader industry goals. The diverse composition of the group enhances the project's credibility and strengthens its connections with influential stakeholders

7. Established two course lectures on Remote Inspection Techniques at the World Maritime University, which shall be delivered on an annual basis every year here on forth

The integration of two course lectures on Remote Inspection Techniques at the World Maritime University (WMU) is a significant achievement. These lectures, designed to be delivered annually, contribute to the academic curriculum, equipping future maritime professionals with the latest knowledge and skills in remote inspection technologies. This initiative ensures the sustainability of the project's impact by educating and preparing the next generation of industry leaders.

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A. LIST OF PUBLICATIONS (2020 – 2022) FOR TASK 1.4

This section contains an overview of the publications produced by the World Maritime University between 2023 and 2024 (February) (*N.B.* publications completed between 2020 and 2022 were aimed at satisfying the criteria for work package 1.4 report deliverable) in accordance with the pre-determined tasks under work package 10.4 (Contribution to Norms, Regulations and Standards). The publications contain findings from the main report found in section D titled “Principal Research Report (2020 – 2024) for Task 10.4” (all publications have attached immediately after this section).

A.1 SUMMARY OF BOOK PUBLICATION BY WORLD MARITIME UNIVERSITY RESEARCH TEAM IN THE CAPACITY AS VOLUME EDITORS

Title	Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance (Edited book)		
Abstract	This book provides a comprehensive overview of smart ports and remote technologies in the maritime industry. It demonstrates how modern advances in artificial intelligence and robotics have transformed the shipping industry, and assesses the impact of this technology from a law and governance standpoint. The book covers a range of topics including port autonomous operations systems, cybersecurity, big data analytics, digitalization and blockchain to throw light on the opportunities and benefits of these new technologies in improving security and safety. It also considers the challenges and threats of their application. It concludes by examining the trajectory of national and international regulatory developments. The book will appeal to scholars and students of maritime technology, law and governance, as well as practitioners and policymakers.		
Publisher	Palgrave Macmillan		
Duration of Work	October 2021 – March 2023		
Impact Factor	The impact score (IS) 2022 of Palgrave Communications is 4.23		
Status	**Under-review**	**Proof-stage**	**Published**
	-	-	x
Citation	-		
Impacts Following Publication	**Text Reads**	**Total Downloads**	**Presentations**
	3042 (as of 15 July 2023)	-	Reference in lectures at the World Maritime University; Dissemination at all events participated in 2023.

A.2 Summary of Book Publication By World Maritime University Research Team In the Capacity as Volume Editors

Title	Autonomous Vessels in Maritime Affairs Law and Governance Implications (*N.B.* The book listed in A.1 and A.2 were originally planned as one treatise. However, at the request of the publisher, they were divided into two separate treatises. Therefore, the connection between BUGWRIGHT2 and the book listed in A.2 (this section), although weak due to the fact that vessels and technologies are completely separate items, the research team would nevertheless, wish to table this book as a BUGWRIGHT2 deliverable since it deals with "autonomy" --- the thematic strand which BUGWRIGHT2 revolves around.		
Abstract	This book examines law and governance implications in relation to maritime autonomous surface ships (MASS). Adopting a multi-disciplinary approach, it focuses on a wide array of timely, topical and thorny issues, including naval warfare and security, seaworthiness and techno-regulatory assessments, global environmental change, autonomous passenger transportation, as well as liability and insurance. It also considers selected national and regional developments. The book provides an insight into the role of innovation-diplomacy as the driving force that could expedite the transition from automation to autonomy. After navigating through the complex law and governance landscape, it concludes by assessing critical findings for further consideration.		
Publisher	Palgrave Macmillan		
Duration of Work	October 2021 – March 2023		
Impact Factor	The impact score (IS) 2022 of Palgrave Communications is 4.23		
Status	**Under-review**	**Proof-stage**	**Published**
	-	-	x
Citation	1		
Impacts Following Publication	**Text Reads**	**Total Downloads**	**Presentations**
	4759 (as of 15 July 2023)	-	Reference in lectures at the World Maritime University; Dissemination at all events participated in 2023.

A.3 Summary of Chapter Publication By World Maritime University Research Team In the Capacity as Lead Authors Disseminating Findings From Strand 1: Review origins, types and status of international, European and national norms, regulations and standards in relation to autonomous robotics

Title	Lessons Learned from Maritime Nations Leading Autonomous Operations and Remote Inspection Techniques
Abstract	The chapter presents key findings from the "national comparative study" segment --- a work undertaken under the auspices of the European Union (EU) Horizon 2020 project titled Autonomous Robotic Inspection and Maintenance on Ship Hulls and Storage Tanks (BUGWRIGHT2) under grant agreement no. 871260. It illustrates, using the case study of autonomous operations, as well as primary data collected through sixty (60) in-depth semi-

	structured interviews with maritime administrations, policy advisors, classification societies, service providers, and subject matter experts—lessons learned from ongoing developments and usage of remote inspection techniques (RIT) for hull inspection from six leading maritime nations: United States of America (US), Canada, the Republic of Singapore (Singapore), the People's Republic of China (China), the Kingdom of the Netherlands (Netherlands), and the Kingdom of Norway (Norway).		
Publisher	Palgrave Macmillan (in the book Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance)		
Duration of Work	March 2022 – December 2023		
Impact Factor	The impact score (IS) 2022 of Palgrave Communications is 4.23		
Status	**Under-review**	**Proof-stage**	**Published**
	-	-	x
Citation	-		
Impacts Following Publication	**Text Reads**	**Total Downloads**	**Presentations**
	421 (as of 2 August 15 July 2023)	-	-

A.4 Summary of Chapter Publication By World Maritime University Research Team In the Capacity as Lead Authors Disseminating Findings From Strand 3: Advance understanding whether new regulatory approaches or self-regulation is best for the future development of robot-technologies for automatic robotic guidance and inspection systems

Title	Towards an International Guideline for RIT End-Users: Spearing Through Vessel Inspection and Hull Cleaning Techno-Regulatory Elements
Abstract	State-of-the-art remote inspection techniques (RIT), namely unmanned aerial vehicles (UAVs), remotely operated vehicles (ROVs), and magnetic crawlers are the resultants of a cascade of technological innovation. RIT usage has gathered momentum since classification societies turned to manuals alternatives during COVID-19 pandemic. Capable of gathering complex data through real-time visual imagery, it is claimed that RIT has the potential to deliver inspection services more safely and efficiently, thus enabling the transformative digitalization of the "ship survey" landscape. The paradigm shift has begun. In this scope, the multi-robot (ship-hull) survey platforms explored by classification societies and service suppliers have the potential to alter the manner in which massive structures are currently being inspected and maintained. This change will eventually improve shipping competitiveness, thus, paving the way for better and safer regulations and standards. Notwithstanding, the current framework derived from international common minimum standards, while noteworthy and creditable, continues to facilitate a number of thorny issues that could arise post-deployment of available techniques. This chapter highlights crucial elements that could altogether serve as a pathway forward against incidental issues acting as market growth barriers resulting in an unwanted impasse in this paradigm shift. This chapter derives from research conducted under the European Union (EU) Horizon 2020 funded project titled Autonomous Robotic Inspection and Maintenance on Ship Hulls (BUG-WRIGHT2) under grant agreement No. 871260.

Publisher	Palgrave Macmillan (in the book Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance)		
Duration of Work	March 2022 – December 2023		
Impact Factor	1 The impact score (IS) 2022 of Palgrave Communications is 4.23		
Status	**Under-review**	**Proof-stage**	**Published**
	-	-	x
Citation	-		
Impacts Following Publication	**Text Reads**	**Total Downloads**	**Presentations**
	243 (as of 2 August 15 July 2023)	-	-

A.5 Summary of Chapter Publication by External Contributors Supervised by World Maritime University on Work Relevant to Strand 4: Review origins, types and status of international, European and national norms, regulations and standards in relation to autonomous robotics

Note	It is important to note that the World Maritime University BUGWRIGHT2 research team was proactively engaged in supervising the development of this chapter, providing regular feedback and supporting the peer-review process in their capacity as editors of this volume within the "duration of work" noted below. The chapter, in principle, covers BUGWRIGHT2 technologies, and as such is placed as a publication deliverable under this section. The chapter will be made available upon request since it is not published open access (please send email to Tafsir Johansson: tm@wmu.se). As noted in the Acknowledgment section of the edited volume: "… The editors would also like to extend sincere appreciation to: the European Union Horizon 2020 Programme for generously funding the project titled Autonomous Robotic Inspection and Maintenance on Ship Hulls (BUGWRIGHT2) (under grant agreement No. 871260); BUGWRIGHT2 Consortium Members; and members of the WMU- GOI BUGWRIGHT2 Senior Advisory Group. The timely findings from the above project served as an inspiration for inclusion of a newly evolving area that concerns remote technologies and the likes—a pivotal component of this volume".
Title	Remote Inspection Schemes: Past, Present, and Future
Abstract	Remote Inspection Techniques (RIT) can increase safety and cost efficiency of maintenance activities, especially, if certain equipment works autonomously without interventions from human-crew. How convenient would it be if the local-crew could simply lower the equipment in the tanks, holds and/or attach the equipment to the hull; the equipment carries out the inspection by itself; obtain image recognition of only the abnormalities and follow-up on work orders created in the asset management system to carry out specific repairs—and the entire process is reliable and class approved? The technology and regulations however are not that far off. In this chapter the author elaborates on the challenges related to technology, approval, and briefly touches upon commercial discussions related to intellectual property and financing.

Publisher	Palgrave Macmillan (in the book Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance)		
Duration of Work	January 2022 – December 2023		
Impact Factor	1 The impact score (IS) 2022 of Palgrave Communications is 4.23		
Status	**Under-review**	**Proof-stage**	**Published**
	-	-	x
Citation	-		
Impacts Following Publication	**Text Reads**	**Total Downloads**	**Presentations**
	100 (as of 2 August 15 July 2023)	-	-

A.6 Summary of Chapter Publication by External Contributors Supervised by World Maritime University on Work Relevant to Strand 4: Review origins, types and status of international, European and national norms, regulations and standards in relation to autonomous robotics

Note	It is important to note that the World Maritime University BUGWRIGHT2 research team was proactively engaged in supervising the development of this chapter, providing regular feedback and supporting the peer-review process in their capacity as editors of this volume within the "duration of work" noted below. The chapter, in principle, covers BUGWRIGHT2 technologies, and as such is placed as a publication deliverable under this section. The chapter will be made available upon request since it is not published open access (please send email to Tafsir Johansson: tm@wmu.se). As noted in the Acknowledgment section of the edited volume: "… The editors would also like to extend sincere appreciation to: the European Union Horizon 2020 Programme for generously funding the project titled Autonomous Robotic Inspection and Maintenance on Ship Hulls (BUGWRIGHT2) (under grant agreement No. 871260); BUGWRIGHT2 Consortium Members; and members of the WMU- GOI BUGWRIGHT2 Senior Advisory Group. The timely findings from the above project served as an inspiration for inclusion of a newly evolving area that concerns remote technologies and the likes—a pivotal component of this volume".
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Publisher	Palgrave Macmillan (in the book Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance)		
Duration of Work	January 2022 – December 2023		
Impact Factor	1 The impact score (IS) 2022 of Palgrave Communications is 4.23		
Status	**Under-review**	**Proof-stage**	**Published**
	-	-	x
Citation	-		
Impacts Following Publication	**Text Reads**	**Total Downloads**	**Presentations**
	100 (as of 2 August 15 July 2023)	-	-

A.7 Summary of Chapter Publication by External Contributors Supervised by World Maritime University on Work Relevant to Strand 2: Develop a methodology for the evaluation of existing norms and standards

Note	It is important to note that the World Maritime University BUGWRIGHT2 research team was proactively engaged in supervising the development of this chapter, providing regular feedback and supporting the peer-review process in their capacity as editors of this volume within the "duration of work" noted below. The chapter, in principle, covers BUGWRIGHT2 technologies, and as such is placed as a publication deliverable under this section. The chapter will be made available upon request since it is not published open access (please send email to Tafsir Johansson: tm@wmu.se). As noted in the Acknowledgment section of the edited volume: "… The editors would also like to extend sincere appreciation to: the European Union Horizon 2020 Programme for generously funding the project titled Autonomous Robotic Inspection and Maintenance on Ship Hulls (BUGWRIGHT2) (under grant agreement No. 871260); BUGWRIGHT2 Consortium Members; and members of the WMU- GOI BUGWRIGHT2 Senior Advisory Group. The timely findings from the above project served as an inspiration for inclusion of a newly evolving area that concerns remote technologies and the likes—a pivotal component of this volume".
Title	Techno-Regulatory Challenges for Remote Inspection Techniques (RIT): The Role of Classification Societies
Abstract	Since the early 1990s, members of the International Association of Classification Societies (IACS) have been using Remote Inspection Techniques (RIT) in ship surveying, utilizing drones and remotely operated vehicles (ROV) with a surveyor in attendance. With the Covid-19 pandemic, remote surveys, activities that have similar attributes to RIT, have garnered much attention given their importance in keeping the Maritime Industry moving. According to a Det Norske Veritas (DNV) report, there has been an increase of about 47% in remote assessments (surveys, inspections, and audits) compared to pre-Covid-19. To match the increasing adoption of remote surveys and concurrently RIT, regulatory authorities should enhance and amend current regulations to ensure that the activities are carried out safely and securely. With the introduction of unified requirements for remote surveys, as a baseline, the remote survey should require delivering an equal level of assurance to that of a survey done via traditional means. This chapter details the techno-

	regulatory challenges related to remote inspections and surveys; it considers existing definitions and how these could change when applied in a remote context. The general approaches adopted by the various class societies are also included. Finally, a case study on drone inspection is presented.		
Publisher	Palgrave Macmillan (in the book Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance)		
Duration of Work	January 2022 – December 2023		
Impact Factor	1 The impact score (IS) 2022 of Palgrave Communications is 4.23		
Status	**Under-review**	**Proof-stage**	**Published**
	-	-	x
Citation	-		
Impacts Following Publication	**Text Reads**	**Total Downloads**	**Presentations**
	106 (as of 2 August 15 July 2023)	-	-

A.8 Summary of Article Publication by World Maritime University As Principal Authors Disseminating Work Relevant to Strand 3: Advance understanding whether new regulatory approaches or self-regulation is best for the future development of robot-technologies for automatic robotic guidance and inspection systems

Title	Applying BUGWRIGHT2 Top-down Regulatory-model to the Aquaculture Sector		
Abstract	Innovation helps transcend human-centric boundaries. It's applied form found in a gamut of technologies are sound alternatives (to the human element) --- only if there is compliance with umbrella standards. Regulatory standards cannot be abrogated. When enforced through a top-down approach, regulatory standards do not limit the potential of technologies, rather they help avoid major bottlenecks and complex challenges that may stall progressive development of a certain branch of technology. Technological applications involving the use of robotics, whether ocean observation, vessel inspection or aquaculture survey, are still young. New and hybrid technologies in this era, often termed as Industry 4.0, will reshape special sectors that support fundamental benefits derived from marine ecosystem services. Drawing on critical findings from the European Horizon 2020 BUGWRIGHT2 project, this essay documents a sequence of important strands-of-influence for consideration so that remote inspection techniques could be effectively and efficiently integrated into aquaculture and its current manual-driven survey and monitoring framework.		
Publisher	Journal of Ocean Technology		
Duration of Work	January 2023 – March 2023		
Impact Factor	The impact score (IS) 2022 of Journal of Ocean Technology is 0.20		
Status	**Under-review**	**Proof-stage**	**Published**
	-	-	x
Citation	-		

Impacts Following Publication	**Text Reads**	**Total Downloads**	**Presentations**
	-	-	-

A.9 Summary of Article Publication by World Maritime University As Principal Authors Disseminating Work Relevant to Strand 2: Develop a methodology for the evaluation of existing norms and standards

Title	Addressing the Hazards of Remote Inspection Techniques: A Safety-Net for Vessel Surveys		
Abstract	Emerging technologies and technologies with emerging applications are stark catalysts of transformation in the maritime industry. As the industry progressively shifts to remote inspection techniques (RIT), there is a growing need to identify and assess the potential hazards that exist within the breadth and scope of vessel surveys and inspections. Such an assessment is essential bearing in mind the limitations, drawbacks and negative externalities pertaining to robotic platforms that are being integrated into the traditional manual-driven system. Moving the RIT-agenda forward entails optimization of human-robotic interface (free from seen and unforeseen impacts) that remains a prerequisite to the conduct of classification and statutory surveys. Drawing on findings from in-depth interviews with subject matter experts, this article makes recommendations for an RIT survey 'safety net' covering pre, ongoing and post operational aspects, and addressing data governance and psychosocial hazards as well as the hazards arising from the absence of a common legal liability framework		
Publisher	Journal of Law, Innovation & Technology		
Duration of Work	January 2023 – March 2023		
Impact Factor	The impact score (IS) 2023 of Journal of Law, Innovation & Technology is 0.433		
Status	**Under-review**	**Proof-stage**	**Published**
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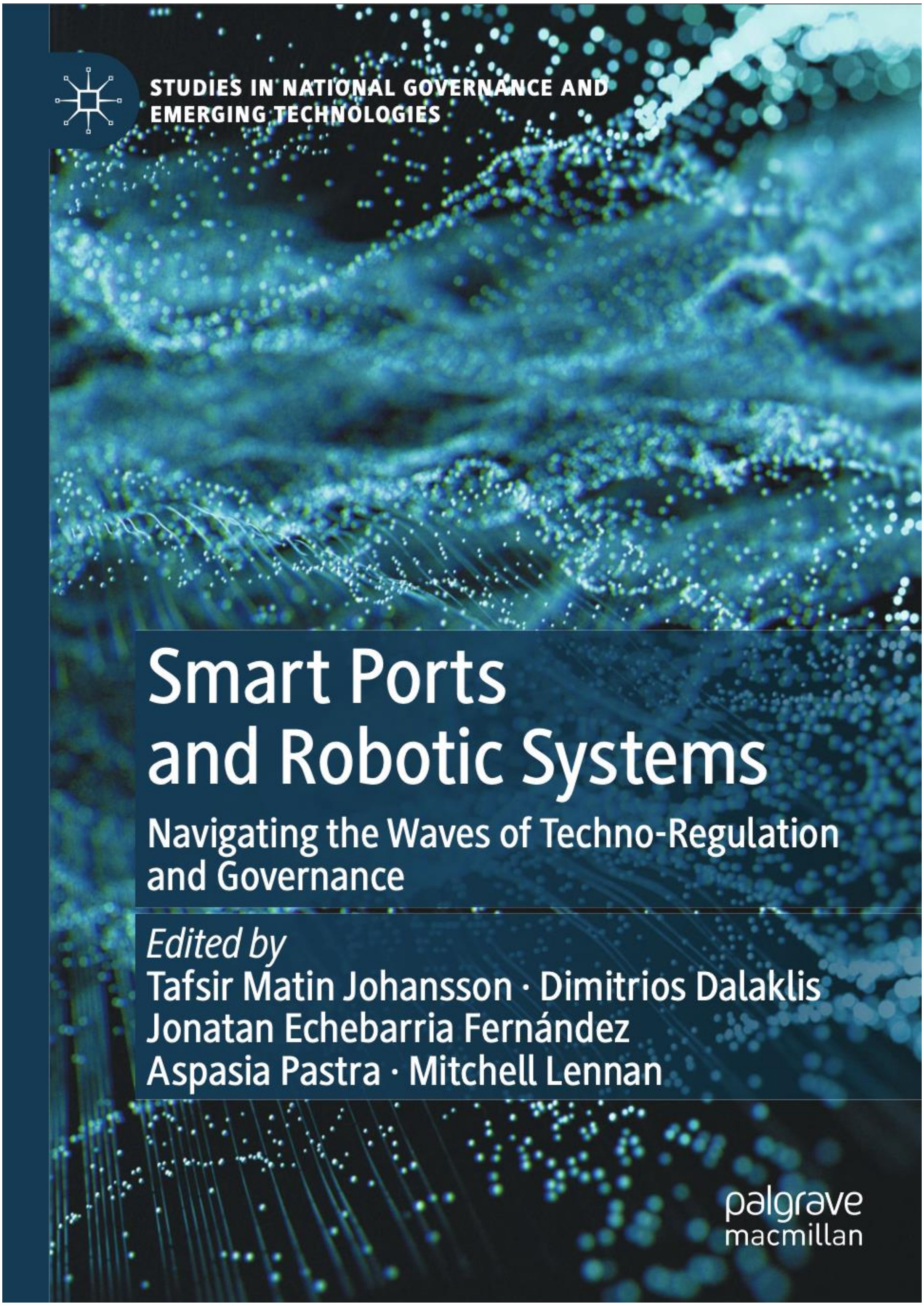
Citation	-		
Impacts Following Publication	**Text Reads**	**Total Downloads**	**Presentations**
	-	-	-

B. PUBLICATIONS ATTACHED

The following publications have been attached to this section of the report:

1. *Acknowledgment* section from the edited volume "Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance" (published, 2023);
2. *Introduction to Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance* from the edited volume "Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance" (published, 2023);
3. *Lessons Learned from Maritime Nations Leading Autonomous Operations and Remote Inspection Techniques* from the edited volume "Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance" (published, 2023);
4. *Towards an International Guideline for RIT End-Users: Spearing Through Vessel Inspection and Hull Cleaning Techno-Regulatory Elements* from the edited volume "Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance" (published, 2023);
5. *Introduction to Autonomous Vessels in Maritime Affairs: Law & Governance Implications* from the edited volume "Autonomous Vessels in Maritime Affairs Law and Governance Implications";
6. *Applying BUGWRIGHT2 Top-down Regulatory-model to the Aquaculture Sector* (published in Journal of Ocean Technology, Vol. 18, No. 2, 2023);
7. IMO-WMU Conference Report: "Protecting the Ocean – Moving Forward at 50: London Convention/Protocol and Stockholm Declaration" --- Long Bios & Panel 8 Composition List;
8. DEVPORT 2023 Conference Publication: *BUGWRIGHT2 Remote Inspection Techniques in Medium and Small-Sized Scandinavian Ports: Application, Advantage & Adversity*;
9. *Addressing the Hazards of Remote Inspection Techniques: A Safety-Net for Vessel Surveys;* and
10. Book dissemination e-prints (Perspective): Journal of Ocean Technology.

C. PUBLICATION E-PRINTS



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CHAPTER 1

Introduction to Smart Ports and Robotic Systems: Navigating the Waves of Techno-Regulation and Governance

Tafsir Matin Johansson, Mitchell Lennan, Jonatan Echebarria Fernández, Aspasia Pastra, and Dimitrios Dalaklis

Technology developed and corresponding benefits unravelled in the past is now continually constant and ergo, ubiquitous in all domains including the transport sector. As the maritime domain slowly progresses towards

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"autonomy" under the auspices of the fourth industrial revolution, port infrastructure and the likes are undergoing major transformations. Currently, ports are in the process of mitigating efficiency-related challenges. To tackle barbed challenges, they are progressively transforming into network developers. It is observed that a number of major international ports, e.g., port of Shanghai, port of Singapore, port of Rotterdam, port of Los Angeles and port of Hamburg are equipped with sensors and devices, and are fully connected to a network infrastructure for integrated communications system between "ship and port". In tandem, ship owners and classification societies are deploying remote inspection techniques (RIT) such as multi-aerial vehicles, hybrid crawlers, unmanned robotic arms, remotely operated vehicles—collectively known as maritime robotics and autonomous systems. In the not-so-distant future, RIT has the potential to replace the existing manual ways of conducting vessel survey and inspection that has been considered as being dull, dirty and dangerous. Whether through transformation towards smart ports or transition towards RIT-based operations, the intention behind going "digital" lies in the objective to conduct tasks with the help of machine learning systems capable of interacting with the environment to achieve pre-set goals while promoting safety, security and environmental protection facets.

This book is the second of two volumes which explore autonomy in ships and ports, with a special focus on ports and robotics from the context of "regulations governing technology" that editors' note as critical techno-regulatory aspects. In doing so, it examines a variety of complex technological, regulatory, legal, psychological and societal issues from experts across a wide range of fields. The key insights in this volume are spread across twenty chapters in 5 parts: (1) setting the scene; (2) vessel autonomy & autonomous systems redux; (3) smart ports; (4) remote inspection techniques; and (5) tying the threads.

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This volume on smart ports and robotic systems opens with a contribution by Andrei Polejack and Luis Fernando Corrêa da Silva Machado. The authors introduce "innovation diplomacy"—a concept at the intersection of international relations and technology development and is used in engagement and partnership between actors including government, academia, industry and society. With the help of concrete examples, the chapter showcases how innovation diplomacy is used successfully in the maritime sector to leverage the various moving parts involved in regulatory governance, or "innovation ecosystems" (Polejack & Machado, 2023). Noting that the chapter offers recommendations on how to leverage ocean diplomacy to benefit countries in the Global South and be used as a tool to support cross-boundary innovation (Polejack & Machado, 2023).

Part II of this volume concerns autonomous vessels and systems, the central theme of the first volume of this collection. Accordingly, the four chapters in this part are a redux on this topic, and seek to refresh the reader in their understanding of the pertinent issues concerning vessel system autonomy, crowdsourced bathymetry and ocean observation prior to diving into the subject of ports and robotic systems.

Chapter 3, authored by Mikael Hilden, opens this part with the discussion of human-generated errors, which make up no less than 80% of errors on board a vessel (Hilden, 2023). Captain Hilden tackles head-on the mostly notion that technological innovation in the maritime sector will reduce the likelihood of human error. Through an insightful discussion on the human nature of error and the flaws in human intelligence Hilden argues that it is too simplistic to assume that improvements in technology is the solution to human error. He then guides the reader through key concepts including artificial intelligence and machine learning, for example, with a projection that these developments may change (and is already changing) our world for the better in the context of autonomous ships. However, he warns us of the dangers of idealising a "Technological Utopia" since technology too can (and does) err (Hilden, 2023).

The next three chapters touch on various aspects of ocean observation. Michael B. Jones, insights the reader in Chapter 4 with a case study of how technological innovation in the sailing sector at the intersection of autonomy can save costs, and reduce emissions. We are guided through the benefits of wind-powered autonomous surface ships through the case study of groundbreaking SubSeaSail innovations, including in the ocean observation and in the global shipping market and beyond (Jones, 2023).

In Chapter 5, we are brought to the nexus of the oceanographer's staple of bathymetry and the relatively novel concept of crowdsourcing by Steven Geoffrey Keating. Keating provides a fascinating discussion on the unique status of crowdsourced bathymetry—where depth measurements form vessels engaged in regular maritime operations are shared cooperatively. This can advance knowledge on maritime depth and improve navigational safety, potentially on a massive scale (Keating, 2023).

Luciana Fernandes Coelho and Roland Rogers close this Part with a discussion on the international legal perspectives of Marine Autonomous Systems (MAS) in ocean observation in Chapter 6. Is the existing legal framework fit for purpose to accommodate the regulation of increased use of MAS? After examining no less than six forms of MAS, Coelho and Rogers turn to the international legal framework governing marine scientific research. They present various scenarios where challenges in the use of MAS arises (Coelho & Rogers, 2023).

Part III concerns itself with the pertinent topic of smart ports. We begin from a security perspective with a contribution from Adriana Ávila-Zúñiga-Nordfjeld, Hans Liwång and Dimitrios Dalaklis. Chapter 7 presents an analysis of the technological tools available to serve port and maritime security. They discuss the co-benefits of these developments including strengthening port and maritime security while simultaneously limiting the illegal trafficking of drugs (Ávila-Zúñiga-Nordfjeld et al., 2023). Importantly, the authors suggest changes to the International Ship and Port Facility Security (ISPS) Code to standardise such equipment on board vessels, arguing that its need and significance is similar to the Automatic Identification System (AIS), or the Long-Range Identification and Tracking (LRIT), to counter drug traffic by sea threats (Ávila-Zúñiga-Nordfjeld et al., 2023). Finally, the importance of continued, iterative adaptability to deter security threats is stressed (Ávila-Zúñiga-Nordfjeld et al., 2023).

Chapter 8 by Andrew Baskin and Mona Swoboda tackles the issue of the future of port governance. Baskin and Swoboda tackle this pertinent topic from the perspective of continued automation of port operations. This is an ever-growing trend which can reduce costs, increase productivity and reliability and improve inclusion, accessibility, safety and environmental performance (Baskin & Swoboda, 2023). In the face of this trend and the evolving governance landscape the authors make the strong case for port governance that is both collaborative and integrated (Baskin & Swoboda, 2023).

The third chapter i.e., Chapter 9 in focus on smart ports, provides us with incise perspectives from Canada from two prestigious contributors: Yoss Leclerc and Michael Ircha. The authors utilise their rich knowledge and navigate the reader through the various innovative approaches taken by major Canadian ports in the shift from "intelligent" to "smart" ports (Leclerc & Ircha, 2023). They highlight partnering with universities and research institutions on groundbreaking projects in transportation, logistics, big data, artificial intelligence and digitalization (Leclerc & Ircha, 2023). This has helped strengthen resilience and help ports across Canada adapt to the changing technological landscape (Leclerc & Ircha, 2023).

Jason Chuah raises crucial points surrounding the issue of project financing and investment for smart ports in Chapter 10. He focuses on developing countries, where lack of access to finance to implement smart port projects abound, and is a key challenge for emerging economies (Chuah, 2023). In particular smart ports as a concept within an emerging legal framework in developing countries causes ambiguity and uncertainty with regard to supporting private financing and awarding concessions in smart port to develop infrastructure, transportation and logistics in these projects (Chuah, 2023). Chuah makes key suggestions as to how emerging economies might change their legislative response to secure financing for smart ports, including specifying clear objectives regarding what aspect of the project the financing is for, and making the important case that all smart port implementation activities and milestones should reflect sustainability commitments (Chuah, 2023).

Chapter 11, penned by Gabriela Argüello takes us to the topic of smart port enforcement through unmanned aerial vehicles (UAVs). We understand UAVs to be cost-effective, labour reducing tools which can handle and process vast volumes of data with reduced human input—particularly in the case of surveillance and enforcement. In that context, Argüello begins with the perennial issue of port State jurisdiction for prevention of ship source pollution. The argument is made that both UAVs and other surveillance technology can assist in enforcement of pollution regulation and influence ship behaviour towards compliance as they come into port (Argüello, 2023). Despite being devices for data collection, UAVs are assimilated smoothly into legal systems as aircraft which simplifies their incorporation into existing frameworks (Argüello, 2023). However, she warns us that increased use of UAVs in smart port enforcement may lead to an expansion of Port State jurisdiction, which is fertile ground for further research in the law of the sea (Argüello, 2023).

We turn to the theme of smart port security. The multi-authored Chapter 12 by Iosif Progoulakis, Nikitas Nikitakos, Dimitrios Dalaklis, Anastasia Christodoulou, Angelos Dalaklis and Razali Yaacob tackles the aspects of digitalization and cyber physical security within maritime transportation and port infrastructure. This rich contribution stresses that cyber security systems should be re-evaluated as new applications of existing technical tools such as Information Technology (IT) and Operational Technology (OT) systems evolve, and new tools develop (Progoulakis et al., 2023). Well-known cyber threats are discussed and existing policies and guidelines that can be harnessed to tackle these are presented, and reviewed in an innovative fashion using bow-tie analysis. Despite the real threat of a cyber physical security incident in the maritime context, the authors conclude that the industry is unprepared despite proactive initiative from the International Maritime Organization—further guidance is needed for maritime owners and operators to avoid these threats (Progoulakis et al., 2023).

Continuing with the smart port security theme, Andrew Baskin contributes another chapter to this volume this time with Max Bobys in Chapter 13. This chapter complements the previous by appraising legislation and regulation on cybersecurity by governments and intergovernmental organisations. This regulatory landscape is growing in size and complexity. As a result, the number of port cybersecurity guidance documents are growing as is an emerging market of port cybersecurity insurance (Baskin & Bobys, 2023). After an assessment of policies and legislation by intergovernmental organisations, they conclude that while these are helpful, they must be taken into consideration with pre-existing frameworks for operational risk, and that implementation must be tailor-made for each individual port or port facility (Baskin & Bobys, 2023). They also highlight the need for coordination in policies and approaches in cybersecurity for the port sector (Baskin & Bobys, 2023).

In the final chapter of this part, i.e., Chapter 14, Dimitrios Dalaklis, Nikitas Nikitakos, Dimitrios Papachristos and Angelos Dalaklis take us through the opportunities and challenges those big data analytics presents for the shipping and port industries. The day-to-day running of the computer systems on a ship creates vast volumes of data, or “big data”. What do we do to manage all this information? Analysis of big data through the use of appropriate software tools to extract and process the key information is of course vital to facilitate transition towards smart shipping and smart ports. Dalaklis et al., follow an innovative

Strength, Weaknesses, Opportunities and Challenges (SWOC) analysis of the various tools and techniques of big data analysis to aid in decision-making and improve operational efficiency. However, they highlight that standards and performance of relevant algorithms vary significantly, and argue that regulatory interventions can ensure a uniform approach, and a discussion around best practices in industry is vital (Dalaklis et al., 2023).

The chapters in Part IV of this volume are presented under the title of "Remote Inspection Techniques", which is, in its simple form, defined as a process of inspection/ means of survey for inspecting critical structures using specific "digital" techniques without requiring physical access on the part of the surveyor/inspector. Part IV, i.e., Chapter 15 opens with a pertinent contribution by Anastasios Kartsimadakis on remote inspection schemes on tanker vessels during the Covid-19 pandemic. The chapter discusses the fact that as a result of the pandemic, remote inspections have become more prevalent, despite being limited by technological and procedural frameworks (Kartsimadakis, 2023). The need for alternative remote inspection methods became vital due to Covid, and in this context Kartsimadakis discusses the Tokyo Memorandum of Understanding which established a remote inspection system with technical specifications at consent of the port Master, as well as the remote inspection policy launched by members of the Oil Companies International Marine Forum (OCIMF) Ship Inspection Report Programme (SIRE), concluding that there is a need for uniformity and coherency in remote inspection policy and guidance must be consensually agreed by stakeholders (Kartsimadakis, 2023).

We turn to the tecno-regulatory challenges presented by Remote Inspection Techniques in Chapter 16. Another prestigious multi-authored chapter, this time by Kin Hey Chu, Marina G. Papaioannou, Yanzhi Chen, Xiaoliang Gong and Imran H. Ibrahim of Maritime Advisory Research and Development, Region S.E.A., Pacific and India. Beginning from the fact that Covid-19 has resulted in an increase in remote inspections and assessments to ensure compliance and safety with the relevant regulations, they detail the techno-regulatory challenges that arise from remote inspections and surveys. They further clarify that there is a difference between remote inspection techniques and remote surveys and should be treated as such, highlight that classification societies offer guidance for the planning and execution of remote inspections as well as remote surveys, and conclude that regulations and technology will continue to evolve alongside the evolution and advancement of remote inspection techniques (Chu et al., 2023).

David Knukkel reminds us in Chapter 17 that while remote inspection techniques are not a necessarily new phenomenon, but today they exist at the nexus of autonomy and human interaction. Technology that will be familiar to the reader includes drones, UAVs and remotely operated underwater vehicles. To that end, Knukkel assesses the challenges related to inspection and certification, technological challenges, approval and briefly touches upon commercial discussions related to intellectual property and financing in remote inspection techniques (Knukkel, 2023).

Building on the human-autonomy point by Knukkel, Chapter 18 by Thomas Ellwart and Nathalie Schauffel brings a fresh perspective and informs us of the psychological perspectives of teamwork between humans and "self-governing" systems. They introduce us to the concept of the "human-autonomy team" (HAT), based on the premise that, like humans, autonomous systems possess a high degree of self-governance concerning adaptation, communication and decision-making (Ellwart & Schauffel, 2023). From a qualitative interview methodology, they enlighten us on three psychological perspectives of HAT (i) level of autonomy; (ii) system trust; and (iii) system knowledge/features, presenting us with opportunities and potential barriers to each (Ellwart & Schauffel, 2023). This important piece then outlines future trends within HAT, and the importance of an adaptive approach as technology and circumstances change (Ellwart & Schauffel, 2023).

The penultimate chapter in this Part on Remote Inspection Techniques provides us with lessons learned from key maritime nations leading in autonomous operations and remote inspection techniques. Chapter 19 is authored by Aspasia Pastra, Thomas Klenum, Tafsir Matin Johansson, Mitchell Lennan, Sean Pribyl, Cody Warner, Damoulis Xydous and Frode Rødølen. An assessment of AI national plans within the major maritime nations through a comparative study of the United States of America, the Netherlands, Canada, Norway, China and Singapore conducted through 60 interviews with maritime administrations, policy advisors, classification societies, service providers and subject matter experts on remote inspection techniques (Pastra et al., 2023a). They conclude that since no specific international guidance on remote inspection techniques exists, the adoption of an international regulatory framework could certainly lead to an increased uptake in the use of remote inspection techniques (Pastra et al., 2023a).

That brings us to the final chapter in this Part (Chapter 20), authored by Aspasia Pastra, Miguel Juan Núñez-Sánchez, Anastasios Kartsimadakis, Tafsir Matin Johansson, Thomas Klenum, Thomas Aschert, Mitchell Lennan, Marina G. Papaioannou and Maria Theodorou. This chapter presents the key findings arising from the BUGWRIGHT2 project which aims to alter the landscape of robotics for structure-inspection and maintenance in the EU. To that end, they present a blueprint that could serve as a foundation for the anticipated international guidelines on remote inspection techniques alluded to in the previous chapter, which should be developed in an inclusive, multi-stakeholder fashion (Pastra et al., 2023b). In any case, the guidelines should harmonise existing practices by flag States, and should be implemented on a case-by-case approach in line with the development of training and certification requirements of remote inspection techniques (Pastra et al., 2023b).

Finally, Paul Topping ties together in Chapter 21 the important threads discussed by authors of this volume in a strategic manner. His key conclusion is that development of technology is the limiting factor in the use of automation in smart ports and robotic systems. At present, most systems are still subject to some degree of human monitoring and/or control—things will become more complex as technology evolves and automated systems become more independent (Topping, 2023. From a regulatory point of view, Topping raises issues of liability, finance and safety standards, especially the fact that ship owners and port authorities are responsible for the automated systems they operate, which much be accounted for through human control or other methods (Topping, 2023).

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CHAPTER 19

Lessons Learned from Maritime Nations Leading Autonomous Operations and Remote Inspection Techniques

Aspasia Pastra, Thomas Klenum, Tafsir Matin Johansson, Mitchell Lennan, Sean Pribyl, Cody Warner, Damoulis Xydous, and Frode Rødølen

1 Introduction

Digitalization and the emergence of artificial intelligence (AI)-based technologies are increasingly pervading all areas of our lives, and in parallel, posing multiple challenges for nations. It is observed that the AI agenda remains a strategic priority for governments. Combinedly, respective

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priorities have led to a form of global competition with regard to the development of AI applications and policies (Smuha, 2021). In 2017, Canada became the first country to establish a national plan for AI. The "Pan-Canadian Artificial Intelligence Strategy" fosters a collaborative AI ecosystem by establishing interconnected nodes of scientific excellence in three major centers for AI: Edmonton, Montreal, and Toronto. The EU AI strategy of 2018 specifies the region's goal to "lead the way in developing and using AI for good and for all, building on its values and its strengths". In the following year, the US, through Executive Order 13,859, promised to sustain and enhance the scientific, technological, and economic leadership position in AI research and deployment through a coordinated Federal Government strategy (Federal Register, 2019). During the same year, Singapore launched the "National AI Strategy" that spelled out plans to deepen the usage of AI technologies and rethink business models by 2030. From an Asian context, with its ambitious "Next Generation Artificial Intelligence Development Plan", China has

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set out a top-level design blueprint charting its approach to developing AI technology by 2030.

In short, governments from across the globe are catering to the needs of end-users through the adoption of policies that could stimulate beneficial innovation while protecting their citizens from risks involving the usage of AI. Safety, responsibility, and product liability aspects of AI, including negligence, design defects, and manufacturing defects, usually fall into a legal and regulatory vacuum. At the same time, participants of regulatory debates hold divergent views on the so-called term "autonomy". A unified and well-synchronized "safety" and "liability" approach is vital to the mitigation of potential damages caused by AI. According to the participants, the above is what makes AI trustworthy, i.e., legal, ethical, and robust.

AI national plans also set specific targets for niche ocean and maritime sectors. In this context, semi-autonomous RIT platforms for unmanned aerial vehicles (UAVs) or drones, remotely operated vehicles (ROV), and magnetic crawlers, *inter alia*, do not explicitly reside on the national agenda despite having gained attention from relevant stakeholders and end users. Today, RIT platforms are being tested and used by service providers, classification societies, and ship owners. However, many intrinsic matters, similar to ones that emanate from the usage of AI, remain undiscussed and therefore, ambiguous. Problems have been projected: standard definitions, third-party liability, data management, and insurance are to name a few thorny issues. The absence of unified guidelines (covering the above) leads to the hypothesis that a single RIT platform may be governed by dissimilar rules and requirements. Today, this is evident from the content found in RIT procedural documents issued by leading classification societies. The current state-of-fragmentation and lack of a standardized approach have the potential to stall innovation in the long run. The authors assert that, before any attempt is made to standardize RIT approaches, it is important to assess the lessons learned and best practices from countries that are taking the lead in AI and RIT-based operations.

2 National Comparative Study

2.1 The Case of the US

The US is a maritime nation comprised of 25,000 miles of coastal and inland waters and rivers home to 361 ports (USCG, 2018). It is axiomatic that the US marine transportation system is expansive. The US maritime domain involves a complex regulatory framework in a variety of locations, from inland ports and waterways to the high seas, often with overlapping legal authorities and agency responsibilities. Several jurisdictional zones exist in the maritime domain that may implicate international and domestic law. The location and use of the autonomous systems' operations may call into play multiple overlapping jurisdictional concerns, including domestic and international legal obligations (Pribyl, 2018). The US Coast Guard (USCG) has 11 statutory missions and maintains broad authority over navigation safety in the navigable waters of the United States, including the inspection of vessels registered in the US or sailing in US waters. In terms of autonomous vehicles, the USCG is the lead agency for marine vehicles and exercises its oversight in this regard under its port state control, vessel inspection, environmental compliance, and navigational safety authorities. The US Flag fleet includes 18,967 vessels subject to inspection with Coast Guard marine inspectors conducting 19,474 inspections (United States Coast Guard, 2021). The majority of the US fleet is comprised of barges, passenger, and towing vessels.

The Coast Guard delegates this responsibility to the Officer in Charge, Marine Inspection (OCMI), whose primary responsibility is to inspect vessels to ensure compliance with applicable laws and regulations related to safe construction, operation, and manning. The Coast Guard Office of Commercial Vessel Compliance (CG-CVC) is the designated body for the development and maintenance of marine safety and security policies and standards.

There are currently no US regulations that expressly govern the use of RIT or remote inspection technologies. However, as a response to the Covid-19 pandemic crisis, including considerations of the lessons learned from the pandemic, the Coast Guard is taking steps to encourage its inspectors to use remote methods as a means to verify vessel compliance (Marine Safety Information Bulletin, 2020). Many statutory surveys are also performed by Recognized Organizations (ROs) that act on behalf of the Coast Guard. The American Bureau of Shipping (ABS) is the largest RO in the US. For remote inspections, the Coast Guard generally approves the usage of remote techniques on a case-by-case assessment. ROs that use remote survey in lieu of attendance on vessels that are both classed and certificated should contact the relevant Coast Guard office, such as the Flag State Control Division (CG-CVC-4) or the Towing Vessel National Center of Expertise (TVNCOE), to propose the methods and administrative procedures that will be used (Marine Safety Information Bulletin, 2020).

Given the current stage of technological development, remote techniques have not yet achieved an optimum level since they continue to develop equivalent functions on par with human senses used in inspections (i.e., sight). More peer review studies are needed to compare the existing regime of inspections with remote techniques to provide evidence as to which option is better suited and feasible.

The ABS Guidance Notes on the Use of Remote Inspection Technologies (ABS, 2022) offer best practices for class surveys and non-class inspections carried out using unmanned aerial vehicles (UAVs), ROVs, and Robotic Crawlers. The document offers a holistic approach to govern RITs and adequate emphasis is given to "data security policies and procedures" in Sect. 4.11.1. Nonetheless, according to the document, it should be noted that those policies and procedures should be developed by the concerned end-users, including service providers. The Guidance Note includes reference to the following relevant international documents:

- IACS Recommendations No. 42, Guidelines for Use of Remote Inspection Techniques for Surveys;
- IACS UR Z7, Hull Classification Surveys 1.6 Remote Inspection Techniques; and
- IACS UR Z17, Procedural Requirements for Service Suppliers.

According to the ABS Guidelines, during the planning stage, the ship owner/operator should liaise with ABS and decide jointly on whether to proceed with the survey using RIT (Fig. 2 below). The owner is responsible for selecting an ABS Recognized service provider. Approved service providers should possess all applicable certificates of authorization from recognized national/local authorities and have an internal Quality Management System, Safety Management System, Safety Risk Management, Safety Assurance, and competent personnel to oversee all the above aspects. It is also noted that the owner should provide all documents and drawings related to the work scope to the selected provider, approve the remote inspection plan, and set the Survey Planning (Fig. 1 below). The service provider, during this stage, develops an inspection plan that includes different types of RIT to be used based on risk assessment. The Class reviews the survey planning document to verify whether the survey plan satisfies the applicable ABS Rules. During the operation, which is the second stage of the inspection process, the owner coordinates the survey with the surveyor and the provider (Fig. 1 below). The provider conducts the inspection according to the survey planning document, RIT operation plan, and ABS requirements. The attending class surveyor ensures that the RIV operations team conducts the survey according to the relevant requirements. During the reporting phase of the survey, the provider shares the report and data with the asset owner and Class. Finally, based on the reports, the Class surveyor shall confirm if an additional inspection is required (Fig. 1).

2.2 The Case of the Netherlands

The Netherlands has a longstanding maritime tradition dating back over five centuries and holds a strategically significant geographical position with connections to rivers and seas. According to the Maritieme Monitor (2020), the Dutch maritime cluster incorporates eleven sectors: shipping, shipbuilding, offshore (energy), inland shipping, dredging, ports, navy, fishing, maritime services, yacht building/watersport industry, and marine equipment supply. The cluster generates 3.1% of the total GDP of the country and employs approximately 284,917 individuals, which equates to 3.0% of the national workforce (Maritieme Monitor, 2020). The Ministry of Infrastructure and Water Management is currently working to facilitate new initiatives and innovations in the inland maritime sector. Moreover, the Port of Rotterdam has positioned itself as an EU frontrunner in autonomous shipping technology and services through partnerships with tech-start-ups, leading institutions, and national authorities.

According to the Ministry of Infrastructure and Water Management, there is no single legislation for all types of transport modalities to facilitate autonomous drones or any other types of service robots. Maritime autonomous robotic systems are not permitted to operate within Dutch inland waterways; however, experiments are ongoing with (semi-) autonomous inspection vessels. Parties that wish to experiment

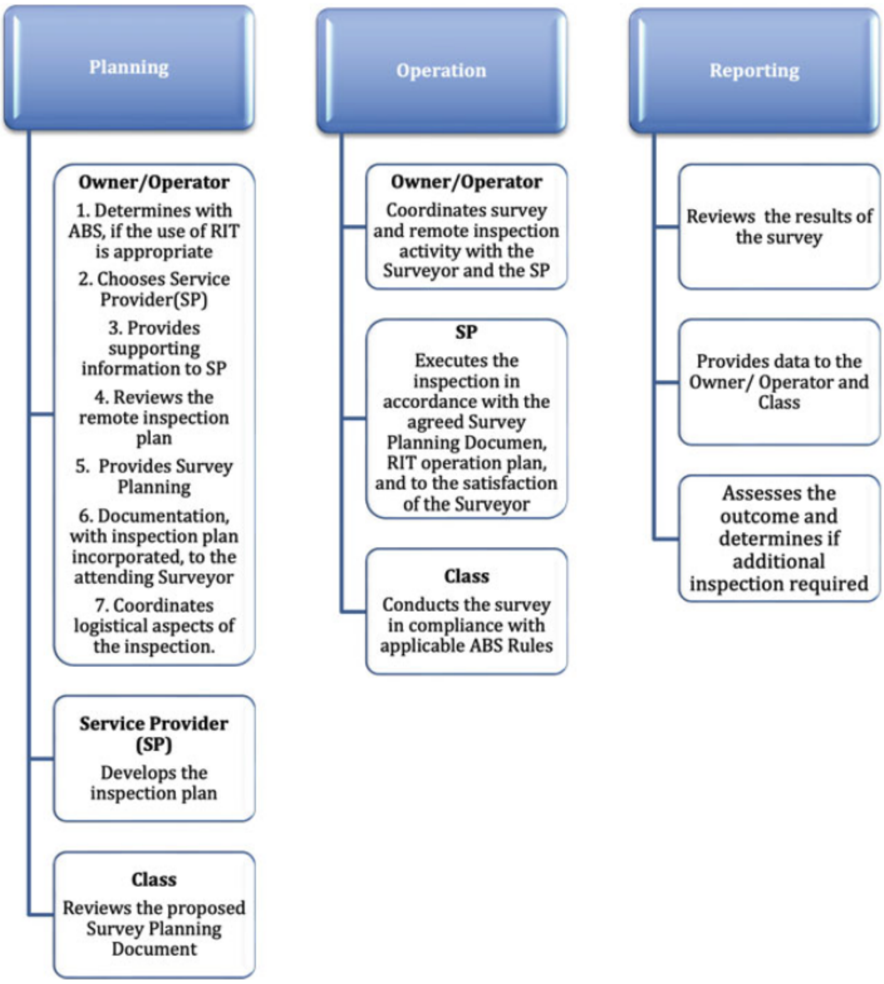

Fig. 1 Roles and responsibilities of the key stakeholders during the 3 phases of the inspection process (*Source* Adapted from ABS [2022])

with any categories of smart shipping, including maritime drones and robotic systems, are invited to contact *Rijkswaterstaat* (RWS) to evaluate the possibilities.

It goes without saying that the Dutch maritime sector is subject to national, as well as international and European regulations. The *Schepenwet* (Ships Act) is the central instrument that applies to all seagoing vessels flying the Dutch flag (Government of the Netherlands, 1909). The Act aims at preventing shipping disasters at sea and addresses issues such as ship safety and shipping disaster investigations. There are no provisions in the Act related to the use of remote technologies. In the inland maritime sector, the national legal framework on inland waters, excluding waterways governed by the standards and regulations of the Central Commission for the Navigation on the Rhine (CCNR), can be found in the Inland Navigation Act-*Binnenvaartwet* (Government of the Netherlands, 2007).

The Dutch Flag Registry is known as the Netherlands Shipping Inspectorate/NSI (Inspectie Leefomgeving en Transport), which is a part of the Human Environment and Transport Inspectorate (ILT) of the Ministry of Infrastructure and Water Management. The Registry has delegated all statutory certification services to eight pre-assigned EU RO: ABS, Indian Register of Shipping, Lloyd's Register, Nippon Kaiji Kyokai (Class NK), DNV, RINA Services S.p.A., BV (Buraeu Veritas), and Register Holland. It is noted that the Register Holland is a Classification Society that conducts only non-Conventional and/or non-European legislation-based surveys. The Administration supports the use of remote inspection in minor statutory deficiencies and minor damages. However, if an inspection is performed remotely, a physical inspection still needs to be performed afterward.

In cases where the ship owner/manager, in agreement with the captain and personnel on board, requests a remote survey, written justifications should be provided. If the RO accepts this request, then IACS 42 Rev.2 should be followed. Remote inspections are evaluated on a case-by-case basis and as such, no uniform guidelines apply.

It is noted that the request for remote inspection imposes an additional burden on the ship owner/manager and the RO, and that is why it is important to justify why a remote survey is more appropriate than a physical inspection.

Respondents noted that the Covid-19 pandemic could have been the catalyst and the paradigm for remote inspections, but unfortunately, the flag registry did not explore this option further. Instead of remote inspections, extensions were mainly granted for the statutory ship certificates by the Human Environment and Transport Inspectorate. Moreover, the Dutch fleet is in decline, and vessels are usually too small to obtain financial benefits from the usage of UAVs and ROVs. What is observed is that ship owners are yet to be convinced about the advantages of deploying remote technologies for the conduct of surveys and inspections. The following set of challenges were revealed during discussions with Dutch key experts in addition to the aforementioned:

- Visibility in the Dutch water imposes a burden for underwater inspections with autonomous underwater vehicles (AUVs);
- Problems have been noted with live-streaming technology. The sector needs companies that can provide effective live-streaming video-audio tools for a thorough examination of the structural defects;
- Drones, during the livestream operation, should always show their exact location during the inspection (which is currently not the case). This facilitates the work of the surveyors;
- Permission for hull cleaning from the Port Authority remains a challenging task. It should be kept in mind that hull cleaning is not a part of the Statutory certification and remains at the ship-owner's discretion;
- Flag Registries like Liberia are keener than their European counterparts to promote the use of remote technologies; and
- Specific Regulations are needed for trials and inspections. The findings of these trials should be crosschecked with findings from physical inspection to address gaps and overcome barriers.

2.3 The Case of Canada

With the world's longest coastline and connection to three oceans, the maritime sector in Canada contributes around CAN$31.7 billion annually in gross domestic product and accounts for close to 300,000 jobs (Government of Canada, 2021). Similar to other major maritime nations, Canada aims to be a global leader in the blue economy by integrating growth with ocean conservation and climate action. Activities dependent on the ocean, such as fish processing, shipbuilding, and marine transportation, create stable jobs and prosperity for coastal regions. Currently, there are no regulations/provisions for remote inspection techniques. However, the current four-level regime that entered into force in June 2021 is said to facilitate the eventual adoption of new inspection techniques in the future. The four documents relevant to the Canadian vessel inspection are described in Table 1 (below).

Table 1 Documents relevant to the hierarchical system of vessel inspection

Regulations and standards (Sources)	*Description*
1. Canada Shipping Act, 2001	Overarching legislation for marine safety and pollution prevention. The Act set the legal framework, and inspection authority, details of inspection are found either in regulations or supporting instruments
2. Regulations, such as the Vessel Safety Certificate Regulations (VSCR) as of 10 of June, 2021	The regulations specify which vessel needs a safety certification, and therefore need to be inspected. The regulations do not specify the inspection details; these are included in the TP 15456 document titled Canadian Vessel Plan Approval and Inspection Standard (Government of Canada, 2022)
3. Standards, such as the new Canadian Plan Approval and Inspection Standard, TP 15,456	The objective of this standard entered into force on 23 June 2021 is to provide instructions and guidance for inspections of vessels subject to the Vessel Safety Certificates Regulations under the authority of the Canada Shipping Act, 2001 (CSA, 2001). This document contains crucial details, for example, when a vessel needs to be inspected and what elements need to be inspected. If modern remote inspection techniques will be included in the Canadian regime, it will be done at this level or at the next one (fourth level). This would be an administrative exercise (done by Transport Canada Marine Safety and Security), rather than a legal one (e.g., Act or regulatory amendment, with Canadian Justice Department and others)
4. Supporting material such as Guidelines and works instructions	These may be developed on a needed basis to address certain specific elements

Source Transport Canada (Sources indicated in the first column)

In the context of the Covid-19 pandemic, like many other administrations, Transport Canada adapted its inspection processes on a case-by-case basis and accepted remote inspections to a certain extent. Transport Canada is looking forward to developing a framework that would support the use of new emerging technology. To this effect, there is a multi-modal (air, surface, rail, marine) departmental modernization initiative, and the usage of RIT is one of the end objectives of this initiative. The discussions with Deep Trekker, one of the largest providers in the country for remotely operated vehicles and robots, confirmed the limited use of remote techniques on Canadian vessels. The advantages and disadvantages of underwater inspection methods are summarized in Table 2 (below):

Table 2 Advantages and disadvantages of underwater inspection methods

Inspection method	*Certainty*	*Pros*	*Cons*
Drydock	High certainty	Clear visibility above water	Extremely high cost and time-consuming
Divers	Moderate certainty	1. Proven to perform adequately well, regulated and guided worldwide 2. Moderately high cost	1. Difficult to clarify if divers have inspected the entire vessel and difficult to know their exact position when finding defects 2. It can be time-consuming to wait and schedule a dive team 3. It is dangerous to send divers underwater
Remotely Operated Vehicles (ROVs)	Lower certainty but technology is evolving rapidly	Quick to deploy, most cost-effective and safest alternative	Inability to know its position. The ROV can run in transects along the hull in straight lines to maintain an understanding of position

Source Deep Trekker

Respondents underlined that three main obstacles are present when it comes to using ROVs:

1. Understanding what you have inspected (vs. not inspected);
2. Visualizing the data in a meaningful way; and
3. Sending the data to stakeholders in a meaningful way.

The first obstacle is related to the location of the inspection. GPS positioning systems do not work underwater as they can travel only a couple of inches through the water. One potential solution is the utilization of technology such as the underwater positioning system (USBL), which provides a position of the ROV using acoustic positioning. USBL consists of a transceiver mounted on the vessel and a transponder mounted on the ROV which jointly cooperate to communicate the ROV's position relative to the vessel. However, there are cases that USBL on its own does not work well because the vessel is an obstacle for acoustics to communicate from the dunking transducer to the ROV's transponder. USBL is also inherently inaccurate by 20 cm of error and with seconds of delay between pings, making autonomous motions difficult and unreliable using just

USBL. Deep Trekker is currently working on other methods for getting positioning and allowing for autopilot functionality.

The second obstacle is the visualization of the data in a meaningful way. Like a diver's eyes, video has a limited field of view to give positional context to the images the surveyor is seeing. A 3D rendering or model allows the surveyor to analyze the aggregate of the data points collected during an inspection. Currently, underwater 3D models are too time-consuming and require expert-level expertise whereby the technology remains prohibitively expensive.

The third obstacle is the proper interpretation of the data. The surveyors usually rely on divers' expertise to confirm the vessel's condition. In contrast, an ROV allows video streaming or video recording through which stakeholders could monitor the inspection process. However, there are many hours of footage to comb through to get the answers needed for the surveyor. The operator of the ROV should still be certified and experienced in hull inspections to identify issues. If the surveyor can monitor the inspection process next to the pilot, the quality of the report could be increased. A hull survey report engine must enter the inspected data and then produce a PDF report with photos of points-of-interest and easy access to key milestones during the video with text added for additional details.

Despite the obstacles that have been identified, it should be underlined that 3D RIT and reporting technologies are paving the way for significant developments in ship inspections. Interpreting changes over time with the use of a 3D model is helpful for maintenance purposes, evaluating corrosion, fouling changes, and damage. Providing classification societies with historical information on the vessel could prove valuable in their determination if the vessel is seaworthy and safe. There are three main methods for building underwater 3D models: Sonar, Laser, and Photogrammetry. There are other interesting combinations of other sensor technology such as hyperspectral imaging and LiDAR that could provide good data as well, but these are still unproven underwater.

Sonar is very useful for larger areas and general target identification with its longer range and capabilities even in murky water, but it should be noted that 3D sonar technology is limited in its capability for identifying small defects or changes over time in structures such as the propeller. The most used technology for propeller and small structure evaluations is the laser. Nonetheless, laser scanning has a very short-range capability (1–5 m) and is severely impacted by water clarity, making it more difficult for it to effectively provide full hull 3D models in a reasonable and cost-effective manner. Photogrammetry faces similar range and clarity issues, but there are encouraging developments that have found ways to utilize stereo cameras to stitch together 3D models faster and with less manual effort. As these technologies come down in size, price, and complication, they will play a critical role in making effective hull inspections easier.

2.4 *The Case of Norway*

Norway is a leading ocean economy with well-developed business clusters and local communities living along the coastline. The Norwegian shipping industry is at the forefront of exploiting new technologies like autonomous ships and onboard systems. The Norwegian Maritime Authority (NMA) is an agency of the Ministry of Trade, Industry, and Fisheries and the Ministry of Climate and Environment. NMA is the administrative and supervisory authority for environmental, safety, and legal issues of vessels flying the Norwegian flag and foreign ships in Norwegian waters.

The Register of NMA consists of the Norwegian ordinary ship register (NOR), the Norwegian International Ship Register (NIS), and the Shipbuilding Register (a sub-unit of NOR). For the NOR, there is a mandatory registration for all Norwegian ships of 15 meters and above and voluntary registration of Norwegian fishing and commercial vessels less than 15 meters. The regulatory framework for registration to NOR is based on the Norwegian Maritime Code of 24 June 1994 no. 39 (NMA, 1994). The NOR is open to EU or Norwegian owners and is the responsible authority for surveys and statutory certificates of vessels registered in NOR. International ship certificates for cargo ships above 500 gross tonnages (GT) are usually delegated to RO—upon request from the owner in accordance with the Class Agreement (NMA, 2013).

NIS was formed as a competitive alternative for Norwegian shipping companies operating in international waters and mainly competes with flags of convenience registers such as Panama and Liberia. NIS, which aims to maintain Norwegian vessels under the Norwegian flag, is open to owners of all nationalities. Ships are registered according to the law of 12 June 1987 No. 48 related to the Norwegian International Ship Register (NMA, 1987). Vessels above 500 GT classed by a RO are delegated to class according to the Class Agreement. The NMA inspects ships less than 500 GT as well as NIS ships of 500 GT and more which are not classed by one of the ROs. The number of vessels by the end of 2020 for NOR and NIS are presented in Table 3 (below).

Six classification societies are authorized to carry out surveys on behalf of the Norwegian administration namely, ABS, Bureau Veritas (BV), DNV, Lloyds Register of Shipping, RINA, and Class NK. Classification societies are used for the inspection of NIS vessels. For surveys of the NOR, the inspectors of NMA are usually appointed. The 130 in-house surveyors of the Norwegian Maritime Authority perform all vessel-related surveys and thickness measurements as seen fit. NMA Surveyors do not conduct thickness measurements themselves. These are performed by RO-approved suppliers on the "IACS List of Thickness measurement Firms", and according to IACS UR-Z7.

Currently, there are no specific regulations and policies for remote surveys, especially when it comes to surveys conducted for the Norwegian Ordinary Ship Register. The NMA may utilize remote technologies when achieving equivalency with a traditional survey. As a consequence of Covid-19 pandemic, the NMA allowed RO to extend the validity of statutory certificates for three months (NMA, 2020). DNV works in close cooperation with the NMA and completed the world's first in-water remote ship surveys using ROVs in 2020. When a classification society decides to perform a remote survey, especially for NIS-registered vessels, no further approval is required from the NMA.

It is important to note that respondents displayed a high level of trust in remote technologies, especially in drones given that mitigating technical challenges through drone testing has been successful in other sectors (i.e., aerospace and oil industries). Discussions also revealed that in the near future, more emphasis should be given to the development of guidelines for data-relevant issues, such as minimal requirements for

Table 3 Norwegian registered vessels 2020

Norwegian Registered Vessels 2020	*Registry*	*Norwegian owned 2020*	*Foreign owned*
Ships in the Merchant fleet	NOR	892	24
	NIS	485	170
Ships not in the Merchant fleet	NOR	20,417	73
	NIS	29	11

Source Statistics Norway

data quality, data ownership, and data flow. Guidelines will be required to govern the work of service robots once they reach the stage of full autonomy. Drone swarms are expected to be the next generation of robotics in the maritime sector. Aerial drone swarms deployed from an unmanned marine robotic station will autonomously inspect the vessel removing the need for a manual human inspection system.

2.5 The Case of China

With an array of ambitious AI plans and policies, China is said to be leading the way for AI technological developments and market applications. These policies aim to motivate different stakeholders on the ground that AI is a field that is being backed by the government and is worth investing in (Li et al., 2021).

The Maritime Safety Administration of the People's Republic of China (CMSA) is the governmental agency for maritime safety, vessel inspection, and pollution from ships. The Agency is responsible for regulations, technical codes, and standards in safety supervision, marine pollution prevention, and navigational aid. The Agency supervises the statutory survey and certification for ships. For international ships trading internationally, the statutory survey processes have been delegated to the China Classification Society (CCS). According to respondents, no specific regulations or guidelines have been released by the Agency that enables the use of remote inspections.

CCS provides classification services to ships, including statutory surveys, verification, certification and accreditation, and other services in accordance with the International Maritime Organization (IMO) rules and requirements and relevant regulations of the authorizing flag States or regions. Class services are provided to more than 32,000 international and domestic shipping ships and 2,600 ocean fishing vessels. Surveys utilizing RITs are mainly operational and not statutory. These techniques are applied on oil tankers, but not for hull survey, inspection, and cleaning. In 2018, the CCS released the "Guidelines for Use of Unmanned Aerial Vehicles for Surveys" (CCS, 2018) for ships and offshore installations following the relevant requirements of IACS Recommendation 42 titled "Guidelines for Use of Remote Inspection Techniques for surveys". Remote inspections by way of UAVs are to be carried out by professional organizations. The specified technical standards are relevant to safety, operational performance, endurance capacity, data transmission and communication, storage, airborne lighting, and airborne cameras. Provisions also exist for the collection and processing of visual data and data security.

Steel ships are built and surveyed following the Rules for Classification of Sea-going Steel Ships published by CSS (CCS, 2022). The updated version of the rules includes provisions for RIT utilized in (a) thickness measurements and close-up surveys—hull structures and (b) In-Water Survey (Table 1). For surveys conducted using RIT, one or more of the following means for access, acceptable to the Surveyor, is to be provided: (1) unmanned robot arm; (2) ROV (3) UAV/Drones; and (4) Other means acceptable to the Society.

2.6 *The Case of Singapore*

Singapore's maritime network is an amalgam of entrepreneurs, research and development institutions, classification societies, technology companies, and international partners. Over the last two decades, the MPA has developed the Maritime Innovation and Technology (MINT) Fund to expand its maritime innovation ecosystem. The Singapore Registry of Ships (SRS), with more than 4,400 vessels, aggregating over 96 million gross tons (GT), ranks fifth among the list of global fleets (MPA, n.d.b). The Merchant Shipping (Safety Convention) Regulations is the instrument for traditional surveys and certificates (Singapore Statutes Online, 2021). MPA has delegated the survey and certification of ships under the Singapore Registry of Ships (SRS) to eight (8) Recognized Organizations that are full members of the International Association of Classification Societies (IACS): ABS, BV, CCS, DNV, KR, LR, NK, and Rina.

Singapore advocates the usage of emerging technologies to improve the safety and efficiency of the maritime industry. Since 2018, Singapore has accepted the conduct of surveys on board Singapore Registered Ships via the use of RIT. Where permitted, RIT may be used to facilitate the required external and internal examinations. Before any inspection, the Flag State should proceed toward approval on a case-by-case basis. Shipping Circular No.13 of 2018 dated 23 Oct 2018 was promulgated to inform all stakeholders regarding approval aspects concerning RIT (Table 4, below). The RIT, to this end, may comprise the following:

- Unmanned Robotic Arm;
- ROV;

Table 4 MPA Circular No. 13 of 2018: Acceptance for the use of RIT for surveys

UAS	For periodical surveys using UAS, if the UAS is not operated by the RO itself, the company engaged to operate the UAS for the inspection is to be approved by the RO for carrying out such services in accordance to the RO's criteria for approving service providers. Inspections should be carried out in the presence of the Surveyor
Inspection Plan	An inspection plan for the use of remote inspection technique(s), including any confirmatory survey/close-up survey/thickness measurements, is to be submitted to the RO for review and acceptance in advance of the survey. The proposal for usage of UAS in periodical surveys is to be submitted by the RO to the Administration for acceptance
Acceptance	The results of the surveys by remote inspection techniques when being used towards the crediting of surveys are to be acceptable to the attending Surveyor. Confirmatory surveys/close-up surveys may be carried out by the Surveyor at selected locations to verify the results of the remote inspection technique, if required
Thickness Gauging	The acceptance of remote inspection techniques does not waive the requirement for thickness gauging where applicable. Thickness gauging by remote inspection techniques can be accepted subject to the same criteria of approval as applied to other Non-Destructive Test (NDT) techniques by the RO. Confirmatory thickness measurements on-site may be requested by the attending Surveyor, if required
Close-up Survey	Reference is made to the ESP Code Annex A (Bulk Carrier) and Annex B (Oil Tankers); "Close-up survey is a survey where the details of structural components are within the close visual inspection range of the surveyor, i.e., normally within reach of hand." In addition to requirements in paragraph 1 to 7 above, the usage of remote inspection techniques such as UAS can be accepted for close-up survey on ships subjected to the ESP Code, if the attending surveyor is satisfied that the information provided by the remote inspection technique, such as video footage from the UAS, is equivalent to a survey where the details of structural components are within the close visual inspection range of the surveyor

(continued)

Table 4 (continued)

Annex 1	Unless agreed by the Administration, the usage of remote inspection technique is not accepted or not to be continued for the specific location on the ship, at the following conditions: • Where there is existing record or indication of abnormal deterioration or damage to structure or to items to be inspected; • Where there are existing recommendations for repairs or conditions affecting the class of the vessel; • Where during the course of the inspection survey, defects were found such as damage or deterioration that requires attention. In such cases, the normal closeup survey/thickness measurement without the use of remote inspection technique is to be carried out to determine the scope of repairs required; and • Where the coating condition of the tank/hold is rated as less than "Good" by the Surveyor. This does not app apply to sections of cargo oil tanks that are not coated and stainless-steel cargo tanks

Source MPA (2018)

- Unmanned Aircraft System (UAS); and
- Other means acceptable to the Administration.

Remote surveys have been embraced by the sector for quite some time, but albeit still lack a standardized approach. Singapore seeks to address the lack of industry standardization and for this reason a Joint Industry Project (JIP) has been launched for the development of a Singapore standard in remote surveys, inspections, and audits.

In 2020 BV Singapore cooperated with PSA Marine to conduct the first remote survey for a harbor tug registered under the Singapore Registry of Ships. The tug underwent a fully accredited annual survey of the hull, machinery, load lines, safety, and telecommunications equipment using smart mobile devices and optimized live-streaming without the physical presence of a surveyor. During the Covid-19 pandemic outbreak, another joint remote inspection was conducted by BV, Nokia, and Sembcorp Marine. The inspection set the basis for establishing a new class procedure for the remote survey of vessels under construction that could optimally assess the integrity of the hull components efficiently.

The service providers that conduct hull inspection and surveys using RIT are authorized service providers under the respective RO. Relevantly, RO follows UR Z17 Rev14 CLN issued by IACS for the procedural requirements for approval and certification of service providers. RO, after being authorized by MPA to carry out statutory survey and certification, are required to ensure that the service providers meet the service standards. Respondents informed that disputes concerning liability between service provider and client should be settled through appropriate legal clauses in the service contract governing the unsatisfactory quality of service rendered on board.

Participants from the MPA informed that they anticipate the development of detailed guidelines from IACS on RIT, in particular, with reference to IACS Recommendation—REC 42 REV 2 CLN. Currently, they have noted a plethora of guidance and notes prepared by different classification societies, such as ABS, DNV, LR, and RINA. A comprehensive guidance from IACS, detailing the principles of usage, limitations, and procedures, according to the respondents, would be helpful for the flag administration and its stakeholders, such as ship owners/managers to assess the suitability of RIT deployment subject to specific conditions experienced by the ship. Subsequently, a global framework promulgated under the auspices of the IMO, as noted by the participants, would help achieve governance uniformity in the likelihood of RIT mass deployment by IMO member States.

3 Conclusions

The current study highlights that there are robust AI national plans in place by some of the major maritime nations. Those plans set specific targets for the ocean and maritime sectors. However, autonomous and semi-autonomous RIT platforms (e.g., drones, ROVs, and magnetic crawlers) have been used in the past by flag States only on a case-by-case basis.

As work continues to expand the usage of RIT, participants note the value of a "lawful system" that could serve as a tool to boost trustworthiness in RIT given that reliance on law is important to certain stakeholders involved in the RIT business model, such as policymakers and flag state officials that are not familiar with the system technicalities (Pastra et al., 2022). In parallel, IACS and IMO techno-regulatory instruments could be updated as well. Altogether, based on the responses provided by respondents, the following elements could be taken into account with a view to making the system "lawful":

- *Regulation*: IMO harmonized System aligned with IACS Unified Requirements;
- A separate *Codes of Conduct*: IACS rules and procedures;
- *Standardization*: ISO Standards or the IEEE P7000 standards series for maritime remote technology;
- *Certification*: Certificate standards for service providers and RITs operators;
- *National legislation for UAVs*: (a) for their operation in Visual Line of Sight (VLOS), Extended Visual Line of Sight (EVLOS), and Beyond Visual Line of Sight (BVLOS) and (b) the certification of operators;
- *Energy Efficiency*: While AI and new technologies, including RIT, introduce efficiency gains and offer many advantages in undertaking tasks that were previously done partly or fully manually, then it will introduce new energy demands which in turn could result in a negative impact on greenhouse gas emissions and the environment. Therefore, it is important that in parallel with the introduction of RIT that renewable and green energy forms are integrated into this process to best ensure a sustainable way forward. For example, underwater hull cleaning can result in a true win–win situation if using hull cleaning crawlers that are fueled by electricity that has been produced using solar or wind power, sustainable biofuels, or any other renewable energy forms. The same can be said for drones used for close-up inspections and thickness measurements.

In summary, flag States are, slowly but steadily, supporting and developing requirements for the use of RIT and are currently going through an experience-building phase. It could, therefore, be beneficial if the noteworthy developments and best practices could be consolidated and applied in the development of harmonized guidelines in order to establish a global level playing field that fosters investments in the technology. As RIT, generic emerging technologies, and technologies with emerging applications are becoming increasingly robust, the human element is still an important part that cannot be overlooked. This will have to be duly understood and reflected in all future work with regards to RIT (progressive autonomy) regulatory frameworks. The authors assert that further developments leading to the adoption of an international regulatory framework could certainly lead to an increased uptake in the use of RIT.

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CHAPTER 20

Towards an International Guideline for RIT End-Users: Spearing Through Vessel Inspection and Hull Cleaning Techno-Regulatory Elements

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1 Introduction: Setting the Scene

Over the last few years, discussions have taken place at various international fora in regards to RIT in performing inspections of steel structures on ships and floating offshore. Primarily, RIT represents systems based on machine learning that offer time-efficient and conceivably cost-effective

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alternatives to existing manual-driven survey and maintenance operations (Johansson, 2022). What is certain is that manual inspections could be replaced through the usage of UAVs, ROVs, magnetic crawlers, and any other technological apparatus approved by classification societies.

From a specific-functionality standpoint, UAVs are capable of performing general visual inspection (GVI), ultrasonic thickness measurement (UTM), and close-up surveys on ships requiring statutory and or classification surveys. On steel plates, magnetic crawlers could conduct UTM for scanning plates should there be restrictions to access a vessel's

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interior. Crawlers are also designed to perform hull cleaning. Finally, ROVs are tethered, maneuverable underwater robots that could perform tasks below water without the need for divers.

Noticeably, RIT have been approved by several flag State administrations on a case-by-case basis. National flag State authorities, classification societies, and ship owners are slowly but steadily adapting to RIT-based alternatives, especially during the COVID-19 pandemic that engendered special challenges and limitations of human-presence on board ships.

Currently, RIT mass deployment, should it continue to remain an international objective, calls for a holistic governance framework that could optimally dissipate fragmented methods and dissimilar procedural matters. In other words, the smooth integration of RIT alternatives for the conduct of dull, dirty, and risky tasks requires for the development and implementation of uniform international standards (Johansson, 2022). Targeting uniformity, generally speaking, means developing standards, policies, and guidelines that could stimulate innovation and safeguard people from risks emanating from automated technologies (Smuha, 2021). Given that the RIT governance framework is at nascent stages of development, the authors (of this chapter) assert that a blueprint covering all essential elements could help overcome regulatory barriers that may hinder RIT deployment resulting in a substantial and well-founded impact on the field.

Evidence-based research also indicates that efforts to maintain good environmental stewardship, principally at the EU level, will not only require seamless technical integration of RIT but also a guarantee that all techno-regulatory elements vital to semi-autonomous platforms are built into an international stand-alone *guideline for end-users* through international multi-stakeholder consultation. Ideally, all efforts should be aligned with the EU "Next Generation Digital Commission" of 2022, which aims at optimizing processes and automating workflows through the usage of digital technologies, products, and services with the view to increase productivity and digital sovereignty.

Against the foregoing, this chapter presents critical findings derived from project BUGWRIGHT2 which aspires to change the EU landscape of robotics for vessel structure-inspection and maintenance. The research-findings provide important insights into key elements that constitute a harmonized regulatory blueprint that could serve as a foundation for the anticipated international stand-alone *guideline for end-users*—bridging all potential gaps through cooperation-based strategic techno-regulatory governance founded on critical safety, security, quality, performance, and efficiency standards with regards to maritime semi-autonomous platforms.

2 Main Elements of a Regulatory Blueprint

At the outset, it is important to note that the threads of individual elements discussed below are tied to International Maritime Organization's (IMO) Strategic Directions (SDs):

- (SD 1) aiming at the efficient and consistent implementation and enforcement of the provisions of the IMO instruments;
- (SD 2) aiming at integrating and advancing technologies in the regulatory framework;
- (SD 3) intending to respond to climate change by reducing greenhouse emissions;
- (SD6) addressing human-element-related issues including consideration of new technologies and human-centered design; and
- (SD7) ensuring regulatory effectiveness in the development of advancing technologies (IMO, 2022, Resolution A.1149 (32)).

All elements have been carefully extracted based on the exposition of legal texts, international instruments, relevant scholarly literature, academic and professional journals containing legal opinions and expert commentaries, industry standards, procedures, requirements, and the likes. Expository research, i.e., an essential component of the doctrinal methodology, serves as the primary methodology employed in the research leading to this chapter. It is used to analyze the extant law (*de lege lata*) pointing out its drawbacks and deficiencies that has been thoroughly understood to determine what the law should be in the future (*de lege ferenda*). Needless to say, this approach highlights the continuum of past, present, and future in terms of the progress of the law.

2.1 Element 1: Compelling Evidence Redux

Effective and efficient environmental performance is the main principle that drives the world fleet's operation (Johansson, 2022). Observing increased fuel consumption and higher emissions emanating from the accumulation of harmful micro-organisms, the adverse effects of biofouling on ship performance and energy efficiency have been well documented (Adland et al., 2018; Coraddu et al., 2019; Deligiannis, 2017; McClay, 2015; Moser et al., 2016). The United Nations (UN) Climate Change Conference of the Parties (COP26) in Glasgow (2021) also stressed the need to mitigate biofouling build-up, which explicitly contributes to increased greenhouse gas emissions, together with technical and operational measures to reduce them. Therefore, niche sources and technological tools for environmental excellence and hull cleaning cannot be overlooked. It should be noted that IMO conventions are subject to continuous amendments. The introduction of risk assessment techniques, such as formal risk assessment or goal-based standards, paves the way for a new regime that might even embark on a decision to carry out surveys depending on risk profiles (Núñez, 2016). Secondary sources confirm that novel data detection methods, machine learning modeling techniques, and new technologies to diagnose hull and propeller fouling enable better asset management—giving the owners the means to predict hull condition and suggest the best time for hull maintenance work (Coraddu et al., 2019).

For vessel survey and inspection, including maintenance, stakeholders are currently focused on two technology-related aspects: RIT and remote survey. Inspection using RIT, for example, by default, requires physical verification through interaction with associated components. It goes without saying that the majority of vessel's class and statutory surveys require the physical attendance of class representatives. Remote verification, on the other hand, is an option that is exercised when physical attendance is not feasible or the extent of survey is deemed limited.

Published documents and online articles are a confirmation of the noteworthy shift towards technology-based alternatives due to their manifold advantages. For instance, it is noted in the document titled "Remote Technology Points to Cost Efficiency and Quality Gains" by Det Norske Veritas (DNV), AI-based alternatives are projected to save ship's operation time that makes up a significant portion of running costs (DNV, 2018). This is further validated by Bureau Veritas (BV) in an online article published in 2021 titled "Proving the Value of Remote Inspection Techniques" (BV, 2021). Patently, the outbreak of COVID-19 pandemic provided an impetus to test RIT. Nonetheless, the integration of RIT raises concern for the viability of common minimum standards developed by international organizations, especially when it comes to guaranteeing the same standard of safety and environmental protection, which is also related to liability.

Noteworthy are the "capex and opex" benefits that include: "reduced travel/accommodation costs; shorter response times; potentially quicker inspection and survey activities; greater scheduling flexibility; instant access to deep technical expertise; and less operational downtime" (Haukerud, 2020). In terms of the economical aspect—a cost–benefit analysis for an RIT-assisted survey was conducted by the members of the EU project titled ROBotics technology for INspection of Ships (ROBINS) (ROBINS, D 9.2, 2021). RIT-in-focus included UAV for close-up Inspection, magnetic crawler for thickness measurement, and ROV for close-up inspection/thickness measurement for hull inspection. The following costs were calculated in the analysis:

- Direct costs for the means of accessibility such as cherry pickers and temporary staging or portable ladders; and
- Indirect costs include (a) the improvements in the safety of the personnel in monetary terms (Probability of Fatal Accident, Probability of Non-Fatal accident, Compensation for Fatal Accident, and Compensation for Non-Fatal accident) and (b) the opportunity cost which is the time the ship stays idle (ROBINS, 2021).

According to the analysis developed solely for the market of large Bulk Carriers, a staggering €190 million could be saved by shifting to RIT-based alternatives (ROBINS, 2021). In sharp contrast, remote verification, dubbed as "remote survey", is contingent on information and communication technology (ICT) and has no direct correlation with costs.

Further research reveals that "remote survey" is, for the moment, associated with consideration of the following factors:

1. Instant accessibility and examination of the initial condition and assessment if physical attendance is required (or not);
2. Data record tracking and condition comparison with past maintenance records;
3. Sharing of data with multiple recipients and affected entities in real time;

4. Development of archives that maintain the data and can be used for research purposes (by shipyards, classification societies' technical teams, etc.), and
5. "Flag state acceptance" in case of statutory Surveys and that before any classification society can take a decision.

It is recalled that in shipping, the term "inspection" entails a plethora of dimensions. Some inspections are conducted for simple operational reasons, i.e., to improve the efficiency, while others bear a more commercial connotation, especially when it comes to chartering, insuring, or purchasing a ship.

Another important aspect concerns the understanding of "ship classification". In general terms, it is considered as being the development and worldwide implementation of a set of standard published rules and regulations that set and maintain quality and reliability. It is compliance with specific *class rules* that determine the class notation assigned to a ship and recorded in the register book. With that in mind, ***classification*** is a partnership between the flag state, class society, owner, and operator that collectively ensure the correct application of rules to endorse the:

- Structural strength of all essential parts of the hull and its appendages;
- Safety and reliability of the propulsion and steering systems; and
- Effectiveness of all features and auxiliary systems that have been built into the ship in order to establish and maintain basic conditions onboard, so that personnel and cargoes can be safely carried at all times.

To this end, class ensures that surveyors maintain the above through periodical visits to the ship with a view to carrying out corresponding periodical surveys to determine compliance with mandatory rules and regulations.

Relevantly, Enhanced Survey Programme (ESP) requires a close-up survey of defined structures in addition to an overall survey (see Fig. 1 below). It also requires an enhanced number of scantling thickness measurements. In order for these to be conducted properly, prior planning is in order so that tanks and holds are sufficiently clean with well-ventilated and suitable access arrangements provided. Considering the risk of entrance in confined spaces and the time required for those

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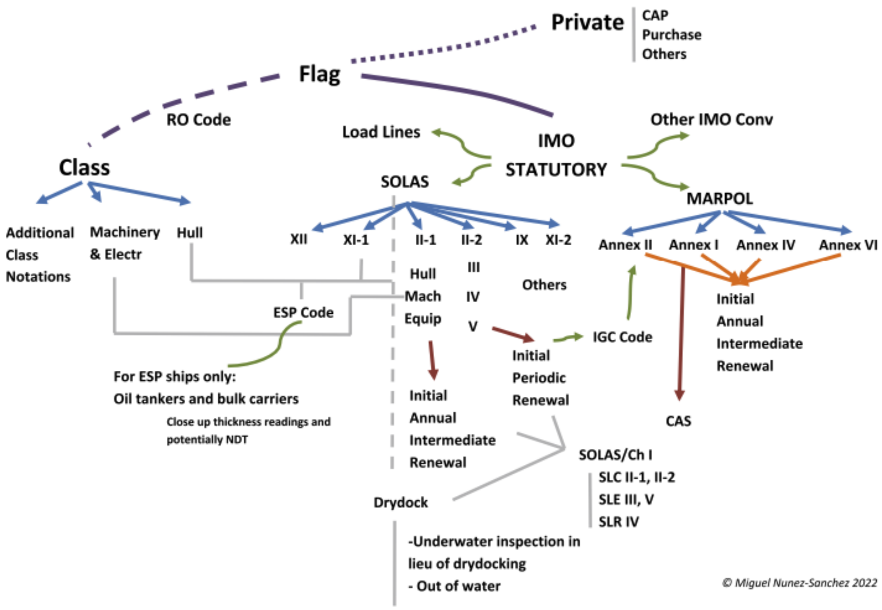

Fig. 1 Diagram synthesizing IMO's Statutory Survey Regime (*Source* Authors) *Note* **Remote Inspection Techniques** for underwater inspection, thickness readings, close-up and non-destructive testing with a need for planning, approval of service providers, validation, and certification; **Remote Surveys** with extreme due care or non-acceptance for structures with coating with a poor condition; and **Remote Survey Techniques** for all statutory and class inspections; and Remote Audit Techniques for verification audits

spaces to be effectively ventilated, as well as the associated costs, alternative methods of remote inspections are taken into account. Taking advantage of the digital tools and processes that are the byproducts of the fourth industrial revolution, DNV and other classification societies have incorporated drone surveys into class services. It should be underlined that drones used for these inspections are intrinsically safe for gas hazardous areas, and operated by trained surveyors. Drones are equipped with high-definition cameras and are able to provide high-resolution video and images even in the absence of light.

The biggest advantage of remote inspection using drones is the opportunity to carry inspection in real-time. The results are reviewed and recorded by the surveyors and vessel's representatives in a safe environment. Obviously, if the inspection reveals issues of concern, then there is a provision that enables surveyors to revert back to traditional physical inspection.

The statutory survey, if carried out by a class surveyor, is being conducted on behalf of the Flag Administration for the country with which the ship is registered. The class survey is carried out on behalf of the classification society itself.

The requirements of the statutory survey are governed by the flag administration and not classification society promulgated rules and requirements. As with statutory surveys, all associated services such as approval of intact and damage stability and approval of safety equipment arrangements offered by the classification society are conducted on behalf of the flag administration.

In most cases, the statutory instruments used for the survey of ships are based on the internationally adopted codes and conventions covering subjects such as safety construction, safety equipment, safety of navigation, pollution prevention, load line, and safety management. It is worth noting that even countries that have adopted international convention codes may, in addition, develop and implement respective national requirements that are commonly known as "flag requirements" (Fig. 1).

The practice of taking thickness readings in conjunction with close-up and hull inspection is delegated to companies authorized either by the Flag administration or the classification society in compliance with the International Association of Classification Societies' (IACS) unified requirement (UR) Z17. The surveyor progresses rapidly during the inspection and with results of the thickness readings reviewed only after a few hours—most likely on a daily basis. With regards to the underwater survey, the divers are normally on the spot and there is visual and audio communication with the surveyor that is on board, or in case of broadcasting in front of his computer, to certify the inspection of the underwater body in case the ship has not been drydocked.

2.2 Element 2: Uniform Definitions

The minimum standard definition of RIT has been specified in s. 1.1 of IACS Recommendation 42. Taking into consideration the evolving nature of innovation, the current types of RIT endorsed by IACS will inevitably branch out into other expeditious complex systems, making the development of unified definitions necessary for each and every type of technique that maneuver in different environments (Johansson, 2022). Table 1 (below) provides a summary of the definitions that currently exist and ones that could set the pragmatic basis for umbrella/uniform definitions for all future varieties.

Table 1 Summary of existing definitions relevant to RIT

Autonomy	***Ability to perform intended tasks based on current state and sensing, without human intervention (ISO 8373:2021)***
Robot	Programmed actuated mechanism with a degree of autonomy to perform locomotion, manipulation or positioning (ISO 8373:2021)
Operator	Person designated to start, monitor and stop the intended operation (ISO 8373:2021)
Validation	Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use have been fulfilled (ISO 8373:2021)
Verification	Confirmation by examination and provision of objective evidence that the requirements have been fulfilled (ISO 8373:2021)
Unmanned Aerial Vehicle (UAV)	An aircraft with no pilot on board that is controlled remotely or can fly autonomously based on a predefined flight route and/or using dynamic automation systems. The industry may refer to Unmanned Aerial Vehicles as "drones", Remotely Operated Aerial Vehicles (ROAVs), or Unmanned Aircraft Systems (UASs) (ABS, 2022)
Remotely Operated Underwater Vehicles (ROVs)	An ROV is an unmanned unit designed for underwater observation, survey, inspection, construction, intervention, or other tasks. Like UAVs, an ROV can be remotely controlled or programmed to travel a predetermined route using the information on a specific asset's condition to target known areas of concern. It can collect visual data, perform Nondestructive Testing (NDT), and measure plate thickness in difficult to-reach areas. (ABS, 2022)
Robotic crawler	A robotic crawler, commonly referred to as a "crawler", is a tethered or wireless vehicle designed to "crawl" along a structure using wheels or tracks. Crawlers are often equipped with magnets to operate on a vertical or inclined surface or hull structures in air or underwater (ABS, 2022)

Source ISO 8373:2021; ABS, 2022

2.3 Element 3: Remote Survey vs RIT

The main IMO Conventions such as International Convention for the Safety of Life at Sea, 1974, International Convention for the Prevention of Pollution from Ships (1973/1978) (MARPOL) and the International Convention on Load Lines, 1966 (CLL) do not deal with "remote survey" because, by default, surveyors should be physically present on board to carry out inspections. While this does not hinder resorting to "remote survey", however, there are legal aspects for consideration due to the fact the ship is certified by flag administration.

The role of recognized organization (RO) surveyors acting on behalf of flag administrations was befittingly reflected in the Protocol of 1988 relating to the International Convention for the Safety of Life at Sea, 1974, the Recognized Organization (RO). It is also stressed that the administration bears all responsibilities even when the work is delegated to a RO. Therefore, the concept of remote surveys could be extended to statutory surveys but it should, nevertheless, remain grounded within the IMO Conventions. Firstly, the use of low-level voluntary instruments, such as circulars with interim guidance might be extended to voluntary resolutions, and, at the latter stage, into mandatory ones once the system is in place and safeguards safety and environmental protection level remain the same. The above serves as important information in the context of "remote survey".

To ensure that all classification societies have uniform guidance on the concept of remote surveys, IACS developed UR Z29 titled "Remote Classification Surveys" (that will enter into force on 1 January 2023), which conceptualizes remote survey as a "process of verifying that a ship and its equipment are in compliance with the rules of the Classification Society where the verification is undertaken, or partially undertaken, without attendance on board by a surveyor" (IACS UR Z29, 2022). In short, and as briefly mentioned before, a "remote survey" denotes the survey conducted via the use of ICT, such as email and zoom, without the requirement of the physical presence of the surveyor. In the process, a remote survey should provide the same level of assurance as a survey with physical attendance on-board of a surveyor.

It is also important to bear in mind that certain audit activities, known as verifications, are carried out by the flag administrations or the RO acting on their behalf. These are mainly connected to safety aspects in relation to the ship and the company (document of compliance) under

SOLAS IX and the International Safety Management Code, and *security* aspects under SOLAS XI-2 and the International Ship and Port Facility Security Code, 2004 (ISPS Code). Since there exist several standards for remote audits—they could be also carried out for ships and companies, provided that risk assessments permit them. According to the authors, the same approach towards their introduction in SOLAS and MARPOL should prevail.

When the focus is on RIT, one could turn to s 1.1 of IACS Recommendation 42 that provides: "Remote inspection techniques may include the use of: Divers; Unmanned robot arm; Remote Operated Vehicles (ROV); Climbers; Drones; Other means acceptable to the Society". Section 1.2 further stipulates that external and internal examinations require the presence of a surveyor. In short, RIT could be identified as technologies that allow external and internal examinations through close-up surveys and thickness measurements (where applicable) without the need for direct physical access of the surveyor. Authors observe that currently, both RIT and "remote survey" are used interchangeably, although the former refers to robotic platforms, and the latter being survey via ICT, and as such does not entail mobile robotic platforms. Moving forward, researchers assert that the following points should be taken into account in all future discussions:

- The inherent differences between RIT and "remote survey" must be preserved so as to refrain from using the two terms synonymously. A way forward could be to develop separate all-embracing definitions on RIT, remote survey and remote audit (see Table 2 below);
- S. 1.2 of IACS Recommendation 42 should be revised and/or complemented with other IACS instruments so as to allow remote surveys using RIT to be conducted without the physical presence of the surveyor being mandatory, for classification purposes. The word "attending" should be omitted, and the word "may" be replaced with "should" so as to provide sufficient flexibility. Given that remote surveys could be surveys conducted using RIT, it is advised that RIT procedures concerning the engagement of surveyor be left open-ended; and
- Remote surveys and audits for IMO statutory certification, either total or partial also need to be agreed upon at the level of the IMO after careful consideration following a step approach (Table 2).

Table 2 Conceptualization of RIT, remote survey and remote audit

Remote Inspection Techniques (RIT) may include:	(i) The use of unmanned robot arm, remotely operated vehicles (ROVs), climbers, drones, or any other techniques acceptable to the Society (ref: IACS Recommendation 42, s. 1.1); (ii) The use of: Divers, Unmanned robot arm, Remote Operated Vehicles (ROV), climbers, drones, other ther means accepted. (ref: ABS, 2022); and (iii) Inspections performed using (a robust system governing the deployment of) techniques mentioned in (i) may be carried out in the presence of the Surveyor (ref: IACS Recommendation 42, s. 1.2)
Remote survey	A "Remote Survey" is a process of verifying that a ship and its equipment are in compliance with the rules of the Classification Society where the verification is undertaken, or partially undertaken, without attendance on board by a surveyor (ref: IACS UR Z29, s. 1.2.1)
Remote audit	"Remote Audit" means a process of systematic and independent verification without being physically present at the site of the audited party, and through the collection of objective evidence through available online tools, to determine whether the Safety Management System (SMS) complies with the requirements of the ISM Code and whether the SMS is implemented effectively to achieve the Code's objectives (modified with ref. to: s. 1.1.1 IACS, Procedural requirements for ISM Code Certification)

Source Adapted from ABS, 2022; IACS recommendation 42; IACS UR Z29 and IACS, Procedural requirements for ISM Code certification

2.4 Element 4: Operational and Technical Considerations Based on Variety

The operational and technical differences that stem from the different types of RIT should be considered when developing standards for these technologies. The objective here is twofold: (i) to set a framework for determining operational limitations; and (ii) as a minimum to get the same level of results that a physical inspection would provide. It is important to note that the American Bureau of Shipping (ABS) has identified different operational challenges for UAV, ROV, and robotic crawlers, which might serve as a model framework should discussions, at any time, lead towards the development of an international stand-alone *guideline for end-users*:

- **Pre-operations**: Items to be discussed during the short briefing session, such as, reviewing weather forecast (AUV), confirmation of enclosed space free of sediments (for ROVs), reviewing RIV maintenance records, reviewing emergency escape/evacuation plan, reviewing identified risks and associated mitigation, verifying the responsibilities of all personnel, assessing field conditions and amending operation plans as deemed fit, and confirming the work-scope of intended RIT operation, and as a part of job safety analysis on the date of the field operations, but prior to the; commencement of the RIV operations, inter alia (ref: ABS, 2022);
- **In-operation**: Items to be included by the service Supplier in the Standard Operation Procedure (SOP) for each RIV, e.g., check-list clearance, RIT Launch, and Recovery Zones, Communication, Documentation, Visual Line of Sight for UAVs, Deconfliction for UAVs, in the Standard operation Procedure by the Service Provider (ref: ABS, 2022); and
- **Post-operation** considerations including logging and maintenance (including launch time, operation duration, recovery time, and the type of work completed) (ref: ABS, 2022).

What is noteworthy is that there are various hazards associated with UAVs, magnetic crawlers, and ROVs that should be considered while expanding operational standards. ABS (2022) has categorized the risk areas as follows: explosion risks in hazardous areas, dropped object risks, Collision risks, Lost link risks, other risks consisting of high-risk working areas, risk associated with other parallel operations, and emergency situations. China Classification Society (CCS) has also specified technical standards for UAVs that touch upon safety performance, operation performance, enduring capacity, data transmission and communication, and data storage (CCS, 2018). The Risk Assessment Report, according to CCS, should be compliant with the ship's hazardous area plan and agreed upon by the shipowner/operator class society and service supplier prior to the commencement of inspection. A noteworthy technical issue (related to operation performance) that needs to be addressed is one that concerns "connectivity". RIT-based remote surveys require high-speed internet connection, which to date, remains a challenge on board vessels, especially in certain trading areas.

2.5 Element 5: Degree of Autonomy

The degree of autonomy is relevant to systems under progressive autonomy. The current technical system governing RIT, as of 2022, is not fully autonomous and requires intervention from the human element. The current stage of RIT is subject to "supervised autonomy" or "semi-autonomy" given that an operator is involved in operating the technology in question remotely. In order to keep track of progress (towards full autonomy) and in order to harmonize standards based on categories and types of RIT (followed by future amendments, if required)—the "degree of autonomy" or the "level of autonomy" for the current system should be conceptualized.

It is noted that RIT could be fully autonomous in the not-so-distant-future, and be able to function without human involvement. The "degree of autonomy" is a stress on carving out the level of the autonomous systems in a fashion similar to what has been done for maritime autonomous surface ships (MASS) (IMO Doc. MSC 100/20/Add. 1, Annex 2). Such categorization (Table 3 below) or assigning RIT to a certain "degree" could help keep track of the advancements towards full autonomy, thereby, assisting classification societies with future potential revisions (Johansson, 2022).

2.6 Element 6: Data Governance and Cyber Security

High-definition cameras, artificial lighting, high-precision sensors, and 3D scene reconstruction models are paramount to data quality. High-quality data plays an important role in detecting vessel's structural defects (Pastra et al., 2022). In digital data such as photos, live-stream, and recorded video, data are the predominant outcomes of conducting inspection using RIT. In this process, "metadata" could also be generated which includes time/date stamps, GPS location, camera orientation, focal length, shutter speed, aperture setting, ISO level, camera type, and lens type (ABS, 2022, 9).

Based on the different types of data generated, authors assert that a data governance framework could be developed to establish provisions and processes that could offer adequate and appropriate protection to data-assets as they are relayed between and among the different stakeholders (Al-Badi et al., 2018; Sarsfield, 2009).

Table 3 Categorization of RIT based on MASS degree of autonomy (hypothetical comparison)

Degree/Level of autonomy	*MASS*	*RIT*
First Degree	Ship with automated processes and decision support with seafarers on board to operate and control the systems. Systems are partially automated, unsupervised with seafarers on board ready to assume control	RIT-survey conducted in the presence of the attending surveyor. This degree aligns explicitly with IACS Recommendation 42 and IACS UR Z17
Second Degree	Remotely controlled ship with seafarers on board	Remote class survey with the possibility of surveyor to intervene, if necessary
Third Degree	Remotely controlled ships without seafarers on board	Remote class survey without attending surveyor
Fourth Degree	Fully autonomous ship	RIT with automated processes and Artificial Intelligence-based machine learning operating systems to support decision-making

Source Authors (with reference to IMO Doc. MSC 100/20/Add. 1, Annex 2)

Data governance has been conceptualized by the Data Management Association (DAMA) as "the allocation of authority and control and shared decision making over the management of data assets" (Earley et al., 2017). By way of explanation, data governance is related to decisions in regards to the allocation of responsibilities, access, control, and use of data, as opposed to data management, which is primarily linked to data collection and protection, as well as the implementation of governance-related decisions (Johansson et al., 2021).

Johansson et al. (2021) underscore that data quality, data ownership, preservation entity, security measures, sharing, data lifecycle, copyright, and data liability are the terms that should be included in the contract-form that is executed by ship owners, classification societies and service suppliers (Fig. 2 below). The roles and responsibilities concerning data ownership, quality, storage, security, and sharing of information currently remain uncatered for and requires an in-depth review of all private contracts developed by service suppliers. What is currently absent is a

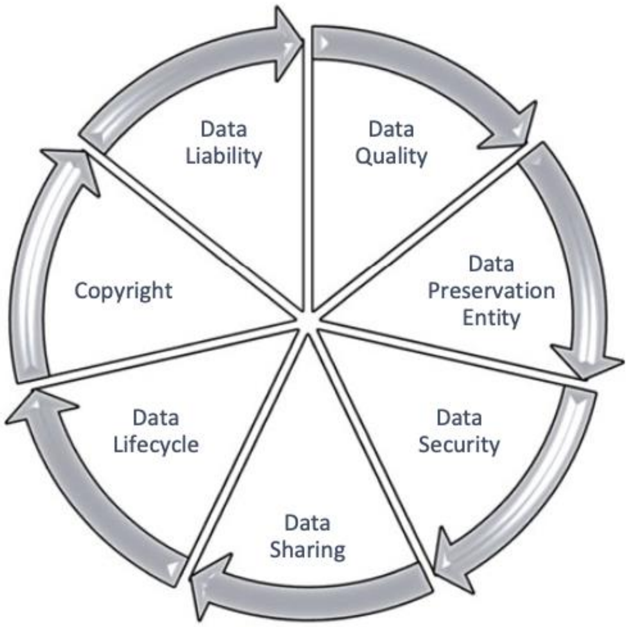

Fig. 2 Data elements to be included in the Contract between service suppliers, classification societies, and asset owners/operators (*Source* Johansson et al., 2021)

reliable instrument that ensures the long-term usability of data and metadata and protection from being misused by third parties (Johansson et al., 2021). Furthermore, the key parties in RIT inspection planning, operation, and reporting stages are advised to utilize a trusted data platform to safeguard the data generated through the systems. Data security and the effectiveness of data collection, data processing, and distribution of analysis outputs need to be demonstrated through further tastings and checks in order for RIT platforms to achieve trustworthiness among the stakeholders of the business model (Johansson et al., 2021; Pastra et al., 2022).

Additionally, data-sharing of confidential audio and visual information by remote means requires sufficient protection against cybersecurity threats. To avoid unforeseen challenges pertaining to non-personal asset-data, it is important to consider the above with reference to the following five concurrent functional elements that bolster support to effective cyber risk management:

- **Identify:** Define personnel roles and responsibilities for cyber risk management and identify the systems, assets, data, and capabilities that, when disrupted, pose risks to ship operations;
- **Protect:** Implement risk control processes and measures and contingency planning to protect against a cyber-event and ensure continuity of shipping operations;
- **Detect:** Develop and implement activities necessary to detect a cyber-event in a timely manner;
- **Respond**: Develop and implement activities and plans to provide resilience and to restore systems necessary for shipping operations or services impaired due to a cyber-event; and
- **Recover:** Identify measures to backup and restore cyber systems necessary for shipping operations impacted by a cyber event (IMO, 2017).

The same would also apply for the protection of the integrity of the data when surveys and audits are carried out via remote means with audio and video end-products. For instance, when SOLAS XI-2/ISPS security verifications are executed, there are documents, such as the ship or port security plan, which are confidential in nature. If those are discussed via video conference, the integrity of the ship or the port facility being audited or inspected may be compromised in the absence of stringent measures against cybersecurity threats. It should also be mentioned that IMO Resolution MSC.428(98) requires actions to ensure that safety management systems take into account cyber risk management in accordance with the objectives and functional requirements of the International Safety Management (ISM) Code, no later than the first annual verification of the company's "document of compliance" after 1 January 2021.

2.7 Element 7: Liability and Safety

There is also a crucial narrower focus: policymakers ought to shape the regulatory conditions having the best interest of end-users in mind so as to ensure accountability for software and product development. Product safety and product liability are two complementary mechanisms that ensure high levels of safety and minimal risk of harm to users. Robotics and Autonomous Systems (RAS), such as autonomous vessels, autonomous vehicles, or RIT, are merely "products". Defective products, incur liability, and ergo, the functional approach could be to apply a legal framework to govern the usage of products (Alexandropoulou et al., 2021).

Risks ranging from dropped objects, collision or lost link, and defective products, inter alia, make it more urgent to solve RIT-induced liability issues through existing regional or national policies, for example, the EU Product Liability Directive 85/374/EEC (EU Product Liability Directive, 1985; Johansson, 2022). RIT is operated using (battery-produced) "electricity"—that is viewed as a product pursuant to Article 2 of Directive 85/374/EEC (Johansson, 2022). Although this needs to be further substantiated, the preliminary connection is clear. According to Article 1 of the Directive, the producer shall be liable for damage caused by a defect in his product. Article 7 of the Directive gives resorts to the defense mechanism of manufacturers, stating that the producer shall not be liable as a result of this Directive if he is able to prove:

a) that he did not put the product into circulation; or
b) that, having regard to the circumstances, it is probable that the defect which caused the damage did not exist at the time when the product was put into circulation by him or that this defect came into being afterward; or
c) that the product was neither manufactured by him for sale or any form of distribution for economic purpose nor manufactured or distributed by him in the course of his business; or
d) that the defect is due to compliance of the product with mandatory regulations issued by the public authorities; or
e) that the state of scientific and technical knowledge at the time when he put the product into circulation was not such as to enable the existence of the defect to be discovered; or
f) in the case of a manufacturer of a component, that the defect is attributable to the design of the product in which the component has been fitted or to the instructions given by the manufacturer of the product (Directive 85/374/EEC).

The original equipment manufacturers (OEMs) of RIT could follow internationally agreed and accepted requirements for safe commercial operations, such as standards developed by the International Organization for Standardization (ISO). Whether a manufacturer is liable will depend on the circumstances and whether relevant international or industry product specification standards have been violated. During the design phase, manufacturers of RIT should exercise due diligence to ensure that connectivity will, under no circumstances, compromise safety (of the product) or data accuracy. In tandem, manufacturers should ensure transparency, accountability, and responsibility for all intelligent information systems that are developed. Certified products following international standards should be provided by manufacturers and subsequently, deployed by end-users. From an RIT perspective, service providers/suppliers should ensure prescribed equipment safety standards for hardware and software. All systems should be rated against the intended operational environment (intrinsically safe in hazardous areas, operational wind speed, etc.).

At this juncture, it is important to note that any progress in terms of "degree of autonomy" inevitably raises the question of who is responsible if RIT should violate a contractual obligation; therefore, clarity on responsibility in connection with the use of remote systems is a requisite. Clearly, embedded provisions in the contract should specify the liable party (manufactures, developer of the AI system, or pilot of the drone) in different scenarios when an RIT operated by a pilot, or fully autonomous RIT drops, crashes, and causes damage. The different scenarios include but are not limited to collisions with asset structures, collisions due to malfunction of the equipment, or unexpected or unforeseen incidents occurring in cases where visual line of sight (VLOS) is not maintained.

Regardless of how provisions on liability take shape in the long run, service suppliers should secure third-party public liability insurance and professional indemnity insurance for protection against legal liability for third-party property damage or injury while using RIT.

2.8 Element 8: Determine "Proof of Concept"

Improving technical reliability and confirming/determining the "proof of concept" of functionalities of the remote survey could be achieved after conducting more live experiments in a controlled environment. Classification societies, once RIT witnesses mass deployment, should ensure that these technologies are robust, and are able to accomplish quicker, safer, and more efficient ship inspections. In short, the validity of these systems will be concretely substantiated if technical robustness and data quality are demonstrated (Pastra et al., 2022). For the former, i.e., technical robustness, systems should function properly and be able to reproduce the verbatim results if the operation is repeated should that fall under the scope of "confirmatory survey" in the future, timeliness, completeness, and credibility (Johansson et al., 2021; Khatri & Brown, 2010). The final step could be to initiate validation of the final output through a series of tests on different types of vessels during close-up inspections and statutory surveys. The results should be compared and contrasted with data gathered through results gathered from physical surveys.

2.9 Element 9: Risk Assessment Framework for Determining the Feasibility of Remote Survey

A strategic risk assessment process could be adopted whereby a common risk assessment framework for the eligibility of remote survey should consider the following elements: the age of the vessel, port state control history, class history, hull condition, and severity of corrosion on hull structure, type of survey, areas to be inspected, ship location, environmental conditions in the area, approved service supplier and well-trained surveyors on remote technologies (Fig. 3 below).

The feasibility of carrying out statutory inspections with RIT should not only depend on ship parameters, e.g., age, historic records, and sister ships, but also on company aspects, e.g., records of deficiencies and trust between the company and administration. Considerations ought to go beyond legal risk parameters. In the case of statutory surveys, for example, there is a need to ensure that all is in good order conditions for carrying out a remote survey satisfactorily. In terms of complexity, stakeholders should be cognizant of whether any special planning is required bearing in mind the "special planning" prerequisites for special surveys with regard to oil tankers and bulk. The survey planning for the above takes into consideration how and where close-up inspections, together with thickness measurements will be carried out. The document is signed or accepted by the company so as to allow for the survey to start. When it comes to remote surveys, planning becomes even more critical because of the need to ensure that the results would be equivalent to the results obtained from manual/physical inspection. Failure to provide the desired quality would increase risks that will have a negative implication on costs.

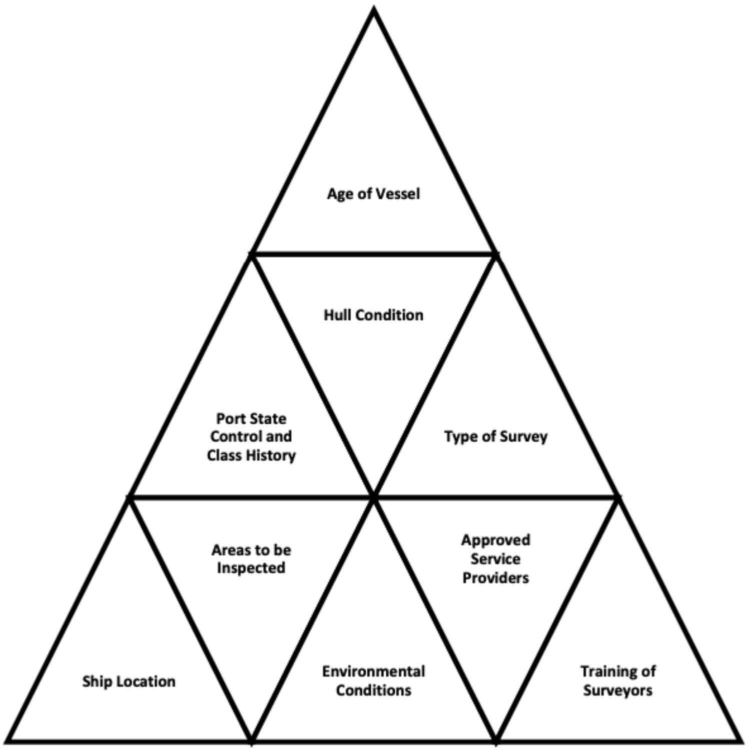

Fig. 3 Considerations when assessing the feasibility of the remote survey (*Source* Authors)

2.10 Element 10: Allocation of Responsibilities

Each party during the different stages of the remote inspection process (planning, operation, reporting) should have clear roles and responsibilities. For example, during the planning pre-inspection phase, the ship owner/operator must determine, in consultation with the class, if the use of RIT is appropriate, and if this is the case, then a recognized service supplier should be appointed (ABS, 2022). The supplier ought to develop the inspection plan that includes the different types of RIT to be used coupled with the results of the risk assessment, whereas the class should review the "survey planning document" provided by the ship operator and verify that the survey plan satisfies the applicable rules (ABS, 2022).

During the second stage of the inspection process, the service provider should conduct the inspection according to the "survey planning document", and the attending class surveyor must ensure that the RIT operation team conducts the survey according to the relevant requirements (ABS, 2022). In the reporting phase, the service provider shall send the report and data to the asset owner and class to assess if a physical or additional inspection is required (ABS, 2022).

3 Conclusions

RIT includes the possibility of effective examination of vessel structure without the need for direct physical access by the surveyor. Remote surveys may be applied to satisfy both statutory and classification requirements during normal situations and force majeure. Markedly, currently, other than procedural requirements stipulated by IACS, no specific international guidance covers the fundamentals of remote surveys/inspections, remote audits, and verifications.

IMO has recently embarked on the development of guidance for assessments and applications of remote surveys, ISM Code audits, and ISPS Code verifications, with 2024 as the target completion year. This may likely result in amendments to current instruments such as Survey Guidelines under the Harmonized System of Survey and Certification (HSSC), 2019 (Resolution A.1140(3)), or guidelines to other security-related instruments, where appropriate, with reference to IACS rules and requirements (ref: IACS Recommendation 42 and IACS UR Z29) to streamline the usage of remote inspection techniques. This would serve the purpose of establishing a strong foundation for moving forward with the conduct of remote surveys since RIT remain at the crux of all surveys conducted off-site.

It should also be noted that IACS UR Z29 on remote survey, which was issued in March 2022 and will be uniformly applied by IACS Societies for remote surveys commenced on or after January 1, 2023, could set the foundation for suitable procedures and instructions for RIT under the purview of its regulations. It is essential to proceed with a different mindset that could assist stakeholders to comprehend the topic, explore different ways to approach it, set a strategic basis for RIT, and finally, move forward towards class certification.

In parallel to the above, policymakers could consider developing and harmonizing existing flag state-initiated practices, given that all IMO rules and requirements concerning survey/inspection are aimed at flag States that can then delegate responsibilities to classification societies. Fragmentation in methodologies for remote surveys must be avoided at all costs. Uniformity contributes to certainty that in turn, is an acknowledgment that technology-policy interface developments are keeping pace with innovation.

The authors stress the need to assess the feasibility of remote surveys adopting a case-by-case approach. In that very process, it would be important to develop training and certification requirements for personnel involved in the conduct of remote surveys. The current IACS rules and requirements for RIT take into account the role of the attending surveyor, which is quite different from remote surveys given that the physical presence of the surveyor is not obligatory.

In conclusion, service robots pave the way for a service revolution that will dramatically improve customer experience, service quality, and productivity (Wirtz & Zeithaml, 2018). Within this context, responsible innovation practices and measures, call for strategic stakeholder engagement (Leenes et al., 2017). Through the process of testing, learning, and reflection, different stakeholder groups should join forces to fill the current vacuum (identified in this chapter) by drafting an international stand-alone *guideline for end-users*. Innovation cannot be contained. As it progresses, a guideline would certainly assist in governing niche incidental areas that could otherwise detract from unleashing the full potential of the byproducts generously bestowed by the fourth industrial revolution. The maritime and ocean community could certainly benefit from autonomy-renaissance. Much work lies ahead.

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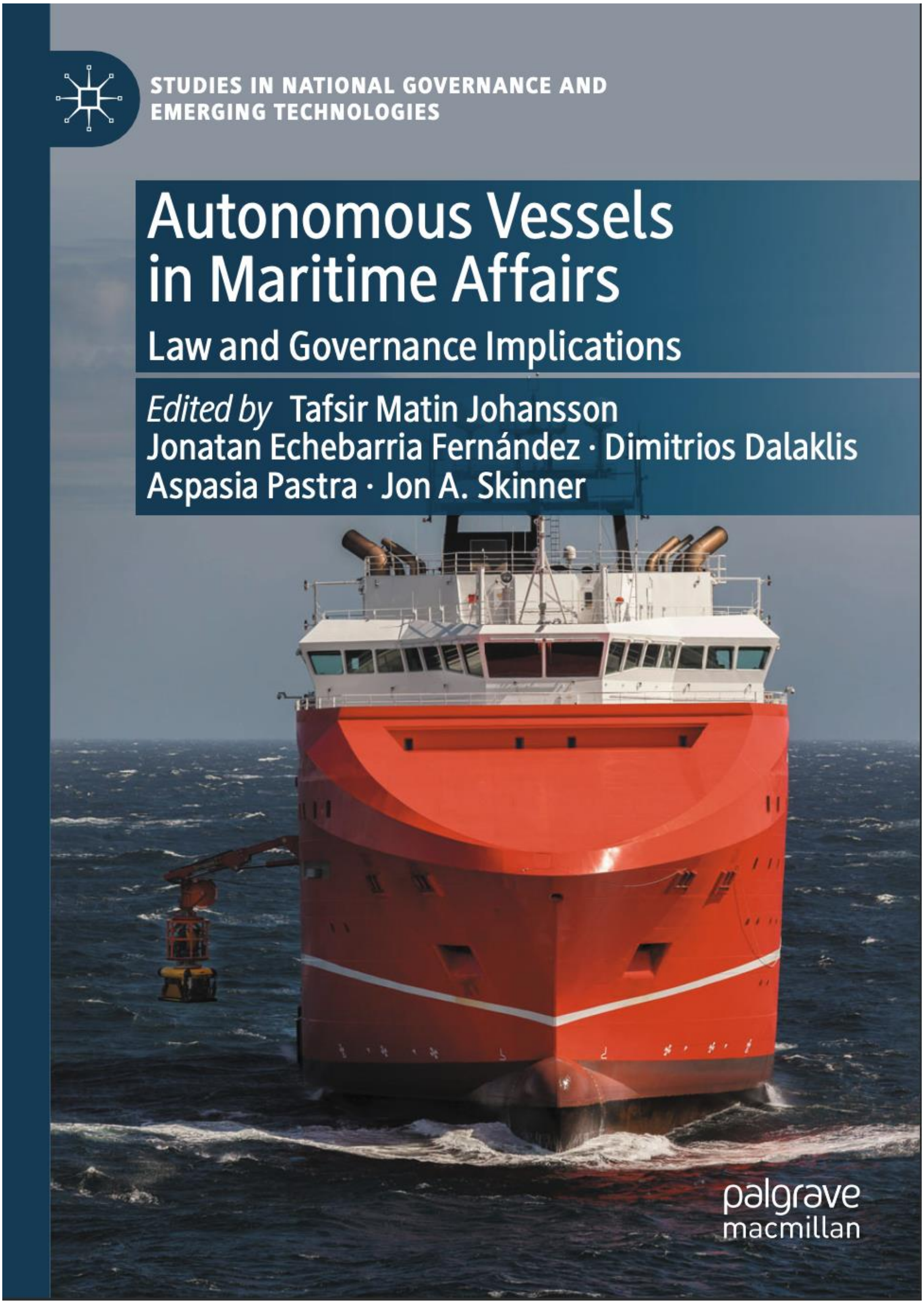
STUDIES IN NATIONAL GOVERNANCE AND EMERGING TECHNOLOGIES
Autonomous Vessels in Maritime Affairs
Law and Governance Implications
Edited by Tafsir Matin Johansson
Jonatan Echebarria Fernández · Dimitrios Dalaklis
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CHAPTER 1

Introduction to Autonomous Vessels in Maritime Affairs: Law & Governance Implications

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Technological innovation under the auspices of the fourth industrial revolution has catalysed the evolutionary growth of autonomous artefacts (Johansson, 2022). Cascade of transformations in science and technology

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has indeed positively influenced the transportation sector. We are turning to autonomous modes, i.e., increased reliance on artificial intelligence—a mere reflection of our intention to reach the plateau of accessibility, independence and dissipation of human error.

It is the presumption of the editors of this volume that all actors and stakeholders in the maritime and ocean domain are, to some extent or another, acquainted with the term "autonomous vessels". As such, the term itself needs no re-introduction. What needs emphasis however is how we define the term. During the initial literature review the editors delved into carving out a definition for "autonomous vessels". This review took into account both primary and secondary sources on law and governance, as well as legal doctrines (perceived as *scientia juris* or a "scientific discipline" during the Middle Ages, as in those times "authoritative interpretation", not empirical research, was the main criterion for the scientific status of a discipline). The word "vessel" was detached from "autonomous" and studied separately.

To develop an overarching definition of "vessel", heavy reliance was made on the United Nations Convention on the Law of the Sea, 1982 (UNCLOS), that applies to vessels or ships, as well as international instruments including International Regulations for Preventing Collisions at Sea, 1972, and International Convention on Salvage, 1989. The review emphasized the recurring discrepancies between definitions found in two or more international instruments. It is also observed that in the absence of a basic definition, authorities have proceeded to define the term "ship" or "vessel" in domestic legislation or policy. Ergo, without submitting to complex discussions on ship/vessel classification based on size and type, we therefore decided to keep the definition of "vessel" open-ended so

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as to allow authors to define or refer to appropriate sources, and align discussions of respective chapters with definitions as deemed fit.

Much can be said about "autonomy". We agree that it is a *prima facie* quintessential basis of legal, technical and ethical debates in this era of emerging technology, and its maturing applications. Specific to transport, especially maritime, "autonomy" is a prevalent topic that is discussed by international organizations, industry, manufacturers, academics as well as end users. "Autonomous" takes from the Greek word "autos" meaning "self", and "nomos" meaning "rule/regulation". Scholarly publications produced to-date generally only hint at the fact that autonomous vessels or autonomous ships, uncrewed vessels and unmanned ships as generic broad terms that refer to a watercraft piloted by self-regulating artificial intelligence. In common parlance, any object with the capacity of self-regulation is capable of interacting with the environment on its own and able to make decisions and steer itself through movements in any given environment. Whether or not "human-in-the-loop" or "human-on-the-loop" preserves or coexists with "autonomy" (the ability of self-governance)—is a matter subject to further debates and discussions, ideally, with reference to the four degrees of autonomy as found in the work of the International Maritime Organization's (IMO) Maritime Autonomous Surface Ships' (MASS) working group.

When observing numbers crunched by the United Nations Conference on Trade and Development (UNCTAD), we note that around 100,000 ships of more than 100 tonnes constitute the so-called global maritime shipping industry (UNCTAD, 2021). Execution of all operations in a just-in-time-fashion with optimum safety and environmental performance is the principal driver that drives the industry. Today, trial and error revolve around the objective of delivering to the global shipping industry autonomous vessels. In maritime, the notion of "autonomy" is said to revolutionize the industry and help reach that desired level of efficiency, while providing environment-friendly solutions.

Undoubtedly, autonomous vessels are the face of future shipping and ocean commerce. Machine-learning-based self-regulating control systems using sensor technology are maturing as we write. Parallel initiatives include regulating those areas through the development of governance schemes, standards and codes that will not only enable market growth, but also foster future innovation. The above initiatives have, in tandem, paved the way for academics to delve into research work to explore the legal and governance implications pertaining to vessel autonomy. As "automation" (derived from predetermined heuristics) in the maritime domain slowly progresses towards "autonomy" realized through design and concepts associated with MASS, there is a vital need to capture the grey areas of governance challenges and regulatory considerations. In other words, a study on MASS requires international actors to thoroughly revisit governance and policy implications with a state-of-the-art focus. This is because, at the heart of the transition-phase lies the need to ensure that ships continue to complete tasks while maintaining the tenets and international provisions critical to maritime safety, security and environmental protection. For a holistic insight into MASS—all important niche strands and key insights from multitude angles need to be extracted and critically assessed.

Key insights in this volume are spread across a number of chapters under six specific parts: setting the scene; naval warfare and security; safety, seaworthiness and techno-regulatory assessments; global environmental change; autonomous passenger transportation; liability and insurance; selected national and regional developments; and tying the threads.

Two papers authored by senior figures in the field of techno-regulatory governance open this volume on autonomous vessels. The second chapter, by Andrei Polejack provides new insights into the role of maritime technological innovation in a global context. By introducing the concept of "innovation diplomacy" to the maritime sector, that is, the intersection of technology development with international relations, the author presents timely examples of how a balance between cooperation and competition, as well as between national and global interests, can shape the decisions of the global maritime community with regards to trends in maritime technology (Polejack, 2023). By advocating that most of the technological innovation belongs to the Global North—the author presents new perspectives rooted in the disruptions that maritime technologies could have in the Global South (Polejack, 2023).

The Chapter 3, authored by Henrik Tunfors, is a detailed insight into the state-of-play concerning the endeavour to develop international legislation for MASS (Tunfors, 2023). It is difficult to perceive a book on "autonomous vessels" without a first-hand comprehension of the evolving landscape of MASS over the years. Stages of discussions are wrapped around the work conducted at various sessions (at IMO) starting in 2018 with MSC 99 (Tunfors, 2023). An important foundation to this volume, this chapter highlights key outputs and achievements, joint efforts and correspondences as well as a first-hand appreciation of what lies ahead (Tunfors, 2023).

After setting the scene, Part II picks up on a timely topic concerned with naval warfare and security. In Chapter 4, Raul Pedrozo discusses the rules applicable to the missions and tasks of autonomous and unmanned systems during both peace and war. The author confirms that unmanned surface vessels and unmanned underwater vehicles will operate in an autonomous or semi-autonomous mode and will transform maritime operations as we know them today (Pedrozo, 2023). These systems, according to the author, provide an ideal alternative to manned platforms for dull, dirty, and dangerous missions, all at a reduced cost and less risk to human life (Pedrozo, 2023). Therefore, their enhanced survivability and ability to remain on station in high threat environments will free up manned platforms for more vital missions (Pedrozo, 2023).

In Chapter 5, Anna Petrig considers unmanned ships as a game changer for the commission of crimes at sea due to the fact that they open new avenues to compromise maritime security while lowering the perpetrator's risk of being killed, injured, arrested, or even detected. According to the author, the use of unmanned ships for the commission of crimes at sea amounts to a watershed moment for maritime security law as its rules are firmly based on the assumption that perpetrators act from on board the offender ship, and that a human–human encounter between enforcers and suspects at sea takes place, with the possibility for direct interaction and communication as well as an exchange of physical documentation (Petrig, 2023). Against this backdrop, it is unsurprising that the absence of a crew on board offender ships queries the continued applicability and relevance of many—if not most—rules designed for the suppression of crime at sea (Petrig, 2023). The author submits that the need for regulatory steps is evident, formal amendment of relevant treaties—such as the UNCLOS, the United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, 1988, and the Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation, 1988 and 2005 respectively—seems out of sight (Petrig, 2023). In the author's opinion, rather than through an update of formal law, the turn to unmanned ships will more likely be accommodated through informal law—at least for the time being (Petrig, 2023).

Three distinct strands of discussions comprise Part III. This part covers three chapters on "safety and seaworthiness" authored by eminent scholars and practitioners. Chapter 6, by Mikis Tsimplis notes that an autonomous ship must be able to call for salvage assistance and deviate from the planned route in appropriate situations. The author observes that cargo interests are likely to object to contributing to a salvage reward if the need for assistance is created by a loss of communication with the autonomous ship instead of an actual danger (Tsimplis, 2023). States have a legal obligation to protect life that is at risk at sea. This duty is discharged by imposing a duty on the master of the ship to assist in collision cases as well as in general situations where human life is at risk (Tsimplis, 2023). The development of autonomous ships, according to the author, would necessitate transferring this obligation to its owner or operator or through the broadening of the legal definition of the master (Tsimplis, 2023). Agreeing on the exact requirements an autonomous ship should satisfy in order to be of use in search and rescue operations and to assist in a collision will facilitate the quick development of compliant autonomous ships (Tsimplis, 2023).

In Chapter 7, Vera Alexandropoulou and co-author Klimanthia Kontaxaki refer to "seaworthiness" as a variable and evolving concept, emanating from IMO instruments and generally accepted industry standards and practices at the relevant time. Authors note the safety concerns and seaworthiness challenges in relation to MASS in the shipping and port sector, and stress on the current calls for the design of a comprehensive safety regulatory framework and a safety management system (Alexandropoulou & Kontaxaki, 2023). Authors are of the opinion that such a novel system, if developed, should potentially integrate automation and digitalization in a befitting manner while relying on a holistic and risk-based approach that reflects all the "interoperation" and "interrelation" aspects and addresses major issues and concerns of the stakeholders involved in the maritime sector (Alexandropoulou & Kontaxaki, 2023).

Chapter 8, by Mika Viljanen asserts that MASS autonomous navigation systems are key drivers of MASS safety, and therefore, autonomous navigation systems should be targets for future regulatory interventions (Viljanen, 2023). The author holds the position that the technological nature of autonomous navigations systems will likely force regulators to adopt performance-regulation as their primary regulatory strategy (Viljanen, 2023). Simulation-based testing will likely be the only feasible approach to verifying MASS navigational safety (Viljanen, 2023). As such, the author projects that the future regulatory framework will be layered, consisting of navigational performance standards verified by simulations and real-world tests and limited technical standards for select equipment (Viljanen, 2023).

Part IV titled "global environmental change" contains a chapter of paramount importance considering complex human interactions and interferences within the global ecosystem. Chapter 9 authored by Sean Pribyl details and assesses autonomous vessels from a "global environmental change" standpoint. As Sean Pribyl demonstrates, the regulatory landscape governing marine autonomy remains unsettled and environmental compliance in the maritime space is becoming more complex (Pribyl, 2023). Financial institutions and shipowners continue to closely monitor emerging sustainability initiatives and seek incentives to meet decarbonization goals at the international and domestic levels. Consequently, according to the author, the maritime industry is experiencing a sea change in innovation as early movers and new entrants offer novel solutions to emerging operational, crewing and environmental risks (Pribyl, 2023). While the full reach of smart autonomy in marine operations is yet to be realized, new solutions and reliable legal frameworks are still evolving although proponents of autonomy support the position that autonomous shipping has clear environmental benefits as vessel owners and operators are seeking available technologies to meet goal-based measures on which to base their investments (Pribyl, 2023). To this end, the author draws reference to the United States (US) that offers several use cases that are spurring development in several important emerging areas that can support greater efficiency in marine operations as well as reductions in greenhouse gas emission monitoring (Pribyl, 2023).

As the title suggests, the two chapters contained in Part V delve into the extraordinarily complex domain of "autonomous passenger transportation". The author of Chapter 10, Øyvind Smogeli, proffers an incisive examination into regulatory dimensions designed to ensure safety as well as societal trustworthiness of new autonomous mobility modes. The author emphasizes that both European and international private and governmental entities have identified the need to transition to cleaner, smarter and eventually unmanned forms of transportation in inland waterways (Smogeli, 2023). The author highlights that despite recent regulatory developments at the international, regional and national levels—there remains no readily available path towards autonomous and unmanned operations (Smogeli, 2023). The author is of the view that projects with this ambition will, therefore, need to carve out the necessary measures to close any gaps through equivalent safety principles in close cooperation with regulators (Smogeli, 2023). To this end, a compelling commencing point (containing both commercial and regulatory threads) could be a network of small, electric urban passenger ferries operated at a given city centre with operations overseen by a safety operator in close proximity. The author also notes that building trust in such a system will require a fit-for-purpose assurance process focusing on the needs of an extended set of stakeholders and the construction of a systematic assurance case—providing evidence in support of technical safety, perceived safety, societal trustworthiness and sustainability (Smogeli, 2023).

Christoph Thieme, has co-authored Chapter 11 together with Marilia Ramos, Even Holte, Stig Johnsen, Thor Myklebust and Øyvind Smogeli. This pioneering piece presents findings from two major projects: Automated safety solutions for passenger ferries (AutoSafe) and Meaningful Human Control in autonomy/digitalization of safety critical systems (MAS). In this very chapter, authors grapple with regulatory challenges emanating from the design and operational aspects pertaining to remotely supervised and autonomous passenger ferries (Thieme et al., 2023). The authors present a high-quality academic paper based on the results of a "gap analysis" that assesses the planned design and operation against the current rules and regulations (Thieme et al., 2023). Based on this assessment, the authors outline procedural aspects that could potentially address those identified gaps. A relevant use-case (under development) for developing emergency procedures is presented and subsequently, analysed through a Concurrent Task Analysis (Thieme et al., 2023). The procedures above help to highlight information-needs and decision-points, which, according to the authors, must be made available in a meaningful manner for efficient supervisors on land (Thieme et al., 2023).

The next five chapters under Part VI cover erudite discussions on two interrelated topics, namely liability and insurance. The first of the five, i.e., Chapter 12, by Matti Eronen, focuses on coastal States' administrative concerns in a hypothetical new situation where automatization increases and the share of human labour consequently, decreases. Increased automation and the declining human factor, in the author's view, poses a number of challenges for coastal States (Eronen, 2023). Here, the author also underscores an existing drawback: indemnity questions have been studied in several presentations and articles whereby examinations only illuminate the shipowners' context with little to no focus on coastal authorities' liability (Eronen, 2023). Administrations can execute "control" and "safeguard" responsibilities when ships operate within merchant fairways—that is a given (Eronen, 2023). In light of the given, the author holds that as digitalization increases and ships shift towards autonomy, the legal thoughts surrounding those two responsibilities need re-examination (Eronen, 2023). To this end, the author brings to light specific coastal State concerns by highlighting the significant areas where efforts should be focused (Eronen, 2023).

In Chapter 13, i.e., the second chapter under the thematic strand of liability and insurance, Vibe Ulfbeck and Aslı Arda, examine vicarious liability for remotely controlled vessels. This examination is conducted from a twofold context: Scandinavian law and English law (Ulfbeck & Arda, 2023). The authors note that currently, the exact legal status of a shore-based controller (SBC) of a remotely controlled ship remains uncertain. Notwithstanding, the assessment of this status will have a significant bearing on the allocation of liability that may arise from the remotely controlled operation of a ship (Ulfbeck & Arda, 2023). Authors pose questions: will SBCs be considered employees or independent contractors? Or perhaps neither of the above? Through this intellectual piece, the authors propound that English and Scandinavian laws provide different approaches concerning the vicarious liability that may be imposed on the shipowners, and accordingly, the evaluation of the new legal status of the SBCs necessitates the comparison of the liability regimes adopted in these legal systems (Ulfbeck & Arda, 2023).

Proshanto Mukherjee explores the precarious legal position of SBC in Chapter 14. Here, the author focuses on the liability of the SBC and puts forward the view that in the event of a collision, the controller should be at the receiving end of sanctions, penal or civil, in no less a way than an on-board master would, in traditional shipping (Mukherjee, 2023). Maritime Safety Committee (MSC) and Legal Committee (LEG) documents indicate that the current international maritime legal regime will have to undergo significant changes to accommodate MASS and the position of the remote-control operator (Mukherjee, 2023). In the opinion of the author, regardless of how advanced MASS technology is, or is poised to be, traditional mariners and seafarers will suffer tremendously (Mukherjee, 2023). Only stakeholders in the wealthy world will be able to afford it (Mukherjee, 2023). The author is obviously concerned that what becomes of the majority of seafarers who hail from the developing world is a question mark (Mukherjee, 2023). Moreover, the author posits that SBC's will all become "techies" is an absurd proposition, and that the liability regime of MASS is as yet underdeveloped and therefore it is unlikely to become a universal practical reality anytime soon (Mukherjee, 2023).

Chapter 15 is the fourth chapter under this important strand that analyses civil liability for MASS through the prism of Bertolini's risk-based management approach. Anil Ozturk argues that existing legal mechanisms offered by private law systems cannot adequately address questions regarding civil liability for undesirable outcomes arising from independent activities of autonomous vessels (Ozturk, 2023). On the assumption that the primary function of existing legal mechanisms offered by private law systems is to resolve the conflicts between legally recognized interests of legal persons, the author suggests that these mechanisms were not developed with autonomous artificial agents (including MASS) in mind (Ozturk, 2023). These mechanisms, according to the author, cannot balance legally recognized interests in the manner intended since they do not recognize that autonomous artificial agents can make and execute decisions independently but have no individual interests to drive these independent decisions (Ozturk, 2023). There are some proposals advanced by various scholars, as well as some lawmaking bodies, to allow the law to accommodate the distinctive characteristics of autonomous artificial agents, including suggestions regarding new types of legal personhood and expansions to existing no-fault liability regimes (Ozturk, 2023). However, the author's evaluation leads to the proposition that even though these proposals give effect to the distinctive characteristics of autonomous artificial agents, and therefore MASS, most do not pay enough attention to maintaining the balance of interests foreseen by existing legal mechanisms (Ozturk, 2023). Ozturk shows that the exception to that general trend is the risk-management approach that suggests distributing civil liability for undesirable outcomes arising from autonomous artificial agents' independent activities based on who is best placed to manage the risk of such outcomes (Ozturk, 2023).

The final chapter under Part VI is authored by Manuel Varela Chouciño, Jonatan Echebarria Fernández and Johanna Hjalmarsson. Authors of Chapter 16 provide an intriguing detail of risk allocation, seaworthiness and technological challenges from the perspective of an underwriter (Chouciño et al., 2023). Authors stress that the "evolution" introduced by MASS in the shipping sector is not alien to existing marine insurance practices (Chouciño et al., 2023). As such, if developments in operational technology confirm the reduction of crew on board for MASS, the implied warranty of seaworthiness in respect of crewmembers may require an update (Chouciño et al., 2023). Authors stress that cyber risk management must be considered by marine underwriters as material information in relation to MASS insurance contracts (Chouciño et al., 2023). According to the authors, marine underwriters could rely on traditional insurance clauses to provide insurance cover for MASS; however, marine cyber-related events represent a new frontier which still requires further analysis by the market (Chouciño et al., 2023). In that continuum, the exercise of due diligence in respect of cyber security will be a crucial factor to consider in relation to marine insurance (Chouciño et al., 2023).

The chapters in Part VII of this volume are presented under the heading "Selected National and Regional Developments". In Chapter 17 Maria Katsivela offers a comparative overview of selected industry issues from a Canadian backdrop (Katsivela, 2023). At the outset, the author views MASS as an emerging reality in Canada and other major maritime nations (Katsivela, 2023). The author explains that frequently recurring issues constraining the development of MASS include: the need to further MASS through regulation, the absence of widespread use of these vessels by the domestic marine industry, and the need to develop supporting mechanisms/services in anticipation of their increased use in the future (Katsivela, 2023). Intensifying collective efforts in the process of developing and deploying MASS, strategizing through implementation of overarching regulations and policies, developing smart ports and other support mechanisms/services/platforms before MASS become an everyday reality are proposed ways forward according to the author (Katsivela, 2023).

In Chapter 18, Ørnulf Rødseth and distinguished co-authors Dag Atle Nesheim, Agathe Rialland and Even Holte touch upon societal impacts of MASS drawing reference to best practices and lessons learned from Norway while bearing in mind the critical global effects. In this chapter, authors take into account both qualitative and quantitative data when assessing the desired impacts. Authors argue that the concept of autonomous ships for most practical purposes can be bound by a clearer definition: "an uncrewed ship with advanced but limited automation and supervision and assistance from a remote control center" (Rødseth et al., 2023). The main societal impacts identified by the authors include, inter alia, improved working conditions and creation of new types of jobs, yet fewer jobs in most areas; reduced burden on society's infrastructure with less terminal space required, less truck transport; contributions to more resilient sea transport systems, improved mobility and more flexible sea transport; contributions to lower energy consumption, decarbonization and less harmful emissions; confirmed higher-level of safety at sea and better regulated shipping (Rødseth et al., 2023). The identified societal effects, according to the authors, are linked to the main attributes of autonomous ships as well as to the 2030 United Nations Sustainable Development Goals (Rødseth et al., 2023). According to the editors, exploring the above link through a visual is a unique contribution to academia that could serve as an important reference for both policy makers and academics. Another noteworthy contribution comes with reference to examples of key performance indicators (KPI) that have the potential to quantitatively measure some of the effects in the selected area (Rødseth et al., 2023).

Chapter 19, by Annie Brett provides an overview of the US regulatory perspectives on maritime autonomy. According to the author, autonomous vessels are being widely used in the US by a variety of different actors, from commercial maritime industries to scientists to the US military (Brett, 2023). The author notes that the US has begun scoping for the initial regulation of commercial autonomous vessels, a process that will take several years before final rules are in place (Brett, 2023). Regulation of other types of autonomy in the US, for instance the Federal Aviation Administration's rules for aerial drones, in the view of the author, could provide important lessons for the Coast Guard's regulation of autonomous vessels (Brett, 2023). Relevantly, the author highlights that most regulatory attention in the US has been focused on how autonomous vessel use can be harmonized with existing maritime regulations, a process that will require amending existing laws, particularly in safety areas (Brett, 2023). Squarely, the author suggests that the Coast Guard and other regulators should also ensure that broader impacts of autonomous vessels, including novel and non-commercial uses, workplace changes and environmental consequences, are also included in future regulatory frameworks for autonomous vessels (Brett, 2023).

Finally, Paul Topping ties in Chapter 20 of Part VIII all important threads discussed by authors of this volume. In other words, this final chapter brings together the many pieces that need to be in place, including technology, technological progress, societal trust and law (Topping, 2023). Through a careful assessment Paul Topping illuminates a range of strategic approaches while weighing both sides of the coin (Topping, 2023). Among Paul Topping's multifaceted expert insights remains his recognition for considering the cost and economic side of things (Topping, 2023). We concur that without a concrete proposal demonstrating how MASS will help generate a reasonable return on investment within the short-term period—there is indeed a possibility that ship owners will remain discouraged from investing in autonomous ships (Topping, 2023). One final observation made by the author that captures the main essence of this volume: “As we move forward in time, one wonders if people in the later future may see some of today’s industry and regulatory responses as either prudent approaches or another kind of rule to carry a red flag”. Self-explanatory from the sub-title of this book, authors have made an endeavour to shed light on that very aspect by navigating through the complex landscape of “law and governance implications”.

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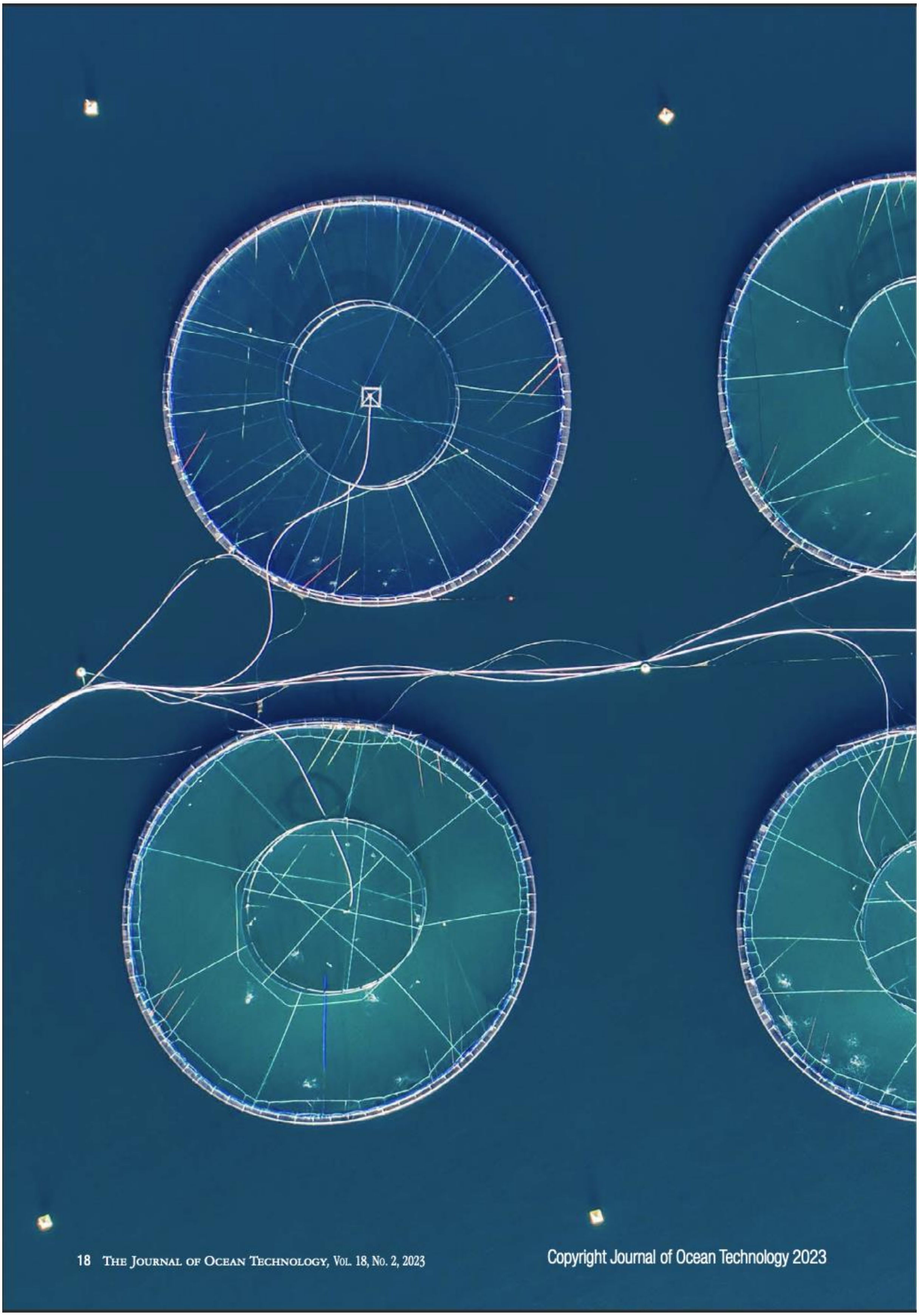
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Innovation helps transcend human-centric boundaries. Its applied form found in a gamut of technologies are sound alternatives (to the human element) only if there is compliance with umbrella standards. Regulatory standards cannot be abrogated. When enforced through a top-down approach, regulatory standards do not limit the potential of technologies; rather, they help avoid major bottlenecks and complex challenges that may stall progressive development of a certain branch of technology. Technological applications involving the use of robotics – whether ocean observation, vessel inspection, or aquaculture survey – are still young. New and hybrid technologies in this era, often termed as Industry 4.0, will reshape special sectors that support fundamental benefits derived from marine ecosystem services. Drawing on critical findings from the European Horizon 2020 BUGWRIGHT2 project, this essay documents a sequence of important strands of influence for consideration so that remote inspection techniques could be effectively and efficiently integrated into aquaculture and its current manual driven survey and monitoring framework.

Historically, the fishery and associated activities are moored to the notion of food security. Evidently, continuing in this anthropocenic epoch, fishery remains an acknowledged source of nutrition and is supporting the livelihood of more than three billion people globally. The estimates provided by the United Nations Food and Agriculture Organization (FAO) adds credence to the above claim. Numbers crunched by FAO researchers note that fisheries and aquaculture production have already reached a record peak of 214 million tonnes in the year 2020 with a total of 20.2 kilogram per capita designated for human consumption. Unfortunately, fishery resources are plummeting. Recognizing the invaluable potentials of aquaculture to the staggeringly increasing population of the world, invested efforts seek to achieve sustainability in the fisheries domain.

At the outset, we note that innovation and sustainable fisheries are conjoined concepts. A cascade of technological breakthroughs under the auspices of the fourth industrial revolution (Industry 4.0) has catalyzed a paradigm shift in maritime and ocean operations. Innovation bolsters support in sustainable movements and approaches – a concept that applies to natural resources.

Labelled as robotics and autonomous systems (RAS), a conflux of disruptive technologies, such as micro aerial vehicles, crawlers, and remotely operated vehicles (ROVs), has added meaning to the abstract concept of sustainability. Central in this innovation-led environment is the intention to sustain the ability of the human element. In other words, integrating RAS and machine learning systems helps complete monitoring and inspection tasks that are otherwise dull, risky, and at times strenuous in nature.

Observably, a plethora of challenges are associated with manual inspection, especially when it comes to underwater monitoring that entails inspecting water salinity, temperature, and/or potential of hydrogen (pH) level, as well as oversight in feeding and breeding tasks. Moreover, real-time observation is required to contain corollary effects from untreated effluent discharges with heavy organic load and fish farming infrastructure development. Patently, qualitative assessments indicate that net/fish cages are prone to biofouling and other sources of stress caused by waterbody movements that could potentially lead to net/fish cage deformation. These are instances where RAS integration could act as an improved and perhaps safer method of completing the necessary monitoring and inspection tasks (Figure 1). The industry, as it appears, is slowly turning to service suppliers that are unleashing intervention tools replacing divers with the simultaneous objective of saving time and money, and mitigating environmental concerns.

It is correct to assume that the world of technology is standard reliant. The technology industry, similar to its counterparts, is

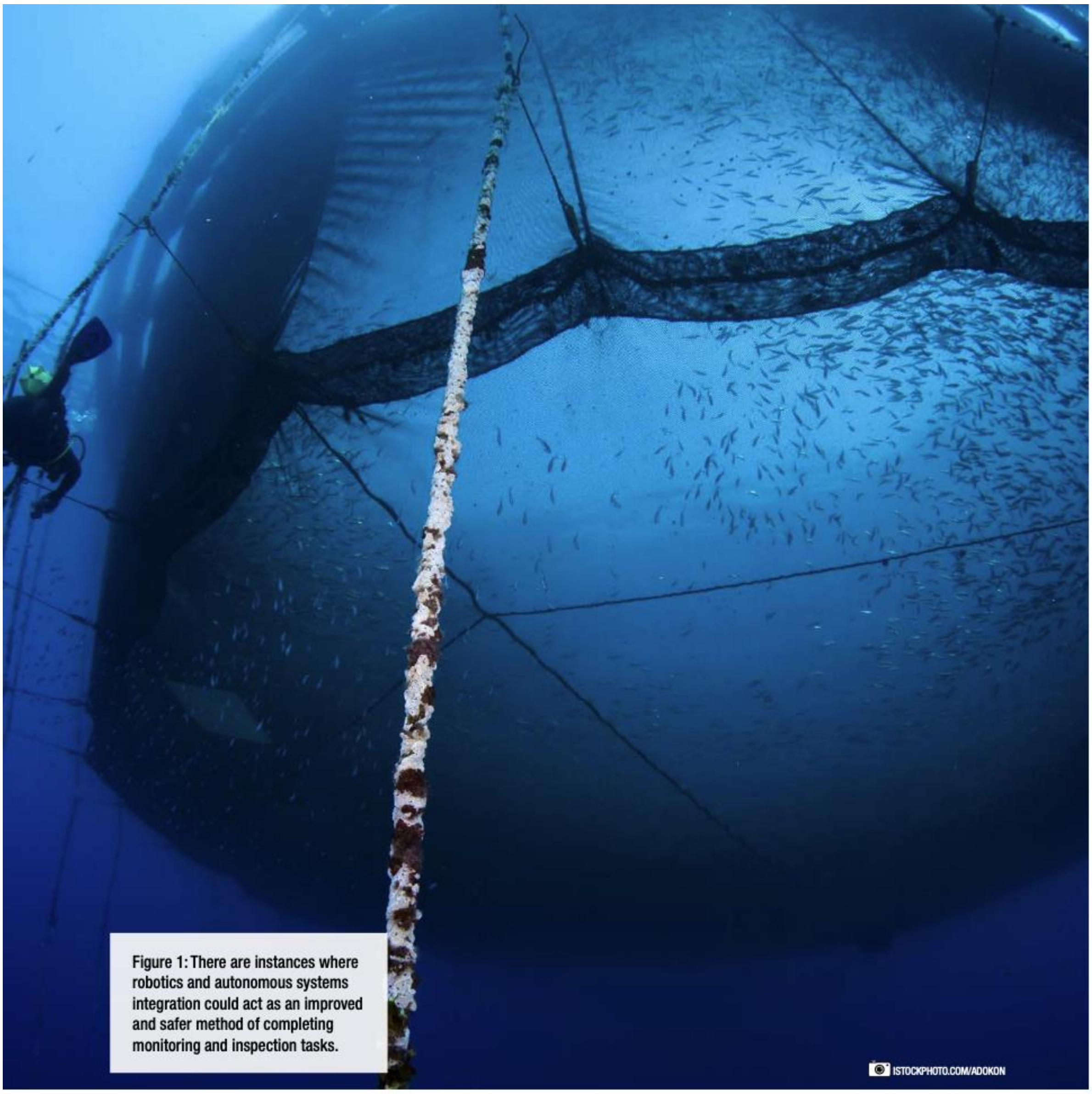


Figure 1: There are instances where robotics and autonomous systems integration could act as an improved and safer method of completing monitoring and inspection tasks.

assessed based on performance built on safety and risk management systems, among other things. Today, safety and management systems are being integrated into standards. Systems and standards are collectively intertwined into a horizontal topic that necessitates the interaction between public and non-public norms. Private and industry developed standards, as well as corresponding norms and guidelines, serve as external sources of the wider regulatory regime. Adherence and compliance are critical to the economic value of those industries, while safeguarding public interests. The latter is deemed as one of the principal mandates of governmental bodies that encourage regulators to orchestrate the use of industrial standards. This is done with a view to striking a balance between "hard" and "soft" elements embedded in the subject specific regulatory regime. Taking advantage of industry-based standards can help national regulators maintain a robust regulatory regime and navigate in a complex landscape shared with other stakeholders to keep pace in a changing technological environment.

Markedly, there is no international regulatory guidance that underscores the "dos" from the "don'ts" with reference to aquaculture related underwater inspection and monitoring tasks. Notably, the 2018 FAO publication titled Guidance on Spatial Technologies for Disaster Risk Management in Aquaculture only proffers insights into opportunities from spatial technologies including remote sensing, geographical information system, and information and communication technologies while highlighting the need for policy support. Inspection and monitoring technologies remain outside the scope of the 2018 publication.

Deficits are conspicuous when deploying remote inspection techniques. Other than issues emanating from latent defects, usage of emerging technologies or technologies with emerging applications may sporadically give rise to collateral problems that require more than just rebooting the system to eradicate technical errors. In fact, one is faced with challenges for reconciling the tensions between human and robots simply because the techno-regulatory landscape is not fully autonomous despite autonomy being a term that is in common parlance. We notice a system that is marked by "human-in-the-loop" or "human-on-the-loop."

In the context of human-robot interaction, BUGWRIGHT2: Autonomous Robotic Inspection and Maintenance on Ship Hulls and Storage Tanks (funded by the European Union's Horizon 2020 research and innovation program under grant agreement No. 871260) is a project that deals with remote technologies applied in vessel hull inspection and maintenance that are statutory and classification in scope. Notably, project BUGWRIGHT2 has proceeded with the objective to bridge the gaps between current and desired potentials of selected remote technologies that are also deployed in aquaculture inspection and monitoring.

Three years into the project's life cycle, academic partner World Maritime University has produced a state-of-the-art regulatory blueprint comprised of several strands of influence. Founded on state-of-the-art qualitative analysis and 33 interviews with organization representatives from the United States, Canada, China, Singapore, Netherlands, and Norway, the final outcome could serve as a tangible reference once dialogue and discussions commence at the International Maritime Organization (IMO) level pursuant to previous requests tabled by member states (MS) for amendments to the Harmonized System of Survey and Certification and to the Revised Guidelines on the implementation of selected IMO instruments.

It is important to note that BUGWRIGHT2 regulatory blueprint mirrors the need for "harmonization" of international rules and requirements that come into play taking into account the 1982 United Nations Convention on the Law of the Sea's rule of reference through which MS could implement generally accepted international rules and standards. Cutting a long way short, "harmonization" requires the existence of several parallel stand-alone rules and requirements developed by individual international organizations. Unfortunately, the aquaculture domain, apparently, lacks common minimum standards developed by a specific mandated organization unlike the vessel survey and inspection regime where classification societies are seen as playing a proactive role. A brief overview of standards developed by the International Organization for Standardization (ISO) seems to indicate that ISO/TC 34, ISO/TC 94, and ISO/TC 207 do not necessarily provide insights into procedures for technology integration.

What are the noteworthy takeaways from BUGWRIGHT2 that could be applied to aquaculture technology? The starting point could be that the existing vacuum of procedural requirements should be viewed with a positive outlook since stakeholders have the opportunity to reap the benefits of lessons learned from trial and errors from other sectors; move forward in unison from the start which would inevitably preclude the need for complex bureaucratic harmonization process (due to efforts being duplicated) in the long run; and establish a top-down platform comprised of organizations/ actors that could collectively reform/amend standards at any given stage. Opportunities are many. That being said, top-down efforts need to concentrate on determining the breadth and scope of specific provisions that could altogether serve as the main frame of reference.

When dissecting two primary regulatory standards, case in point the 1996 *Guidelines for Use of Remote Inspection Techniques for Surveys* and Unified Requirement Z17 titled *Procedural Requirements for Service Suppliers*, developed by the International Association of Classification Societies, we note elements for a common minimum standard blueprint. The above documents prescribe the types of permissible technologies and areas of application (under the heading titled *general*); specific conditions for technology deployment (under the heading titled *condition*); procedures concerning niche applications (under the heading titled *procedures*); and procedures related to the work of the human element/service suppliers and the service firm that is approved by the main company (under the heading titled *procedural requirements for service suppliers*).

Subsequently, we turn to the BUGWRIGHT2 strands of influence to take stock of the dispensable elements that require consideration for transition from manual to technology-based solutions, which would ameliorate and expedite technology integration into aquaculture inspection and monitoring activities. Axiomatically, the first of these strands call for research into cost-benefit assessments to observe whether the advantages of technology deployment outweigh the disadvantages, taking into account, e.g., duration of inspection, costs of deploying technology, and operational downtime. Such assessment could help companies determine the economic feasibility of turning to remote inspection techniques and rationalized through evidence-based research.

The second strand considers the need for vetted, refined, and up-to-date definitions on each and every type of remote techniques. In tandem, there needs to be in place definitions of important terms, such as autonomy, robot, service robot, and mobile robot. Template definitions exist. Examples are ripe in documents such as ISO 8373:2021; ISO 19649: 2017; ISO/IEC 17000 (2020); *Guidance Notes on the Use of Remote Inspection developed by the American Bureau of Shipping*; and *Guidelines for Use of Unmanned Aerial Vehicles developed by the China Classification Society*. Whether template definitions are adapted or whether a completely new set of definitions are developed, it is important to benchmark the term autonomy through a clear and distinct overarching definition. Closely connected to this aspect is a strand that calls for the need to follow the degree of autonomy thread that currently guides the state of affairs for maritime autonomous surface ships (Table 1).

Identifying levels of autonomy and associating them with different classes of techniques could help keep track of the autonomy-paradigm trajectory. Again, the current system is not fully autonomous (i.e., systems that enable machines to interact with the environment (through built-in sensors) and respond/take decisions accordingly), and requires categorization so as to help review the extent of involvement of the human element. This, in turn, has an explicit nexus to what is known as a well-calibrated trustworthy ecosystem that requires a form of constructive balance between the human agency and autonomous modes. Until the human stays "in-the-loop" or "on-the-loop," carving out the degrees of autonomy is a vital stepping stone to ascertaining, projecting, and designing effective and efficient human-robot teams for the conduct of survey and inspection. The next strand that would apply to the aquaculture profile is the need to carve out

Table 1: Potential remote inspection techniques (RIT) degree of autonomy. Source: Adapted from IMO Doc. MSC 100/20/ Add. 1, Annex 2

Degree	Maritime Autonomous Surface Ships Definition	Potential Aquaculture Remote Inspection Techniques Definition
First Degree	Ship with automated processes and decision support with seafarers on board to operate and control the systems. Systems are partially automated, unsupervised with seafarers on board ready to assume control.	Underwater survey with divers operating remote inspection techniques that are semi-autonomous and semi-supervised and could at any point witness intervention from surveyor/diver.
Second Degree	Remotely controlled ship with seafarers on board.	Underwater survey with divers. Survey controlled from a different location. Survey could at any point witness intervention from attending surveyor/diver.
Third Degree	Remotely controlled ships without seafarers on board.	Underwater survey without divers. Survey fully controlled from a different location.
Fourth Degree	Fully autonomous ship.	Remote inspection techniques with automated processes and artificial intelligence-based machine learning operating systems to support decision-making. No intervention required from the human element.

operational and technical common minimum standards. Generally speaking, operational standards emanate from tests and risk assessments that help narrow down all potential risks associated with the deployment of each and individual categories of technologies. Risk information is relayed (by manufacturers) via product information notes for consideration by end users or service suppliers. Different remote inspection techniques are marked by operational and technical differences. It is worth noting that surveys using aerial drones, unlike crawler and ROVs, can easily be compromised due to humidity, lighting, and air turbulence. Furthermore, hybrid techniques that have the potential to conduct underwater biofouling cleaning, in addition to survey operations, require limiting all possible risks prior to deployment.

Risks on air or underwater tend to range from dropped object risks to collision risks (with other remote inspection technologies) to lost link risks (that originate from network compromise), which could be an issue once technologies reach the fourth degree, i.e., full autonomy. “Stealth technology” is a term often ascribed to autonomous underwater vehicles and the likes, and therefore, completion of tasks without disturbing underwater ecosystems is highly anticipated. Contingency plans will, nevertheless, need to be developed taking into account operational standards so that solutions could be forged before the occurrence of environmental damages.

Another important strand of influence corresponds to a feature innate to technological devices applied in observational work and is aptly known as data management. Generally speaking, data acquisition lies at the heart of all technological interventions. Stakeholders involved in this process generally include non-human actors, e.g., technological tools and infrastructure, and human actors, i.e., service providers and companies (end users). The latter is coined as “human-in-the-loop” with supervisors, operators, and surveyors remaining engaged during data storage and verification of data collected through remote inspection technique-based inspections and surveys. In essence, the technological platform communicates data to “human-in-the-loop” via five independent layers: hardware, network, internet, infrastructure, and application. The last layer, i.e., application, mirrors implementation of decision.

Although the BUGWRIGHT2 regulatory model considers survey and inspection data as belonging to the asset, i.e., the ship, thus forming a part of the owner’s proprietary rights, this very theory on ownership might not apply verbatim in the field of aquaculture. Notwithstanding, the following questions may still be subject to further consideration from an aquaculture perspective:

- Who should retain the copyright of data gathered from underwater remote technologies?
- What are the secured ways through which data could be shared between end users and stakeholders?
- To what extent do provisions on data control and security apply in the field of aquaculture survey and inspection?
- What is the duration of data preservation, and should there be any mechanisms to safeguard service providers against third-party liability?

The final strand is tied to a critical aspect: in-water environmental consideration. Depending on the location of aquaculture method and practice (freshwater, brackish water, and marine), risk assessments will need to be conducted at regular intervals to check for impacts and water conditions, especially if hybrid remote techniques will be used to clean pen nets and cages. This begs the question whether those techniques are properly equipped with storage systems for storing debris collected during clean-up operations. In this regard, the Baltic and International Maritime Council developed standards for in-water cleaning that could serve as a foundation for furthering control over impact of technology in-water. Although developed for in-water cleaning of a vessel's hull and other niche areas, the ROV cleaning standards encapsulated in the section titled "operating requirements of the cleaning system" contains an important checklist comprised of post-cleaning inspections (s. 9.3), post-cleaning safety and environmental requirements (s. 9.4), and service reports after cleaning (s. 9.5) that serve as model provisions for consideration by the industry. The checklist may very well be pertinent to remote inspection technique-based operations underwater.

At this juncture, it is essential to ask one final question: why are the strands of influence discussed relevant? Technology is a terraforming practice – one that could possibly shape and structure the environment. Yet technology, in parallel, is merely a product. Products can be defective. Defective products could give rise to unforeseen circumstances. Those are the circumstances that might inhibit end users from untethering the full potentials of Industry 4.0 byproducts that are able to add strength in projects that purport to support sustainable actions. Standards embedded in previous discussions are strands that could positively influence technology deployment in maritime projects. Strands such as liability and in-water environmental damage will certainly have a bearing on the technologies that will be deployed in aquaculture so that companies may derive good results from automated farming practices.

Fragmentation must be avoided should there be any intention to transfer technology to other parts of the world, namely developing and least developed countries where aquaculture production is relatively higher than other parts of the world. Despite current practices, self-regulation does not always help set robust standards that determine the strengths and limits of a certain technology. By the same token, self-regulation may not be a viable approach as different industries utilizing the same type of technology for different purposes contribute to the development of disparate standards. If the status quo is not rectified beforehand, collateral dormant problems will be transferred with the technology. Whatever pathways are explored, it is important to establish standard methodologies for technological platforms to buttress adherence and compliance.

Dr. Tafsir Matin Johansson is an assistant professor at the World Maritime University-Sasakawa Global Ocean Institute (GOI) in Malmö, Sweden. Dr. Johansson is a techno-policy analyst with a PhD in maritime affairs from the World Maritime University. His duties at the GOI include ocean governance and policy research, teaching, and developing innovative policy models to better assess drivers and indicators relevant to ocean research agenda. He has published extensively on maritime and ocean issues including techno-regulatory dynamic governance, Arctic governance, vessels of concern, corporate social responsibility, marine pollution, climate change, conflict management and trust ecosystem, and Brexit and fisheries. He has worked on or led a number of multidisciplinary projects, including regulatory development projects funded by Transport Canada (Government of Canada) since 2014, as well as those funded under the Canadian Government's Oceans Protection Plan covering numerous topics critical to the maritime and ocean domain. Currently, Dr. Johansson serves as a CO-PI in a European Union Horizon 2020 Programme funded project titled "Overcoming Regulatory Barriers for Service Robotics in an Ocean Industry Context."

Dr. Dimitrios Dalaklis joined the World Maritime University in 2014, upon completion of a 26-year distinguished career with the Hellenic Navy. His expertise revolves around the interrelated maritime safety and security domains. He is an associate fellow of the Nautical Institute and a member of the International Association of Maritime Economists. With a bachelor's degree from the Hellenic Naval Academy, his postgraduate studies took place in the Naval Postgraduate School of the United States (M.Sc. in information technology management, with distinction, and M.Sc. in defence analysis). He then conducted his PhD research at the University of the Aegean, Department of Shipping, Trade, and Transport. He is the author/co-author of many peer-reviewed articles, books, and studies in both Greek and English languages, with a strong research focus on issues related to the implementation of the SOLAS Convention and especially electronic equipment/ systems supporting the safety of navigation.

Dr. Aspasia Pastra has been appointed as a post-doc fellow and maritime policy analyst at the World Maritime University-Sasakawa Global Ocean Institute in Malmö, Sweden. To date, she has been involved in a number of state-of-the-art regulatory projects in maritime policy, ocean technology, environmental protection, port governance, and gender diversity in the maritime sector. Dr. Pastra has published extensively in the field of maritime policy and governance, maritime robotics and techno-regulatory advancements, global environmental change, team dynamics, and leadership. She has been a lecturer in U.K. institutions in the field of business and maritime administration. She has extensive experience in shipping as she worked for many years in large shipping companies. She has also participated in the Marine Environment Protection Committee and Maritime Safety Committee of the International Maritime Organization, as a member of the Greek Delegation. Dr. Pastra holds a B.Sc. in public administration from Panteion University of Social and Political Sciences in Greece, an MBA from Cardiff University in the U.K., and an M.Sc. in maritime administration from the World Maritime University. She was awarded her PhD in the area of corporate governance from Brunel University in London.

22. ANNEX B: EXTENDED BIOGRAPHIES OF THE CONFERENCE CONTRIBUTORS, FACILITATORS AND SUPPORT TEAM

The conference profiles provided below feature the Contributors, Facilitators and Support Team involved in the event. The biographies commence with the President of the World Maritime University and the Keynote Speakers, followed by the contributors, facilitators and the support team in the order of their appearance.

Cleopatra Doumbia-Henry
Former President of the World Maritime University

Dr. Cleopatra Doumbia-Henry (LLB, LLM, PhD International Law) joined WMU as President in the summer of 2015. Prior to joining WMU, she served as the Director of the International Labour Standards Department of the International Labour Office (ILO) in Geneva, Switzerland. Dr. Doumbia-Henry began her career at the University of the West Indies, Barbados, as a lecturer in law. She later worked with the Iran-US Claims Tribunal in The Hague, The Netherlands and then joined the ILO in 1986 where she served both as a senior lawyer of the Organization and in several management positions. As the Director of the International Labour Standards Department, she was responsible for developing the ILO Maritime Labour Convention in 2006 and remained responsible for it until she joined WMU.

Since the late 1990s, she led the ILO's participation in a number of IMO/ILO interagency collaborations on several issues of common interest to the International Maritime Organization (IMO) and ILO, including the Joint IMO/ILO Ad Hoc Expert Working Groups on Fair Treatment of Seafarers and on Liability and Compensation regarding Claims for Death, Personal Injury and Abandonment of Seafarers.

Arsenio Antonio Dominguez Velasco
Director, Marine Environment Division,
International Maritime Organization
Keynote Address Day 1

Mr. Arsenio. Dominguez currently serves as Director, Marine Environment Division of the International Maritime Organization (IMO), having served previously as Director, Administrative Division and Chief of Staff. Prior to joining IMO in July 2017, Mr. Dominguez worked for the Panama Maritime Authority, starting in 1998 as Head of the Regional Technical and Documentation Office, and as Alternate Representative and Technical Adviser of Panama to IMO from 2004 to 2014. In July 2014 he was appointed as Ambassador and Permanent Representative of Panama to IMO.

From 1998 to 2017, Mr. Dominguez represented Panama at IMO, as well as at the International Labour Organisation (ILO), the International Oil Pollution Compensation Funds (IOPC Funds) and the International Mobile Satellite Organisation (IMSO). He also represented Panama at several shipping conferences, exhibitions, seminars and workshops. Having chaired a number of meetings at international organisations, Mr. Dominguez served as Chair of IMO's Marine Environment Protection Committee (MEPC) from 2014 to 2017, having previously served as Vice-chair from 2012 to 2013. He also served as Chair of the Technical Committee at the 29th IMO Assembly in 2015, Chair of IMO's Maritime Safety Committee (MSC) Working Group on Maritime Security and Piracy from 2010 to 2014, and as Vice-Chair of the Subcommittee of Dangerous Goods, Solid Cargoes and Containers (DSC) from 2009 to 2011.

Mr. Dominguez holds a degree in Naval Architecture from Veracruzana University, Mexico. He also obtained an MBA in Management at the University of Hull and a Certificate of Higher Education in International Law and European Politics from Birkbeck University, London, England.

HE Ambassador Nancy Karigithu
Principal Secretary and Special Envoy for Maritime and Blue Economy, State Department for Maritime and Shipping Affairs, Kenya
Concluding Keynote Address of Day One

Mrs. Nancy Karigithu, CBS is the Principal Secretary of the State Department for Shipping and Maritime, the State Department charged with responsibility for promotion of the Maritime and Shipping Industry in Kenya. She holds a bachelor's degree in law and a Master's degree in International Maritime law from the IMO International Maritime Law Institute, Malta.

Prior to joining the State Department, Mrs. Karigithu worked at the Kenya Maritime Authority as Director General for nine (9) years. She has previously served as the Chair of the Technical Cooperation Committee of the International Maritime Organization (IMO) for two (2) terms. Currently she sits on the Boards of Governors of the World Maritime University (WMU) based in Malmö, Sweden and the IMO International Maritime Law Institute based in Malta.

She was involved jointly with IMO, in the setting up and launch of the Association of Women in the Maritime Sector in Eastern & Southern Africa (WOMESA), where she served two terms as Chairperson and now sits on the governing council. WOMESA is a first regional body which brings together women professionals in the maritime sector of 26 countries in Eastern and Southern Africa.

Before her present appointment Mrs. Karigithu was working as a legal expert for the European Union (EU) project, Critical Maritime Routes, aimed at enhancing maritime situational awareness in the Indian Ocean.

Mrs. Karigithu was bestowed with an Honorary Fellowship by the World Maritime University, in recognition of her distinguished service to the international maritime industry, and recently appointed by His Excellency the President of the Republic of Kenya as Ambassador and Special Envoy for Maritime and Blue Economy in Kenya.

HE Ambassador Rena Lee
Ambassador for Oceans and Law of the Sea Issues and Special Envoy of the Minister for Foreign Affairs, Singapore; President of the BBNJ
Conference Opening Keynote Address of Day Two

Rena is Singapore's Ambassador for Oceans and Law of the Sea Issues and Special Envoy of the Minister for Foreign Affairs. She specialises in the practice of public international law, covering areas including law of the sea, environmental and climate change law. Rena was elected as President of the UN Intergovernmental Conference on Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ) in 2018. She is also a member of the Legal and Technical Commission of the International Seabed Authority.

Rena joined the Singapore public service in 1992 and has served in a number of roles, including with the Attorney-General's Chambers and the Ministry of Foreign Affairs. She currently also serves as the Chief Executive of the Intellectual Property Office of Singapore.

Ronán Long
Director, WMU-Sasakawa Global Ocean Institute

Professor Ronán Long is the Director of the WMU-Sasakawa Global Ocean Institute at the World Maritime University (WMU), Malmö, Sweden, and holds the Nippon Foundation Professorial Chair in Ocean Governance and the Law of the Sea. He leads a world-class team of specialists that are undertaking a diverse range of projects on land-to-ocean leadership, climate change and the Law of the Sea, BBNJ, marine debris and Sargassum in the eastern Caribbean, robotics and AI in the maritime domain, as well as women's empowerment for the UN Decade of Ocean Science for Sustainable Development. He is the author/co-editor of 14 books and over 100 scholarly articles on ocean law and policy. He read for his PhD at the School of Law Trinity College Dublin, he has been a Senior Visiting Scholar-in-Residence at the University of California, Berkeley, and a Visiting Scholar at the 'Centre for Oceans Law and Policy' at the University of Virginia. Additionally, Professor Long teaches on the Law of the Sea programme at Harvard Law School. Prior to his academic career, he was a permanent staff member at the European Commission and undertook over 40 missions on behalf of the European Institutions to the Member States of the European Union, the United States of America, Canada, Central America as well as to African countries. During his previous career in the Irish Naval Service, he won an academic prize at Britannia Royal Naval College and held a number of appointments ashore and afloat, including membership in the Navy's elite diving unit. As a keen yachtsman, he has represented Ireland at the top competitive level in offshore racing. Ronán is passionate about the law of the sea, conservation and global sustainability, as well as the implementation of the 2030 Agenda for Sustainable Development.

Aspasia Pastra
Postdoctoral Fellow, WMU-Sasakawa Global Ocean Institute
Rapporteur Keynote Address Day 1, Commentator Panel 3, Commentator Reporting Session Day 2

Dr. Aspasia Pastra has been appointed as a Postdoctoral Fellow & Maritime Policy Analyst at the WMU-Sasakawa Global Ocean Institute in Sweden. Before joining the BUGWRIGHT2 team as Postdoctoral Fellow, Dr. Pastra worked as Research Associate at WMU, involved in various Transport Canada and European Union funded state-of-the-art regulatory development projects. Prior to joining WMU, she worked in Greek shipping companies/organisations for two decades as an internal auditor and maritime researcher. She has also participated in the Marine Environment Protection Committee (MEPC) and Maritime Safety Committee (MSC) of the IMO as part of the Greek delegation. She holds a BSc degree in Public Administration from the Panteion University of Social and Political Sciences in Athens and an MBA from Cardiff University in the UK. She was also granted a scholarship from HELMEPA, in memory of the ship-owner George P. Livanos, for the World Maritime University in Sweden. After obtaining her MSc in Maritime Administration, Dr. Pastra received a PhD in Corporate Governance from Brunel University in London. Her expertise lies in maritime policy and governance, ocean technology, environmental management and shipping management.

Fredrik Haag
Head of the Office for the London Convention/Protocol and Ocean Affairs, International Maritime Organization
Moderator Panel 1

Mr. Fredrik Haag has a background in applied environmental research, focusing on marine and coastal zone management, and holds several postgraduate degrees; an MSc in Earth Sciences and a Licentiate of Philosophy (Phil. Lic.) in Environmental Impact Assessment from Uppsala University, Sweden, as well as a Master in Maritime Affairs from the World Maritime University. Mr. Haag joined IMO in 2006, represents IMO in several UN wide processes, and has been deeply involved in matters related to the 2030 Agenda for Sustainable Development and the SDGs, Biodiversity in Areas Beyond National Jurisdiction (BBNJ), as well as the Joint Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP). As head of the Office, his primary task is to support the implementation of the London Convention and Protocol on dumping of wastes and other matters at sea, but he is also involved in IMO's work on PSSAs, marine litter, noise and ship-strikes. He has also contributed to work on GHG emissions from ships and Ballast Water Management.

Betsy Valente
Chief, Freshwater and Marine Regulatory Branch, U.S. Environmental Protection Agency (EPA)
Speaker Panel 1

Ms. Betsy Valente manages a diverse portfolio focused on protecting and restoring waters of the United States, including wetlands, and protecting ocean waters. More specifically, Betsy leads efforts associated with the Clean Water Act section 404 wetlands program and the Marine Protection, Research, and Sanctuaries Act, which implements U.S. policies and international obligations relating to ocean dumping.

Since 2009, Betsy has led and contributed to London Convention/London Protocol (LC/LP) activities for the United States, led national ocean dumping management efforts, and supported EPA's marine pollution control programs generally. Ms. Valente has served as the Chair of the LC and LP Contracting Parties Meetings since 2020, having previously served as a vice-chair from 2014 to 2019.

Ms. Valente has also supported water sector emergency response and resiliency efforts. Prior to joining the EPA, she worked as an environmental scientist, focusing on contaminated sediments in the Great Lakes, urban wet weather pollution, and water quality issues. Betsy has conducted research in the United States as well as in the Brazilian Amazon and Great Barrier Reef regions. Betsy received a bachelor's degree from Denison University and a Master of Applied Science from James Cook University.

Woong-Seo Kim
President, Korea Institute of Ocean Science and Technology (KIOST)
Speaker Panel 1

Dr. Woong-Seo Kim received a B.S. and M.S. at Seoul National University, Korea, and a PhD at the State University of New York at Stony Brook, USA. He is the President of the Korea Institute of Ocean Science and Technology (KIOST), as well as Chair of the Korea Oceanographic Commission (KOC). He was previously the Director of the Ocean Resources Department and Vice President of KIOST. He also played roles as the Director of IMMS (International Marine Mineral Society), and the Legal and Technical Commission of ISA(International Seabed Authority). He was the President of the Korean Society of Oceanography.

Nilüfer Oral
Director, Centre for International Law, National University of Singapore & Member of UN's International Law Commission
Speaker Panel 1

Dr. Nilüfer Oral is Director of the Centre of International Law (CIL) at the National University of Singapore, and a member of the UN International Law Commission, where she is also Co-chair of the Study Group on Sea-level rise in relation to international law. She was a climate change negotiator for the Turkish Ministry (2009 – 2016). She also appeared before the International Tribunal for the Law of the Sea. Dr. Oral is a Distinguished Fellow of the Law of the Sea Institute at Berkeley Law (University of California Law Berkeley); a Senior Fellow of the National University of Singapore Law School; and Honorary Research Fellow at the University of Dundee. She is a member of the Legal Experts Group of the Commission for Small Island States on Climate Change and International Law. She is currently a member of the Steering Committee of the World Commission of Environmental Law and a member of the Board of Governors of the International Council on the Environment. She was a member of the IUCN Council from 2012-2016.

Dr. Oral is on the board of editors of several academic journals and has published widely in international journals and books.

Måns Jacobsson
Former Director and CEO, International Oil Pollution Compensation Funds (IOPC Funds)
Commentator Panel 1

Måns Jacobsson has been Director and Chief Executive Officer of the International Oil Pollution Compensation Funds (IOPC Funds) 1985-2006. In his earlier career, he served in the Swedish judiciary at the district court and appellate court level, and he has held the post of President of the Division of the Stockholm Court of Appeal. He has also been Head of the Department of International Civil Law of the Swedish Ministry of Justice.

He has been a member of the Board of Governors of the World Maritime University (WMU) in Malmö (Sweden) since 2010. After his retirement from the IOPC Funds he worked as a consultant in maritime and environmental matters and as an academic lecturer at numerous institutions in a number of countries, inter alia as Visiting Professor at the WMU and at the Maritime Universities in Dalian and Shanghai and as Visiting Fellow at the IMO International Maritime Law Institute (IMLI) in Malta. He is also a corresponding member of the Argentine Academia nacional de derecho y ciencias sociales. He is an Academic Associate of Quadrant Chambers, a set of leading barristers in London specialising in commercial law. He has published three books and numerous articles in various fields of law.

The University of Southampton has conferred upon him the Degree of Doctor of Laws honoris causa. In 2010 he was awarded the King of Sweden's Gold Medal for significant achievements in the fields of marine environment and shipping.

Zhen Sun
Associate Professor, WMU-Sasakawa Global Ocean Institute
Commentator Panel 1

Dr. Zhen Sun's main research interests include the law of the sea, international regulation of shipping, gender equality in ocean governance, climate actions and the protection of the marine environment.

At WMU, Dr. Sun has played an active role in the launch and execution of a number of high-level research programmes, including serving as Co-Principal Investigator (PI) for both the Land-to-Ocean Leadership Programme and the Empowering Women for the United Nations Decade of Ocean Science for Sustainable Development Programme. She contributes to the delivery of the MSc Ocean Sustainability, Governance & Management (OSGM) specialisation, and the PhD Programme in Maritime Affairs through substantial teaching and supervision commitments.

Prior to joining WMU, Dr. Sun was a Research Fellow at the Centre for International Law (CIL), National University of Singapore. She was a member of the CIL Ocean Law and Policy team, in which she worked on a wide range of subjects in the law of the sea. Dr. Sun was the researcher-in-charge for a number of research projects and capacity-building activities at CIL, including projects funded by the Singapore Ministry of Foreign Affairs and the Maritime and Port Authority of Singapore.

Dr. Sun has contributed to the editorial work of a couple of book projects and published a number of book chapters and journal articles on various topics on the law of the sea. Zhen received a Bachelor of Laws Degree from Hainan University and an LLM in International Law from China University of Political Science and Law in China. She continued her education in the United Kingdom where she received an LLM in Public International Law (with distinction) from the University of Edinburgh and a PhD from the University of Cambridge.

Renis Auma Ojwala
PhD Candidate and Research Assistant, WMU-Sasakawa Global Ocean Institute
Rapporteur Panel 1, Speaker "The People We Need for the Oceans We Want: Women's Empowerment"

Ms. Renis Auma Ojwala is conducting PhD research the "Empowering Women for the United Nations Decade of Ocean Science for Sustainable Development" Programme, funded by the Department of Fisheries and Oceans Canada (DFO) and hosted at the WMU-Sasakawa Global Ocean Institute. Her research topic focuses on "Evaluating Gender Equality in Ocean Science for Sustainable Development in Kenya." Ms. Auma Ojwala received a Bachelor of Science Degree in Applied Aquatic Science from Egerton University in 2014. She later obtained a Master of Science Degree in Limnology and Wetland Management, a Joint International Master of Science Programme from BOKU University in Vienna Austria, Egerton University in Kenya and UNESCO-IHE (Currently, IHE-Delft) Netherlands in 2017. Ms. Auma Ojwala is passionate about gender equality and women's empowerment in Ocean science and fisheries research-related fields. She has worked with various institutions such Egerton University, World Wide Fund for Nature (WWF-Kenya), Victory Fish Farms and National Museum of Kenya.

Andrew Birchenough
Technical Officer for Office for the London Convention/Protocol and Ocean Affairs, International Maritime Organization
Moderator Panel 2

Dr. Andrew Birchenough is the Technical Officer for the Office for the London Convention/Protocol and Ocean Affairs at the International Maritime Organization (IMO). He has a background in applied environmental research, focusing on marine pollution and ocean and coastal zone management, and holds a doctorate from Newcastle University. He joined the IMO in 2017, his primary task being to support the implementation of the London Convention and Protocol, the international treaties that regulate the dumping of wastes and other matters at sea.

He is also involved in the Office's Ocean Affairs portfolio, including the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) and in other IMO Marine Environment Division work including on Particular Sensitive Sea Areas (PSSAs), matters related to the 2030 Agenda for Sustainable Development and the SDGs, and leading on anthropogenic underwater noise.

Prior to joining IMO, he worked for Cefas and was responsible for providing scientific policy and regulatory advice to UK Government and regulators on the potential risks and impacts to the marine environment, and represented the UK at international and regional fora.

Enrique Vargas Guerra
Head of IMO Audit Division, Chilean Maritime Authority (DIRECTEMAR)
Speaker Panel 2

Commander Enrique Vargas is a graduated naval officer from the Chilean Naval Academy. He has a bachelor's degree as a Maritime Administration Engineer and multiple studies related to environmental protection and climate change, including a Master's Degree in Maritime Affairs with a specialisation in Maritime Safety and Environmental Protection, from the World Maritime University in Malmö, Sweden (2006).

Between 2012-2021 he served as Head of the Marine Environment Protection and Marine Pollution Service of the Chilean Maritime Authority (DIRECTEMAR) and since 2017 as Head of the Climate Change Office of the Chilean Navy.

In these positions, he was responsible for implementing the environmental policy and international regulations in the roles of the Maritime Authority, leading working groups for the development of technical guidelines in matters related to environmental impact assessment and compliance with activities that take place in the marine environment.

Over the last 10 years, he has represented Chile at multilateral forums on environmental protection, including the International Maritime Organization (IMO) and the APEC Forum. He has also managed technical cooperation programs in the Latin American Region and the Community of Caribbean Countries (CARICOM), as well as projects of the Asia-Pacific economic cooperation forum (APEC).

Since 2012 he has been involved with issues associated with the London Convention and Protocol, participating as head of the delegation in the meetings of the Scientific Groups and as well as Contracting Parties.

Currently, he is the head of the IMO Audit Division at Directemar, responsible for arrangements for the IMO Member State Audit Scheme (IMSAS) in Chile.

Tracy Shimmield
Co-Director, Lyell Centre
Speaker Panel 2

Dr. Tracy Shimmield is Co-Director of the Lyell Centre. Previously she was Associate Director of the research institute the Scottish Association for Marine Science (SAMS) and Managing Director of their trading subsidiary SRSL (SAMS Research Services Limited), Oban, UK.

Dr. Shimmield is a marine geochemist and has over 30 years of experience in environmental geochemistry. She obtained an MSc From Strathclyde University and a PhD from Edinburgh University. Her research interests include the investigation and assessment of human impacts on the marine environment through the monitoring of pollutants and the study of biogeochemical processes involved in their redistribution. She is also an experienced radiochemist and utilises natural and manmade radionuclides as tracers of marine processes including sediment accumulation and mixing rates.

Dr Shimmield has been the supervisor of 9 PhD students and has been a Principal Investigator on a number of research and commercial grants funded by the UK Natural Environmental Research Council (NERC), the European Union Framework programme and commercial companies.

Dr Shimmield is interested in how science and innovation can come together to realise societal benefit and economic growth. She is a member of the Scotland Can Do Forum established by Scotland's Deputy First Minister. As a marine biogeochemist, Dr Shimmield began working with the government of Papua New Guinea a decade ago, advising on mitigating and managing the impacts of mining on their marine environment, including the writing of 'General' and 'Specific' regulatory guidelines for the use of Deep Sea Tailings Placement (DSTP) in the country. As part of this project, Dr Shimmield organised and participated in an International Conference on Deep Sea Tailings Placement, held in Madang, Papua New Guinea (2008).

Over the years, Dr Shimmield has become a world-renowned expert in the environmental impacts of DSTP and was consequently invited to be a speaker at the Deep Sea Mining Summit held in London in May 2017. She has since travelled to Brussels to take part in a workshop on Technological and Environmental Aspects of Deep-Sea Mining and has presented to the Norwegian Mineral Waste Committee under the Norwegian Mining and Quarrying Industries (Norsk Bergindustri), and at the International Mineral Processing Congress held in Santiago, Chile.

Craig Vogt
President, Craig Vogt Inc., Ocean and Coastal Environmental Consulting
Commentator Panel 2

Craig Vogt was Deputy Director of the USEPA's Ocean and Coastal Protection Division in Washington, DC, USA, for 18 years, responsible for national regulatory programs controlling the disposal of wastes in marine waters. Mr. Vogt was also responsible for coastal ecosystem restoration planning and remediation in the 28 National Estuary Programs across the USA.

Mr. Vogt led the U.S. delegation to meetings of the London Convention & Protocol from 1991 to 2003. He Chaired the Scientific Group of the LC/LP from 2004-2007, during which time updates to the LC/LP Waste Assessment Guidelines were put in place, regional workshops were conducted on marine pollution prevention, and new guidance was developed and adopted on sequestration of carbon in deep seabeds.

Mr. Vogt is now an environmental engineer with Craig Vogt Inc., Ocean & Coastal Environmental Consulting. Projects include dredged material management, marine disposal of mine tailings, deep sea mining, management of contaminated sediments, economic/environmental effects of eroding shorelines, and coastal habitat restoration.

For the Secretariat of the LC/LP, Mr. Vogt prepared reports on marine disposal of mine tailings, low cost/low technology field and compliance monitoring, site selection for waste disposal in ocean waters, control/prevention of microplastics in waste disposed at sea, and the GESAMP Workshop Proceedings on the impacts of mine tailings in the marine environment.

He represents the World Organization of Dredging Associations (WODA) at meetings of the LC/LP and is Chair of WODA's Environmental Commission. Craig is a member of the Western (i.e., hemisphere) Dredging Association's (WEDA) Board of Directors and Chairs WEDA's Environmental Commission.

Roxanne Graham
PhD Candidate and Research Assistant, WMU-Sasakawa Global Ocean Institute
Commentator Panel 2

Roxanne Graham is a current PhD candidate with the NF-WMU 'Closing the Circle Programme: Marine Debris, Sargassum and Marine Spatial Planning' in the Eastern Caribbean, generously funding by The Nippon Foundation, hosted at the World Maritime University (WMU) - Sasakawa Global Ocean Institute. She is also an Instructor at St. George's University's Biology, Ecology and Conservation Department. Roxanne completed her Master of Marine Management Degree at Dalhousie University, Canada in December, 2016.

Prior to her graduate studies, Roxanne was a Project Assistant at Roberts Caribbean, Ltd., Environmental and Development Consulting Division. Roxanne has experience in conducting environmental consultancies and contributing to several agricultural and environmental related national reports for Grenada. Roxanne loves fashion and modelling and tied it with her love of conservation by founding and producing a competition called "Face of Grenada- Beauty with a Purpose". Roxanne is also the Vice-President of Gaea Conservation Network.

Kristie Alleyne
PhD Candidate and Research Assistant, WMU-Sasakawa Global Ocean Institute
Rapporteur Panel 2

Kristie Alleyne is PhD candidate with the NF-WMU 'Closing the Circle Programme: Marine Debris, Sargassum and Marine Spatial Planning' in the Eastern Caribbean, generously funding by The Nippon Foundation, hosted at the World Maritime University (WMU) - Sasakawa Global Ocean Institute. She is also a graduate of the University of the West Indies, Cave Hill campus with a background in Marine Biology and Environmental Management. During her Bachelors degree Kristie became very interested in behavioural ecology which led her to work with the Bellairs Research Institute, examining the behavioural traits of cleaner gobies on both sponge and coral microhabitats in Barbados. With an increased love for ecology and conservation, Kristie pursued her post-graduate studies in marine management with specific interest in social-ecological interactions. Subsequent to her Masters in Resource and Environmental Management where she specialised in Coastal and Marine Resource Management, she was appointed to the post of Research Assistant at UWI-CERMES where she worked primarily on fisheries and sargassum related projects. After working on a variety of sargassum projects for 2 years, Kristie now pursues a PhD degree at the World Maritime University where her main research focuses on spatiotemporal analysis of sargassum influx events in Barbados.

H.E. Ambassador Marie Jacobsson
Principal Legal Adviser on International Law, Swedish Ministry for Foreign Affairs
Moderator Panel 3

Ambassador Marie Jacobsson is the Principal Legal Adviser on International Law at the Swedish Ministry for Foreign Affairs. She was a Member of the United Nations International Law Commission (ILC) from 2007-2016 and a Special Rapporteur for the topic 'Protection of the environment in relation to armed conflicts'. She is a Member of the Permanent Court of Arbitration, a designated arbitrator under the United Nations Convention on the Law of the Sea, a designated arbitrator under the Protocol on Environmental Protection to the Antarctic Treaty and a designated conciliator of the Court of Conciliation and Arbitration within the OSCE. She is designated Special Representative for Inclusive Peace Processes by the Minister for Foreign Affairs and a Member of the Swedish Women's Mediation Network.

Dr. Jacobsson's work focuses on international peace and security matters. She has extensive experience in high-level multilateral and bilateral negotiations on such matters as the law of the sea, polar law, international environmental law, boundary delimitation, regional security affairs, international humanitarian law and arms control.

She is an Associate Professor of International Law at Lund University and holds a Doctorate in Law from that University.

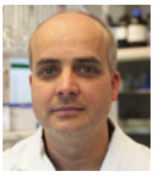
Seokwoo Lee
Professor of International Law, Inha University Law School, Korea
Speaker Panel 3

Prof. Seokwoo LEE is Professor of International Law, Inha University Law School, Korea (2003-). He was Chairman of the Foundation for the Development of International Law in Asia (DILA) (2012-2017) and is Co-Chair of the International Law Association (ILA) Study Group, Asian State Practice of Domestic Implementation of International Law (ASP-DIIL) (2018-). He was Vice President of the Korean Society of International Law (2019) (Executive Board Member (2010-), Director of International Relations (2010-2011)) and served as Chairman of the Research Committee, SLOC (Sea Lanes of Communication) Study Group-Korea (2010-2013).

He is General Editor of Encyclopedia of Public International Law in Asia (EPILA) and Encyclopedia of Ocean Law and Policy in Asia-Pacific (EOLPA), Co-Editor-in-Chief of Asia-Pacific Journal of Ocean Law and Policy (APJOLP) and Asian Yearbook of International Law (Asian YBIL), Executive Editor of Korean Journal of International and Comparative Law (KJICL), Co-Series Editor of the book series entitled Maritime Cooperation in East Asia, and Associate Editor of Brill Research Perspectives in the Law of the Sea, all published by Brill.

He has authored more than 100 publications in English in addition to his more than 100 publications in Korean. His representative publications in English are: "Yeo Woon Taek v. New Nippon Steel Corporation", American Journal of International Law (Vol.113, No.3) (2019) and The Making of International Law in Korea: From Colony to Asian Power (Brill/Nijhoff) (2016).

He is a graduate of Korea University where he received his undergraduate law degree and then went on to receive Master of Laws degrees from Korea University, the University of Minnesota, and New York University, and finally his doctorate from Oxford University. In addition, he has completed the required coursework for his doctoral degree program in Modern and Contemporary Korean History at the Department of Korean History, Korea University.



David Santillo
Senior Scientist, Greenpeace International
Speaker Panel 3

Dr. David Santillo is a marine biologist and analytical chemist who works as a scientist at the Greenpeace Research Laboratories, based at the University of Exeter in the UK. In addition to his research on environmental pollution, Dr. Santillo has represented Greenpeace International at meetings of the Scientific Groups and Governing Bodies of the London Convention and London Protocol since the mid-1990s, contributing to the development of guidance and regulations (including those relating to marine geoengineering activities) and bringing other emerging issues of concern to the attention of those meetings. He has also played an active role in meetings under the OSPAR Convention over the same period, including work within committees addressing the offshore oil and gas industry, hazardous substances and the protection of biodiversity from human activities. David has co-authored papers and technical reports on a wide range of environmental issues, including a number of recent collaborative studies on plastic pollution in marine and freshwater systems, and in a personal capacity was a contributory author to GESAMP Report No. 108 on sea-based sources of marine litter, published in 2021. He recently contributed to a perspectives paper in the journal of the Institute of Environmental Sciences reflecting on the role that NGOs have played in the development of the environmental agenda in the 50 years since the Stockholm Conference.

Atsuko Kanehara
Professor of International Law at Sophia University
Speaker Panel 3

- Professor of International Law at Sophia University.
- Former President of the Japanese Society of International Law.
- Member of the Governing Board of IMO International Maritime Law Institute.
- Advocate for the Government of Japan in "Southern Bluefin Tuna" Cases.
- Counsel for the Government of Japan in the "Whaling in the Antarctic" Case.
- Policy Adviser for the Japan Coast Guard. Member of the Committee on Submarine Cables and Pipelines under the International Law Association

She delivered a course of lectures at The Hague Academy of International Law in 2017, entitled "Reassessment of the Acts of the State in the Law of State Responsibility – A Proposal of an Integrative Theoretical Framework of the Law of State Responsibility to Effectively Cope with the Internationally Harmful Acts of Non-State Actors," which was published in Recueils des cours, Vol. 399 (2019).

Her recent publications in English are: "Refining Japan's Integrative Position on the Territorial Sovereignty of the Senkaku Islands," International Law Studies, Vol. 97 (2021); "Covid-19 and the Law of the Sea: Japan's Port State Jurisdiction in Relation to the Diamond Princess," Japanese Yearbook of International Law, Vol. 64 (2021); "Interplay between the United Nations Convention on the Law of the Sea and Other International Law for Building a Comprehensive International Maritime Order," Japanese Yearbook of International Law Vol. 63 (2020): "The Use of Force in Maritime Security and the Use of Arms in Law Enforcement under the Current Wide Understanding of Maritime Security," Japan Review, Vol. 3, No. 2 (2019).

George Theocharidis
Professor of Maritime Law & Policy, World Maritime University
Commentator Panel 3

Prof. George Theocharidis is a member of the Piraeus Law Bar & a qualified advocate before Areios Pagos (Supreme Court) with extensive litigation practice, as well as a full member of the Hellenic Maritime Law Association since 2000. Prof. Theoccharidis has been a supporting Member of the London Maritime Arbitrators Association (LMAA) since 2004 and is a consultant of the IMO E-Roaster.

His research interests concentrate on Carriage of Goods by Sea, Marine Insurance, Conflict of Laws, Methodology of Law, Ship Arrest and Maritime Policy. He is the author of the books "Tort Liability of the Sea Carrier under Hague-Visby Rules" (2000), "The Co-ownership of Vessels as a legal form for the exercise of maritime commercial activity" (2008) and co-author of " Greek Maritime Law" (2015). He has also published several articles ("All About Freedom of Contract? Bunker Supply Arrangements Post-Res Cogitans in Global Context", "Mechanisms of Protection From Non-Contractual Modes of Recovery in Sea Carriage – A Comparison Between Common Law and Civil Law Systems", "Relationship between forum shopping and flag in satisfaction of security rights on a ship", "Jurisdiction for Provisional Relief under the Brussels Convention in Maritime Context" et al.) His published research work in international referred periodicals (J.Mar.L& C., R.H.D.I.) has received numerous citations from courts and legal theory (Heidelberg Report).

Co-author of the Training Package on "Maritime Transport Policy", instructed by IMO TCD. Member of the Working Group of the Legal Committee of IMO pertaining to "Measures to Prevent Unlawful Practices Associated with Fraudulent Registration and Fraudulent Registries of Ships". Joint Rapporteur of the International Working Group of the Comité Maritime International (CMI) on "Liability for the Wrongful Arrest of Ships".

Holder of LL.M. degree from the University of Cambridge (UK) and a PhD from Aristotle University (Greece).

Rebecca Pskowski
PhD Candidate, WMU-Koji Sekimizu Fellow in Maritime Governance
Rapporteur Panel 3

Ms. Rebecca P. Pskowski is a WMU-Koji Sekimizu Fellow in Maritime Governance, pursuing her PhD at WMU with the support of the Maritime and Port Authority of Singapore. She is also a civilian attorney-advisor to the United States Coast Guard (on leave).

Ms. Pskowski received her B.A. from the University of Chicago, her J.D. from Harvard Law School, and her LL.M. in Admiralty from Tulane University Law School. She clerked for the Honorable Charles S. Haight, Jr. of the Southern District of New York and was a Presidential Management Fellow at the U.S. Department of Labor.

Prior to her legal career, Ms. Pskowski sailed as a merchant mariner for nine years. Her work on passenger sailing vessels took her to five continents and included service as a cook, AB, bosun, deck officer, and relief captain. She is licensed as a mate of vessels less than 3000 gross tons on oceans, and a master of vessels less than 500 gross tons on coastal waters.

Ms. Pskowski is writing her dissertation on the ongoing development of institutional compliance mechanisms for IMO treaties. Specifically, she is researching the development of the STCW 95 list of confirmed parties, the London Protocol Compliance Group, the IMO Member State Audit Scheme, and the IMO data collection system for fuel consumption of ships.

Ms. Pskowski has published widely on maritime legal topics, including articles on ship recycling, bunker contamination claims, and maritime labour protection.

H.E. Ambassador Geneviève Jean-van Rossum
Ambassador and Permanent Representative of France to the International Maritime Organization
Moderator Panel 4

A career diplomat, Ms. Jean-van Rossum has been appointed as the Ambassador and Permanent Representative of France to the International Maritime Organization in 2019.

Before that, she held bilateral positions in the Embassies of France in Haiti (1984-1986), Jordan (1996-1999) and Burundi (2013-2016), in Paris (Southern Africa desk, US desk), as well as multilateral positions abroad (Permanent Representation of France to the UN in Vienna 2004-2008) and in Paris (Permanent Delegation of France to the UNESCO 1990-1992). She has also held senior positions concerning finance and human resources at the French Ministry of Europe and Foreign Affairs in particular as Deputy Director of Programmes and Network at the Directorate General for Globalisation (2010 to 2013).

Most recently, she was a Special Representative in charge of Bioethics and Corporate Social Responsibility (2016 to 2019). She holds a bachelor degree in Foreign Languages from the University of Clermont-Ferrand and a master's degree in International relations from the Paris Institut d'Etudes Politiques. She was made "chevalier de l'Ordre national du Mérite » et de « la Légion d'honneur». Ms Jean-van Rossum is married and has four children.

Richard Cronin
Principal Adviser, Marine Environment Water Division, Department of Housing, Local Government and Heritage, Ireland
Speaker Panel 4

Mr. Richard Cronin is Principal Adviser for the marine environment in the Irish government. He leads a team that develops and implements policy, programmes and measures and legislation for the protection and sustainable use of the marine environment.

He is Marine Director for Ireland under the EU Marine Strategy Framework Directive (MSFD) and is responsible for the expansion of Ireland's network of marine protected areas. He represents Ireland at EU, macro-regional and global levels and negotiates for Ireland and as part of the EU team in different fora.

He holds a degree in Civil Engineering from University College, Cork and has extensive experience in environmental protection, international negotiations and multilateral cooperation; policy design and implementation; and systems analysis and governance.

He is responsible for the implementation of the Convention on the Protection of the Marine Environment of the North-East Atlantic (OSPAR) in Ireland and was chair of the OSPAR Commission from 2018 – 2022.

David Freestone
Executive Secretary, Sargasso Sea Commission
Speaker Panel 4

Prof. David Freestone is a Professorial Lecturer and Visiting Scholar at George Washington University Law School in Washington D.C.

He is the Executive Secretary of the Sargasso Sea Commission, established by the Government of Bermuda pursuant to the 2014 Hamilton Declaration on Collaboration for the Conservation of the Sargasso Sea, now signed by ten governments, which is working to protect this unique high seas ecosystem. The project was awarded the International SeaKeepers Prize in 2013.

He is also the founding Editor of the International Journal of Marine and Coastal Law (now in its 37th year). From 1996-2008 he worked at the World Bank in Washington DC, retiring as Deputy General Counsel/Senior Adviser. From 2008-2010 he was the Lobingier Visiting Professor of Comparative Law and Jurisprudence at the George Washington University Law School. He was the Ingram Fellow at the University of New South Wales in Sydney in 2009 and has held visiting positions at the Fridtjof Nansen Institute (2014-18), University of Cape town (2016) and the Oxford University Martin School (2018). In 2008 he was awarded the Elizabeth Haub Gold Medal for Environmental Law.

Rosemary Rayfuse
Emerita Scientia Professor of Law, UNSW Sydney
Commentator Panel 4

Prof. Rosemary Rayfuse is an Emeritus Scientia Professor of Law at UNSW Sydney, where she led the Public International Law programme in the Faculty of Law and Justice from 1994 to 2020. She is a Fellow of the Academy of the Social Sciences in Australia (FASSA) and has held visiting and conjoint appointments at universities around the world. Prior to joining UNSW she was a Research Fellow at the Lauterpacht Research Centre for International Law, taught international law at the University of Cambridge, and practised law in Vancouver, Canada. She holds the degrees of LLB from Queen's University, LLM from the University of Cambridge, PhD from the University of Utrecht, and a Doctor of Laws honoris causa (LLD h.c.) from Lund University.

Prof. Rayfuse researches in the area of Public International Law in general and more specifically in the Law of the Sea and International Environmental Law. She has published widely on issues of ocean governance, protection of the marine environment in areas beyond national jurisdiction, and the normative effects of climate change on international law and has particular expertise in high seas fisheries, climate change and the ocean, and polar ocean governance. She is on the editorial or advisory boards of a number of international law journals, is a member of the IUCN Commission on Environmental Law, and is Chair's Nominee on the International Law Association's Committee on International Law and Sea-Level Rise.

Mariamalia Rodríguez Chaves
Postdoctoral Fellow, WMU-Sasakawa Global Ocean Institute
Commentator Panel 4

Dr. Rodríguez Chaves has more than fifteen years of experience working with environmental non-governmental organisations and as an independent consultant on diverse environmental topics. She has a Law Degree, and a Masters Degree in Environmental Law, from the University of Costa Rica; and a PhD in Law from the School of Law of the National University of Ireland, Galway (NUIG).

Currently, Dr. Rodríguez Chaves is a Postdoctoral Fellow researcher in the Empowering Women for the United Nations Decade of Ocean Science for Sustainable Development programme at the WMU-Sasakawa Global Ocean Institute; a consultant for the High Seas Alliance, where she is responsible for coordinating the approach of Latin American countries in negotiating a new treaty on biodiversity beyond national negotiations at the United Nations; and she is the programme coordinator of the DOALOS/Norway programmes of assistance to meet the strategic capacity needs of developing states in the field of ocean governance and the law of the sea.

Peter Ohagwa
MSc Student, World Maritime University and Assistant Chief Maritime Safety Officer, Nigerian Maritime Administration and Safety Agency
Rapporteur Panel 4

Mr. Peter Udochukwu Ohagwa is an Assistant Chief Maritime Safety Officer (ACMSO) with the Nigerian Maritime Administration and Safety Agency (NIMASA). He hails from Nkwerre, Imo State, Nigeria. Mr. Udochukwu Ohagwa has a Bachelor of Science in Industrial Chemistry from the Anambra State University, Uli, Nigeria; a Diploma in Marine Surveying from the Lloyds Maritime Academy, UK; Master's degree in Maritime Transport Management (MTM) from the Ladoke Akintola University, Ogbomosho, Nigeria; and recently completed another Master's degree in Maritime Affairs with specialisation in Maritime Safety and Environmental Administration (MSEA) from the World Maritime University (WMU), Malmö, Sweden.

He is a highly motivated individual who aspires to constant improvement in his academic and professional skills. His main areas of interest include; maritime safety, security and environment, hence seeks broader knowledge and experiences in order to efficiently assume higher career responsibilities in the future, as well as be better equipped to contribute towards policies that address the world's challenges, particularly, in the field of maritime.

Mr. Udochukwu Ohagwa is an awardee of the prestigious Nippon/Sasakawa Peace Foundation (SPF) scholarship to the World Maritime University, and has successfully completed a dissertation on the topic, "Analysis of Nigeria's Deep Blue Project: A New Paradigm for Maritime Security in the Gulf of Guinea''.

Kristal Ambrose
PhD Candidate and Research Assistant, WMU-Sasakawa Global Ocean Institute
Keynote Address at Gala Dinner

Ms. Kristal Ambrose, also known as 'Kristal Ocean', is PhD candidate with the NF-WMU 'Closing the Circle Programme: Marine Debris, Sargassum and Marine Spatial Planning' in the Eastern Caribbean, generously funding by The Nippon Foundation, hosted at the World Maritime University (WMU) – Sasakawa Global Ocean Institute.

She is an environmental scientist studying marine debris and plastic pollution in the Bahamas. Her career in the environmental field spans over a decade as she has been working diligently on plastic pollution research and education in her country. She is the Founder and Director of Bahamas Plastic Movement (BPM), a non-profit organisation geared towards raising awareness and developing solutions to plastic pollution.

José Manuel Pacheco Castillo
Project and Research Support Fellow, WMU-Sasakawa Global Ocean Institute
Rapporteur Concluding Keynote Address of Day One

Mr. Pacheco is a Project and Research Support Fellow at the World Maritime University (WMU) – Sasakawa Global Ocean Institute. He holds an LL.M. in International Maritime Law from the IMO International Maritime Law Institute (IMLI) in Malta (2019-2022) with distinction; and an LL.B. from the Pontifical Catholic University of Peru (2014). Mr. Pacheco has worked for the Peruvian Government as a legal adviser in maritime affairs in the Ministry of Foreign Affairs (2013-2019) and the Ministry of Transport and Communications (2020-2022). He has received training in international courses on the law of the sea such as the Yeosu Academy on the Law of the Sea (Republic of Korea) (2017) and as a fellow at the Institute of Advanced Sustainability Studies (Potsdam, Germany) (2018). In 2022, Mr. Pacheco successfully finished the Nippon Foundation fellowship program from the United Nations Division for Oceans Affairs and the Law of the Sea (DOALOS), taking his research stay at the World Maritime University (WMU).

Dorota Lost-Sieminska
Deputy Director and Head of Legal Affairs Office, Legal Affairs and External Relations Division, International Maritime Organization
Moderator Panel 5

Dr Dorota Lost-Sieminska is a Deputy Director and a Head of the Legal Affairs Office in the Legal Affairs and External Relations Division of the International Maritime Organization where she leads her team in the provision of legal advice in various complex subjects of international law, treaty law, maritime law, law of the sea and all other areas related to the activities of the Organization. She regularly represents IMO at various international meetings and conferences, including at the Meetings of the States Parties to UNCLOS and at the IGC on BBNJ. She also regularly lectures at the IMO International Maritime Law Institute in Malta, World Maritime University in Malmö and Queen Mary University of London.

Before joining IMO in 2011 she was a Director of the Maritime Transport and Inland Navigation Department in the Ministry of Transport in Warsaw, Poland and, among other duties, led the Polish delegation to various UN and EU meetings.

Dr Lost-Sieminska obtained a Master of Laws and PhD in international maritime law from the University of Gdansk, Poland and a Master of maritime law and the law of the sea from the IMO International Maritime Law Institute in Malta. She is also an advocate admitted to the Bar in Gdansk and a member of the Polish Academy of Science and the Polish Maritime Law Association.

Richard Barnes
Professor of International Law, University of Lincoln
Speaker Panel 5

Prof. Richard Barnes is a Professor of International Law at the University of Lincoln. He is also an Adjunct Professor of Law at the Norwegian Centre for the Law of the Sea, the University of Tromsø.

He is widely published in the fields of international law and law of the sea. Property Rights and Natural Resources (2009), won the SLS Birks Book Prize for Outstanding Legal Scholarship. In addition, he has edited five highly regarded collections, including Frontiers in International Environmental Law. Oceans and Climate. Essays in Honour of David Freestone (2021), the Research Handbook on Climate Change, Oceans and Coasts (2020), and The United Nations Convention on the Law of the Sea: A Living Instrument (2016). He is currently working on papers on plastics and the circular economy, stewardship of the oceans, global solidarity and the law of the sea, the impact of COVID in maritime law, and the potential for an advisory opinion before international courts on climate-induced sea-level rise.

Prof. Barnes is the Current Legal Developments Editor of the International Journal of Marine and Coastal Law. He is also on the editorial boards of the New Zealand Yearbook of International Law and the German Yearbook of International Law.

He has acted as a consultant for a range of public and private bodies, including the WWF, the European Parliament, the UK Department for Environment, Food and Rural Affairs, the Foreign Commonwealth and Development Office, and Ministry for Transport. He also provided advice to foreign ministries. He has appeared numerous times before Parliamentary select committees on matters related to the law of the sea, fisheries and Brexit.

Alla Pozdnakova
Professor, Scandinavian Institute of Maritime Law, The Faculty of Law
Speaker Panel 5

Prof. Alla Pozdnakova is a Professor at the Scandinavian Institute of Maritime Law, University of Oslo Law Faculty. She holds a doctoral law degree from the University of Oslo (2007), LL.M in International and European Law (2001) from the Riga Graduate School of Law and a law degree from the University of Latvia Law Faculty (1999).

Prof. Pozdnakova is co-editor for the law journal Oslo Law Review published by the Scandinavian University Press, a board member of the Norwegian branch of the International Law Association, a member of the Northern Areas Committee and Chair of the Research Group International Law and Governance at the University of Oslo. Pozdnakova teaches EU/EEA law, administrative law, law of the sea and Arctic law at the University of Oslo. She has published on a broad range of topics of public international law, law of the sea, EU competition law, environmental law, Arctic and comparative law.

Her research interests also include outer space law and she is a member of the Space Law committee tasked with the preparation of a draft proposal for the new Norwegian Outer Space Act. She is a co-editor for the forthcoming book titled 'Environmental Rule of Law for Oceans: Designing Legal Solutions' at Cambridge University Press.

María Carolina Romero Lares
Associate Professor, World Maritime University
Commentator Panel 5

Dr. Romero received a Law degree from the Universidad Católica Andrés Bello in Caracas, Venezuela, in 1995. She initiated her career as a lawyer working for the firm Rodríguez & Mendoza, Abogados and later at the Legal Department of Banco de Venezuela (Bank of Venezuela) in Caracas. She obtained an LL.M. degree from Tulane University, New Orleans, in the U.S. and she continued her education in Germany, where she finished her PhD at Hannover Universität with honours (cum laude).

From 2005 to 2009 she worked at the International Affairs Office of the Venezuelan Maritime Administration (INEA) in Caracas, where she reached the position of Head of the International Office and represented her country in several international meetings at IMO and the IOPC Funds in London. During those years she was elected as President (ad-honorem) of the Advisory Committee on the Law of the Sea and Maritime Law by the Secretary of Transportation's Office of Venezuela; in order to produce maritime legislation proposals to be presented to the Secretary and subsequently to the Venezuelan Parliament.

She started her academic career in 2005 as a part-time Professor at the Universidad Nacional Experimental Marítima del Caribe (Venezuelan Maritime University), where she taught several courses dealing with Law of the Sea and IMO Conventions, supervised master dissertations and acted as referee for several publications. She was also invited to lecture at the Venezuelan Diplomatic Academy.

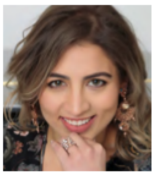
Dr. Romero joined WMU in 2010 and currently teaches the following courses: Maritime Law & International Maritime Conventions, Law of the Sea and Maritime Security, Law and Policy related to the Marine Environment and Principles of Maritime Administration and Management. She is also in charge of organising the annual Moot Court Competition for the Master of Science Law & Policy Specialization focusing on current issues of public international law.

Dr. Romero has been very active in the delivery of Professional Development Courses on the Law of the Sea with a special focus on Maritime Boundary Delimitations. She has also participated as a speaker in several conferences regarding the protection of the marine environment and the advancement and empowerment of women. Her main areas of research are the Law of the Sea, pollution liabilities, ocean governance, and the IOPC Funds.

Dr. Beatriz Martinez Romera
Associate Professor on Environmental and Climate Change Law, University of Copenhagen
Commentator Panel 5

Dr. Beatriz Martinez Romera is an associate professor of environmental and climate change law at the University of Copenhagen Faculty of Law. She has a keen interest in the international climate negotiations, and the regulatory processes at the International Civil Aviation Organization and the International Maritime Organization, as well as the developments at the EU level.

For the last 13 years, Dr. Martinez Romera has been teaching and researching on the field of climate, environment and energy transition law. She is the coordinator of the master courses on Climate Change Law and International Environmental Law and the Advanced LLM on Energy Law (NSELP). In 2020 she was awarded the Young Investigator Carlsberg Foundation Grant for a 3-year project on International Law-Making: Actors in Shipping and Climate Change. She is PI for a number of research projects including the Independent Research Fund Denmark project Enhancing Climate Action through International Law and the NOS-HS project Climate Change and Ocean Governance: Understanding International and Regional Ocean Regimes through the Lens of Climate Change.



Luciana F. Coelho
PhD Candidate and Research Assistant, WMU-Sasakawa Global Ocean Institute
Rapporteur Panel 5

Ms. Luciana Fernandes Coelho is PhD candidate with the WMU 'Land to Ocean' programme supported by the Swedish Agency for Marine and Water Management and the German Federal Ministry of Transport and Digital Infrastructure and hosted at the World Maritime University (WMU) – Sasakawa Global Ocean Institute.

She has been working in academia and civil society with issues related to the law of the sea, fisheries law, environmental justice and law-policy-science interface for over eight years. Her PhD research investigates the implementation of the framework governing Marine Scientific Research under UNCLOS by Small Island Developing States. She anticipates that her findings will have a positive impact on discussions about equity in ocean sciences, achieving the sustainable development goal 14, negotiations on BBNJ, and implementing the 2030 Seabed Survey and the Ocean Decade.

Ms. Fernandes Coelho holds an M.Sc. in Environment, Politics & Society from the University College London, UK, a Masters of Law from the University of Brasilia, Brazil, and a Bachelor of Laws with first-class honour from the Dom Bosco University, Brazil.

Ellen Johannesen
PhD Candidate and Research Assistant, WMU-Sasakawa Global Ocean Institute
Rapporteur Opening Keynote Address of Day Two

Ms. Ellen Johannesen is PhD candidate with the WMU 'Empowering Women' programme supported by the is PhD candidate with the WMU 'Land to Ocean' programme supported by the Swedish Agency for Marine and Water Management and the German Federal Ministry of Transport and Digital Infrastructure and hosted at the World Maritime University (WMU) – Sasakawa Global Ocean Institute.

A Canadian who has spent the past 14 years in Copenhagen, and since 2009 working in marine science administration as the Coordinating Officer at the Secretariat of the International Council for the Exploration of the Sea (ICES).

With an interdisciplinary background, her professional interests include international marine science cooperation and administration, the ecosystem approach, and more recently considering the role of gender in ocean science.

Hide Sakaguchi
President of the Ocean Policy Research Institute of the Sasakawa Peace Foundation
Moderator Panel 6

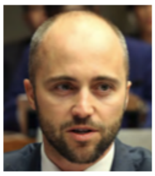
Dr. Hide Sakaguchi has served as president of the Ocean Policy Research Institute (OPRI) of the Sasakawa Peace Foundation (SPF) since April 2021, and as an executive director of SPF since April 2022. Previously, he served as Executive Director at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC, 2018-2021). He joined JAMSTEC in 2003 and led various earth science programs as director of the Institute for Research on Earth Evolution and director of the Center of Mathematical Science and Advanced Technology.

He specialises in granular and fracture mechanics, simulation science and programming, earthquake mechanisms and plate tectonics, and oceanography. He served as a principal research scientist at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia (1998-2002) and adjunct professor at the Earthquake Research Institute, The University of Tokyo (2002–2003). He has a PhD from the Graduate School of Agriculture, Kyoto University.

Suzanne Agius
Head of Policy and Permitting, Environment and Climate Change Canada
Speaker Panel 6

Ms. Suzanne Agius is the current Head of Policy and Permitting in the Marine Programs Division of Environment and Climate Change Canada.

Having studied marine ecotoxicology and law, she now has nearly 20 years of experience with disposal at sea permitting and monitoring. She has attended London Protocol and Convention Meetings as a Canadian delegate for several years and has served as a member of the London Protocol Compliance Group since 2016.



Carl Grainger
Legal Counsellor, Department of Foreign Affairs, Ireland
Speaker Panel 6

Mr. Carl Grainger is a Legal Counsellor at the Department of Foreign Affairs, Ireland. He advises on a wide range of matters involving public international law, EU law and Irish law. He regularly represents Ireland at the EU and UN levels, in particular in the law of the sea forums. He is a member of the EU team in the ongoing BBNJ negotiations, focusing on the area of capacity building and the transfer of marine technology. Previously he held positions with UNHCR, the Irish High Court and the School of Law, at University College Dublin.

He holds an LLB in Law from the University of Durham, an LLM in Public International Law from University College London and a Barrister-at-Law Degree from King's Inns. He was called to the Bar of Ireland in 2010.

Fuad Bateh
2022 G77 & China Chair's BBNJ Team
Speaker Panel 6

Mr. Fuad Bateh consults regularly for a variety of organizations and institutions working in development, law and negotiations related to environment and water resources.

Throughout 2019, he led negotiations on behalf of the Chair of the Group of 77 at the United Nations on the intergovernmental conference to elaborate an international legally binding instrument under the UN Convention on the Law of the Sea, and this support has continued to the 2022 Chairman of the Group of 77.

Previously, he served as the Water Governance and Infrastructure Advisor to the Office of the Quartet; Advisor on Environment and Water to the Secretariat of the Union for the Mediterranean; Advisor to the Palestinian Minister of Water working on multilateral negotiations and water sector reform; Legal Advisor to the Palestinian Chief Negotiator and negotiations team; and also a legal consultant for the International and Environmental Law unit of the World Bank.

Kahlil Hassanali
Senior Researcher, Institute of Marine Affairs in Trinidad and Tobago
Commentator Panel 6

Dr. Kahlil Hassanali is a senior researcher at the Institute of Marine Affairs in Trinidad and Tobago with over ten years of experience in the field of marine policy and governance.

He holds a BSc. in Environmental Sciences from the University of East Anglia (United Kingdom), an MSc in Environment and Development from the University of Reading (United Kingdom) and a PhD in Maritime Affairs from the World Maritime University – Sasakawa Global Ocean Institute (WMU-GOI). Additionally, he was a 2013-2014 recipient of the United Nations-Nippon Foundation of Japan Fellowship where he received advanced training in ocean affairs and Law of the Sea. He was also a 2017-2018 Hubert Humphrey Fellowship recipient in the field of Natural Resources, Environmental Policy and Climate Change. He has served as lead negotiator for the Caribbean Community (CARICOM) on Environmental Impact Assessment in the process to develop a legally binding instrument being negotiated under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (The BBNJ Agreement).

Vasco Becker-Weinberg
Professor, Faculty of Law of the Universidade Lusófona
Commentator Panel 6

Prof. Vasco Becker-Weinberg is a professor at the Faculty of Law of the Universidade Lusófona, teaching Constitutional Law, Public International Law and EU Law. He is also the founder and former coordinator of the Masters on Law and Economics of the Sea at NOVA School of Law, where he lectures on the Law of the Sea and EU Law of the Sea. He has researched at prominent academic institutions and written and published extensively on the Law of the Sea. He is the founder and president of IPDM–The Portuguese Institute of the Law of the Sea (www.ipdm.pt) and the Editor-in-Chief of the recently launched Portuguese Yearbook of the Law of the Sea. He has been on several delegations to international fora and often advises on public international law and the law of the sea matters.

More recently he has been part of the national Portuguese delegation to the intergovernmental conference on an international legally binding instrument under UNCLOS on the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction. He has also been involved in the drafting of policies and legislation on many ocean governance subjects. He is currently Law Clerk at the Portuguese Constitutional Court and was previously Legal Advisor to the Portuguese Secretary of the Sea and a full-time scholar at the International Max Planck Research School for Maritime Affairs at the University of Hamburg.

Lamin Jawara
PhD Candidate and Research Assistant, World Maritime University
Rapporteur Panel 6

Mr. Lamin Jawara is a PhD Candidate and Research Assistant at the World Maritime University in Malmö, Sweden, where he is currently working on his thesis entitled "Addressing Climate Change Emergency Governance in Global Shipping". He is resident in The Gambia and works as the General Manager of the Gambia Ferry Services, a subsidiary company of the Gambia Ports Authority.

Prior to his appointment as General Manager in 2020, Mr. Jawara had started his career at The Gambia Ports Authority as a Cadet Marine Engineer in 1997 and rose through the ranks to Director of Technical Services, Ferries Division. He worked briefly at the New York City Ferry Services (NYC Ferry) as Engineering Projects Manager and Fleet Maintenance Supervisor from 2017 to 2020. At NYC Ferry, he managed remediation projects of several ferries in collaboration with New York City Economic Development Cooperation (NYCEDE).

Mr. Jawara holds an MSc degree in Marine Technology with a specialisation in Technical Operation of Marine Systems from the Norwegian University of Science and Technology (NTNU) where he worked with Statoil on the development, testing and characterization of renewable fuels as part of his Master's thesis from 2010 to 2011. While studying, he worked as a Teaching Assistant at NTNU. He acquired his BSc in Marine Engineering from the Regional Maritime University in Ghana in 2005 with an award for Best Engineering Graduate. Prior to this degree, he had received a Diploma in Marine Engineering from the same University in 2001.

Mr. Jawara is a Chartered Engineer (UK) and a Chartered Marine Engineer certified by the Institute of Marine Engineering, Science and Technology (IMarEST). As a member of IMarEST he currently serves in various IMarEST Special Interest Groups including the Coastal Science & Engineering.

Jens-Uwe Schröder-Hinrichs
Vice-President (Academic Affairs) and Professor, World Maritime University
Moderator Panel 7

Prof. Jens-Uwe Schröder-Hinrichs is the 4th Vice-President (Academic Affairs) of the World Maritime University (WMU), a university established by the International Maritime Organization (IMO), a specialised agency of the United Nations.

He oversees and directs the development of the academic agenda and related activities to strengthen the academic profile of the University, and is responsible for the academic developments needed to keep WMU as the global centre of excellence in maritime and ocean education, research and capacity building.

In this role, he is supported by a wide range of experience gathered over two decades, during which he has taken on increasingly responsible academic and managerial roles at WMU. His current position provides opportunities to shape the University's academic agenda for the future and necessitates extensive interaction with a wide range of international stakeholders in this unique University.

Prof. Schröder-Hinrichs is an internationally recognized maritime safety expert with a special emphasis on the implementation and enforcement of the legal instruments of the IMO, the parent body of WMU. Prof. Schröder-Hinrichs has been involved for more than 20 years in numerous capacity-building missions during which he advised IMO member State administrations in Europe, Asia, the Middle East, the Caribbean, and Northern America as well as the Black Sea and Caspian Sea areas on issues related to their international obligations under various instruments of the IMO.

His special research interests relate to maritime risk and accident causation modelling. His work with the maritime industry focussed on practical applications of risk assessment tools. His recent work has focussed on the safety of passenger ships not engaged in international voyages.

Over the years, Prof. Schröder-Hinrichs developed a strong interest in the implications of increased levels of automation and new technologies in maritime transport. He was the principal investigator for "Transport 2040: Automation, Technology, Employment – The Future of Work", which was commissioned by the International Transport Workers' Federation (ITF) and launched in 2019.

Prof. Schröder-Hinrichs grew up in the beautiful town of Stralsund in eastern Germany and initially pursued a seafaring career. He studied maritime transport engineering and earned a PhD in safety science. His professional career in the German maritime industry included positions in key companies including Germanischer Lloyd. Prof. Schröder-Hinrichs maintains active links with the maritime cluster in northern Germany, especially with the city of Hamburg through mandates such as serving as a Trustee of the Dr. Jens-Peter and Betsy Schlüter Foundation.

Chris Vivian
Co-chair of GESAMP Working Group 41 on 'Ocean Interventions for Climate Change Mitigation' (formerly the Working Group on Marine Geoengineering)
Speaker Panel 7

Dr. Chris Vivian retired from Cefas, the Centre for Environment, Fisheries and Aquaculture Science (an agency of the UK Department for Environment, Food and Rural Affairs) in October 2016 where he had 30 years experience in an advisory role to UK Government on national and international issues relating to the environmental impacts of various human activities in the marine environment.

From 1989, he was a UK delegate in international meetings under the Oslo (now OSPAR) and London Conventions dealing with waste disposal at sea in the North-East Atlantic and the whole world respectively. He was the Chairman of the Scientific Groups of the London Convention and London Protocol from 2008 to 2011 and was the Chairman of the OSPAR Convention's Biodiversity Committee that dealt with species/habitat protection issues as well as the impacts of human activities from 2006 to 2010. At the London Convention/Protocol meetings Dr. Vivian was heavily involved in the discussions on ocean fertilisation and marine geoengineering from 2007 and chaired the working group that finalised the amendments to the London Protocol on marine geoengineering in 2013.

He received a BSc in Geology and Oceanography in 1971 and a PhD in Marine Geochemistry in 1975, both from the University College of Swansea in Wales.

Sara Seck
Associate Professor and Yogis & Keddy Chair, Dalhousie University
Speaker Panel 7

Dr. Sara L. Seck is an Associate Professor and the Yogis & Keddy Chair in Human Rights Law at the Schulich School of Law and Marine & Environmental Law Institute, Dalhousie University. Her research and teaching explore human rights-based approaches to local, transnational, and global environmental challenges, including business & human rights, plastic pollution, and the oceans-climate nexus. Recent co-edited books are (with Meinhard Doelle) the 2021 Research Handbook on Climate Change Loss & Damage (Edward Elgar) and (with Sumudu Atapattu and Carmen Gonzalez) the 2021 Cambridge Handbook of Environmental Justice and Sustainable Development. In 2019 she received a legal specialist award in Peace, Justice and Governance from the Centre for International Sustainable Development Law. In 2021, she joined the editorial team of the Ocean Yearbook.

Christina Voigt
Professor of Law, Department of Public and International Law and the Research Group for Natural Resources Law, University of Oslo
Commentator Panel 7

Prof. Christina Voigt is a Professor of Law at the University of Oslo, Norway. She is an internationally renowned expert in international environmental law and teaches, speaks and publishes widely on legal issues of climate change, environmental multilateralism and sustainability.

From 2009-2018, she worked as principal legal adviser for the Government of Norway in the UN climate negotiations and negotiated the Paris Agreement and its Rulebook. Professor Voigt is Chair of the IUCN World Commission on Environmental Law (WCEL) and Co-chair of the Paris Agreement Implementation and Compliance Committee. She also is a mother of two young boys, Victor and Oscar.

Sebastian Unger
Ocean Commissioner of the German Federal Government and Director for Marine Environmental Protection at the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV)
Commentator Panel 7

Mr. Sebastian Unger is the Ocean Commissioner of the German Federal Government and Director for Marine Environmental Protection at the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV). Previously, from 2011-2022, he led the research group on ocean governance at the Institute for Advanced Sustainability Studies (IASS), Potsdam. In this role, he initiated numerous international research initiatives, lectured on ocean governance, and advised governments and international organisations on key marine policy processes for achieving ocean health.

In 2007 he was appointed to be Deputy Secretary to the OSPAR Commission for the Protection of the Marine Environment of the North East Atlantic. In that role, he supported negotiations of new international legislation for marine conservation and environmental impacts of human activities, including the development of the world's first network of marine protected areas on the "High Seas". From 2004-2007 Mr. Unger served at the German Federal Foreign Office, where he coordinated the Ministry's work on international maritime affairs. He has an academic background in biology with political science.

Sarah Mahadeo
Research Fellow, WMU-Sasakawa Global Ocean Institute
Rapporteur Panel 7

Ms. Sarah Mahadeo is a Research Fellow in the Closing the Circle Programme which looks at exploring challenges and advancing potential solutions to marine debris, Sargassum and marine spatial planning (MSP) in the Eastern Caribbean. Ms. Mahadeo has more than 7 years of experience working both in terrestrial and marine planning.

Prior to joining WMU, she worked with the MSP global initiative of the IOC-UNESCO for capacity development activities on MSP and the Blue Economy in Trinidad and Tobago, as well as on a series of policy briefs related to MSP on a range of topics including Climate Change, Ocean Governance and Capacity Development. Her work in MSP also includes an internship at Nordregio in Stockholm Sweden in 2018, where she was involved in the Pan Baltic Scope project. Ms. Mahadeo was previously employed as a Town Planner in the Ministry of Planning and Development in Trinidad and Tobago from 2011 until 2020 (with a hiatus for study from 2016-2018). Her work in land use planning involved the assessment of applications for building and the development of land and contributing to policy reviews and other planning guidance. She was also a member of the working committee which produced the national standards for accessible buildings and facilities.

Ms. Mahadeo's educational background includes the Erasmus Mundus Masters in Maritime Spatial Planning, jointly conferred by the University of Seville, Spain; the University of Azores, Portugal and the University IUAV of Venice, Italy. She also holds a BSc in Urban and Regional Planning from Heriot-Watt University, Scotland and a BSc in Biology from the University of the West Indies, St. Augustine, Trinidad and Tobago. Her research interests include stakeholder engagement in planning, land-sea interactions, marine and terrestrial planning integration and developing MSP in small island states.

Shuo Ma
Vice-President (International) and Professor, World Maritime University
Moderator Panel 8

Prof. Ma is a Professor of Maritime Economics and Policy at World Maritime University. He is also Vice-President (International) of the University and responsible for the University's Outreach programs which include Asia-based MSc. Programs, Post-Graduate Diploma courses by distance learning, professional development short courses and the newly developed activities related to E-learning Solutions. He has taught shipping management and port management subjects at the University, including maritime economics, the subject that he has been teaching as a foundation study subject of WMU's MSc. Program in Maritime Affairs. He has acted as visiting professor, external examiner, and research fellow in a number of Asian and European Universities. He has been involved in a number of research projects for private as well as public organisations. His latest book on "Economics of Maritime Business" was published by Routledge Taylor & Francis in 2020. He holds a PhD degree in economics from the University of Paris.

Todd Bridges
Senior Research Scientist, United States Army Corps of Engineers (USACE)
Speaker Panel 8

Dr. Bridges is the US Army and US Army Corps of Engineers' Senior Research Scientist (ST) for Environmental Science. He became one of approximately 40 Senior Research Scientists within the US Army in 2006, where his responsibilities include leading innovation and research and development that support goals related to resilience and sustainability. Dr. Bridges is the founder and National Lead for the USACE Engineering with Nature® (EWN®) initiative (www.engineeringwithnature.org), which includes a network of research, field-scale applications, and communication activities to support the development of nature-based solutions. He led a large international collaboration over five years to develop and publish (in 2021) technical guidelines on the use of natural and nature-based features (NNBF) for coastal and fluvial flood risk management.

Dr. Bridges is the technical lead and Program Manager for the Dredging Operations Environmental Research (DOER) program, one of USACE's largest and longest-running R&D programs. He has chaired international working groups and guidance development for the United Nations' International Maritime Organization and the World Association for Waterborne Transport Infrastructure (PIANC). Over the last 30 years, he has published more than 65 peer-reviewed journal articles, several books and book chapters, and numerous technical reports.

Dr. Bridges and his work have been recognized through the receipt of several national and international awards, including receiving a Distinguished Presidential Rank Award from President Biden in 2021 for "sustained, extraordinary accomplishments."

Aleke Stöfen-O'Brien
Assistant Professor, WMU-Sasakawa Global Ocean Institute
Speaker Panel 8

Dr. Aleke Stöfen-O'Brien LLM, is an Assistant Professor (Research/Ocean Sustainability, Governance & Management) at the WMU-Sasakawa Global Ocean Institute, World Maritime University in Malmö, Sweden. Her research interests include the law of the sea, marine environmental protection and sustainable ocean governance. Her work focuses in particular on plastic pollution and equity questions in (ocean) governance.

Prior to joining WMU, Dr. Stöfen-O'Brien served as a Policy Officer in the Marine Unit of the Federal Environment Agency of the Federal Republic of Germany. Dr. Stöfen-O'Brien has extensive professional experience as an Associate Programme Officer at the Secretariat for the Convention on Biological Diversity (CBD), Montréal, Canada, as a Research Associate at the University of Trier, at the Marine Unit of Directorate-General Environment (DG ENV) of the European Commission, the United Nations Institute for Training and Research (UNITAR) as well as the WHO/Europe representation to the EU working on aspects such as marine environmental protection, marine litter, aquaculture, sub-seabed CO_2 capture and storage, capacity-building and broader aspects of international and European law.

Dr. Stöfen-O'Brien's research work has seen her participate in numerous international scientific collaborations, including that of co-convening Chapter 12 on marine debris and dumping of the United Nations Second World Ocean Assessment, which was published in July 2021. She has also contributed to The Economist Plastics Management Index (in collaboration with the Nippon Foundation), which was published in October 2021 as well as The Economist Invisible Blue report on marine chemical pollution, which was published in collaboration with the Nippon Foundation in March 2022. Aleke serves as PI on the WMU-The Nippon Foundation Closing the Circle Project on Marine Debris, Sargassum and Marine Spatial Planning in the Eastern Caribbean Region.

Dr. Stöfen-O'Brien has extensive teaching expertise, which has seen her most recently serving as the lead co-convenor of the Master Course on Sustainable Ocean Governance at the WMU as well as the convenor of the PhD Course on Ocean Governance in the academic year 2021/2022. Aleke supervises PhD and Master students on a wide range of topics.

Tafsir Matin Johansson
Assistant Professor, WMU-Sasakawa Global Ocean Institute
Speaker Panel 8

Dr. Tafsir Matin Johansson is an Assistant Professor at the World Maritime University-Sasakawa Global Ocean Institute (GOI) in Malmö, Sweden. Tafsir is a techno-policy analyst with a PhD in Maritime Affairs from the World Maritime University, and an LLM in Maritime Law from the University of Lund, Sweden. His duties at the GOI include ocean governance and policy research, teaching and developing innovative policy models to better assess drivers and indicators relevant to the ocean research agenda. Tafsir has published extensively on maritime and ocean issues including techno-regulatory dynamic governance, Arctic governance, vessels of concern, corporate social responsibility, marine pollution, climate change, conflict management and trust ecosystem, and Brexit and fisheries. Tafsir has worked on or led a number of multidisciplinary projects, including regulatory development projects funded by Transport Canada (Government of Canada) since 2014, as well as those funded under the Canadian Government's Oceans Protection Plan covering numerous topics critical to the maritime and ocean domain. Currently, Tafsir serves as a CO-PI in a European Union Horizon2020 Programme funded project titled "Overcoming Regulatory Barriers for Service Robotics in an Ocean Industry Context" (BUGWRIGHT2; GA 871260).

Thomas Klenum
Executive Vice President, The Liberian Registry
Commentator Panel 8

Mr. Thomas Klenum (FRINA, C.Eng, Eur.Ing) is Executive Vice President for the Liberian Registry with a career spanning 30 years as Naval Architect and Principal Surveyor to Managing Director with extensive technical, managerial and leadership experience gained through long term international assignments to China, United Kingdom, Luxembourg, the United States and Germany in addition to extensive experience from the Nordic area based in Denmark.

He graduated in 1993 with a B.Sc. in Naval Architecture and after a short period at A.P.Moller-Maersk's shipyard (Odense Steel Shipyard) in Denmark worked for over 20 years for Lloyd's Register prior to taking up the position as Managing Director for SeaNet Maritime Services & Technical Director for Liberian Registry (both part of the YCF Maritime Group) in 2014. He was appointed as Senior Vice President for Maritime Operations in January 2020 and from January 2022 as Executive Vice President for Innovation and Regulatory Affairs with the Liberian Registry.

Yoshitaka Ota
Director of Nippon Foundation Ocean Nexus Centre
Commentator Panel 8

Dr. Yoshitaka Ota has a background in social anthropology at the University College London. He has conducted ethnographic research on various coastal communities, including Palau, UK, Indonesia and Japan, studying socialisation and cultural meanings associated with fishing practices. He is also director of the Nippon Foundation Ocean Nexus Center, an international initiative comprising an interdisciplinary team of 20+ institutes and cross-disciplinary scholars. As an anthropologist conducting social and cultural research on various coastal communities, one recurring theme he has witnessed across the world is the inequity between those who have access to and benefit from oceans and those who rely on oceans to live.

We know that the human relationship with oceans under modern market systems is unsustainable, unstable and inequitable. We hear that in stories about overfishing and plastic straws and coral reefs. What we do not often see are the human stories about the ocean communities that are already facing urgent ecological, social and political problems, even before complex environmental challenges are layered on. We are not in the rooms where scientists and leaders make political and societal decisions to the best of their ability but without the capacity to not further disadvantage the marginalised and the disempowered. We need to create a new platform for ocean governance to identify the inequities that exist, develop knowledge-based solutions, and actually enact these changes to make oceans equitable for everyone.

Tricia Lovell
PhD Candidate and Research Assistant, WMU-Sasakawa Global Ocean Institute
Rapporteur Panel 8

Ms. Tricia Lovell is a PhD candidate with the NF-WMU 'Closing the Circle Programme: Marine Debris, Sargassum and Marine Spatial Planning' in the Eastern Caribbean, generously funding by The Nippon Foundation, hosted at the World Maritime University (WMU) – Sasakawa Global Ocean Institute. Ms. Lovell has over two decades of experience in fisheries management, environmental conservation and broader ocean governance. She holds a Masters of Marine Management from Dalhousie University and is a United Nations Nippon Foundation Fellow.

Ms. Lovell has served as Antigua and Barbuad's National Focal to the Ramsar Convention as well as the Marine and Coastal Biodiversity Focal Point to the Convention on Biological Diversity. She has also served as the Deputy Chair of Antigua and Barbuda's National Ocean Governance Committee.

Clive Schofield
Head of Research, WMU-Sasakawa Global Ocean Institute
Commentator Reporting Session Day 1

Prof. Clive Schofield is Head of Research at the World Maritime University-Sasakawa Global Ocean Institute in Malmö, Sweden, a Visiting Professor with the Australian Centre for Ocean Resources and Security (ANCORS), University of Wollongong (UOW), Australia, a Distinguished Fellow of the Law of the Sea Institute at the Law School of the University of California Berkeley and teaches on the Law of the Sea programme at Harvard Law School.

His research interests relate to international boundaries and particularly maritime boundary delimitation and marine jurisdictional issues on which he has published over 200 scholarly publications. Clive is an International Hydrographic Office (IHO)-nominated Observer on the Advisory Board on the Law of the Sea (ABLOS) and is a member of the International Law Association's Committee on International Law and Sea Level Rise. He has also been actively involved in the peaceful settlement of boundary and territory disputes by providing advice to governments engaged in boundary negotiations and dispute settlement.

Rián Derrig
Postdoctoral Fellow, WMU-Sasakawa Global Ocean Institute
Commentator Reporting Session Day 1

Dr. Rián Derrig is a Postdoctoral Fellow at the WMU-Sasakawa Global Ocean Institute of the World Maritime University. His research focuses on the history and theory of international law and on redistribution in the law of the sea. He is currently writing a book, 'The New Haven School and the International Law of the Twentieth Century United States', which is forthcoming with Oxford University Press.

Dr. Derrig has provided expert legal advice on law of the sea related topics to state delegations participating in international treaty making processes. He has advised national parliamentarians addressing the law of the sea and ocean governance issues and has drafted legislation on these topics. Dr. Derrig is a member of the International Law Association (ILA) Committee on International Law and Sea Level Rise as the nominee of the ILA Irish Branch. He writes annually for the Irish Yearbook of International Law as the reporting correspondent on Irish state practice on the law of the sea.

Before joining the WMU, Dr. Derrig was a Postdoctoral Research Fellow at the Center for Global Constitutionalism of the WZB Berlin Social Science Center. He defended his doctoral thesis at the European University Institute in September 2019. He was awarded the 2018 Young Scholar Prize of the European Society of International Law and the 2020 Antonio Cassese Prize of the European University Institute.

Aykut I. Ölcer
Director of Maritime Research and Professor, World Maritime University
Commentator Reporting Session Day 2

Professor Dr. Aykut I. ÖLÇER is a naval architect and marine engineer holding the Nippon Foundation Professorial Chair in "Marine Technology and Innovation" at the World Maritime University (WMU). He is currently the Director of Research of WMU as well as the Head of Maritime Energy Management Specialization (MSc program). He served as the Editor-in-Chief of WMU Journal of Maritime Affairs (JOMA) and Book Series between February '17 and February '19. Prior to joining WMU, he worked at Newcastle University (England), the University of Strathclyde (Scotland) and Istanbul Technical University (Türkiye) within the fields of Naval Architecture and Marine Engineering. He played an important role in Newcastle University's first international branch in Singapore to help the University achieve its objectives in teaching/learning and research activities in the UG and PG programs of Marine Technology.

For many years, he has conducted research independently/jointly and collaborated with other researchers, academics and students all over the world, in particular from Europe and Asia. Dr Ölçer was involved in numerous EU funded FP5, FP6, FP7, Horizon 2020 and EU Horizon projects and IMO projects as well as IAMU and regional projects in Scandinavia. He currently leads the research priority areas, namely 'Maritime Energy Management" and "Marine Technology and Innovation", at WMU. He has published results of his research in leading, internationally peer-reviewed journals such as the "Journal of Cleaner Production", "Fuel Processing Technology", "European Journal of Operational Research", "Computers and Operational Research", "Applied Soft Computing", "Transportation Research Part D: Transport and Environment" and so on. He is the main Editor of the book "Trends and Challenges in Maritime Energy Management ", which was one of the most downloaded Springer books in 2018. He delivered keynote speeches all over the world, in particular in the discipline of maritime decarbonisation.

FUTURE DEVELOPMENT

16.

MODERATOR
Professor Shuo Ma
Professor and Vice-President (International), World Maritime University

The London Convention regime and the legacy of the Stockholm Declaration continue to shape contemporary policies and law-making addressing new environmental challenges. In this regard, the eighth panel of the Conference dealt with emerging environmental topics such as nature-based solutions, the plastic treaty negotiation process, and maritime robotics and autonomous systems. The discussion, including presentations, commentators, and the Q&A section, underscored the need to foster natural systems to mitigate the adverse impacts of climate change, the importance of reaching an agreement for combating plastic pollution, and the development of a techno-regulatory legal framework that coheres with environmental principles enshrined in the Stockholm Declaration. The panel was moderated by Professor Shuo Ma and Ms Tricia Lovell served as rapporteur.

Prof. Ma introducing Panel 8 contributors at the IMO WMU Joint International Academic Conference, 12 October 2022, Malmö, Sweden.

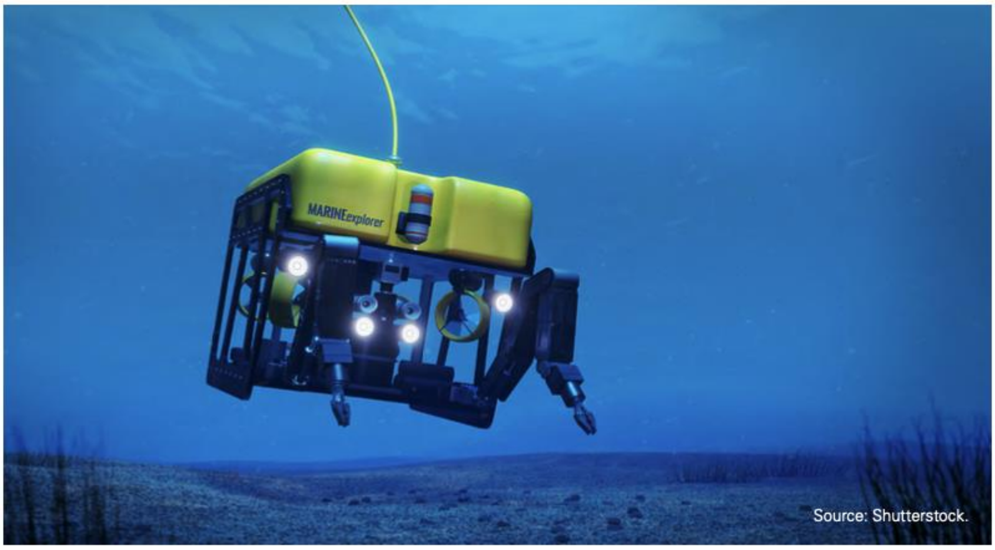
16.3 RECONNOITERING TECHNO-REGULATORY DIMENSIONS OF THE HUMAN ENVIRONMENT IN MARITIME ROBOTICS AND AUTONOMOUS SYSTEMS

Dr Tafsir Matin Johansson
Assistant Professor, WMU-Sasakawa Global Ocean Institute


Source: Shutterstock.

1. INTRODUCTION

We imagine a future where robots would be inspecting and cleaning the hull of a ship that is anchored while loading its new cargo. In the future, we believe that verifying a ship's structural soundness would cost minimal downtime, if any, leading to safer ships and improved competitiveness. Robotic technologies would seamlessly integrate into the current manual classification and statutory surveys. Therefore, integration, as well as a solid legal framework, are key elements of this future.



Source: Shutterstock.

2. TECHNOLOGIES AND THE NEED FOR INTEGRATION

Three specific technologies known as remote inspection techniques are drones, magnetic crawlers, and underwater vehicles. They operate in their own designated environment, namely, air, steel surface, and underwater, respectively. Monitors are used to visualise them in real-time while detecting corrosion, buckling, cracking, and significant deterioration for maintenance purposes. These technologies allow the completion of tasks that are otherwise time-consuming, risky, and very onerous but nonetheless of vital importance for the safety of shipping. Further, as this technology includes the progressive integration of artificial intelligence in manual inspection and reducing vessel source emissions, especially from biofouling, one key element is how to integrate maritime robotics and autonomous systems or remote inspection techniques.

3. FRAMING THE ENVIRONMENT

There are around 53,973 merchant ships of which 9,734 are large vessels and 4,759 are very large vessels. The range of age of the latter is between 0 and 25 years. A layer of slime as thin as 0.5 mm covering up to 50% of a hull surface can trigger an increase of greenhouse gas (GHG) emissions in the range of 20 to 25% depending on ship characteristics, speed, and other prevailing conditions. Furthermore, a light layer of small calcareous growth on an average-length container ship can see an increase in GHG emissions of up to 55%, depending on ship characteristics and speed.

This data is to be read in the context of a legal landscape in which UNCLOS remains at the heart of all discussions. According to Article 94 (3) of UNCLOS, every State shall take measures for ships flying its flag to ensure safety at sea regarding the construction, equipment, and seaworthiness of ships. Likewise, Article 194 (1) mandates States to take, individually or jointly as appropriate, all measures necessary to prevent, reduce, and control pollution of the marine environment from any source and to harmonise their policies in this respect.

The safety of life at sea and joint environmental protection require a harmonised approach. Whereas harmonisation is to be achieved through communication, collaboration, negotiation, and international fora, it may represent a challenge. Therefore, the work done by IMO, particularly as implicitly referenced by Articles 197 and 211 of UNCLOS as a means for cooperation, must be highlighted.

4. THE RO CODE AND THE MAINTENANCE REGIME

Techno-regulatory governance made its entrance with the Code of Recognized Organizations (RO Code) as adopted by IMO Resolution MSC.349(92). The RO Code allows organisations to publish rules and requirements about design, construction, or certification. Concerning the maintenance regime, the RO Code contains minimum criteria against which organisations are assessed towards recognition. It is worth noting that, through the rule of reference, UNCLOS has created a synergistic gateway of integration for discussing the work of other international organisations such as the International Organization for Standardization (ISO) and the International Association of Classification Societies (IACS).

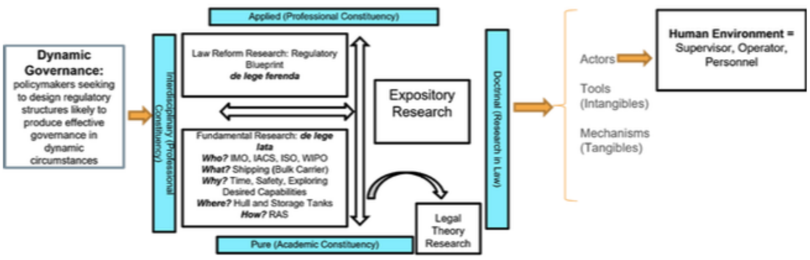
5. THE TECHNO-REGULATORY ENVIRONMENT AND IDENTIFIED BARRIERS

The technical standards from a remote inspection technique perspective as provided by the ISO, as well as the regulatory standards as provided by IACS, are to be considered the technical regulatory environment. Within this environment and as confirmed by the dynamic governance theory, three elements must be brought to the fore. These are tools, mechanisms, and actors. While tools refer to remote inspection techniques, mechanisms are meant to promote regulatory objectives. In addition, actors refer to the stakeholders that come into play. Notably, the human factor resides in the actor category. Whether supervised autonomy, semi-autonomy, or progressive autonomy, human intervention, as supervisor, operator, or personnel, is indispensable since the current system is not fully autonomous.

Despite the importance of the above-mentioned elements, they may also represent external barriers to future development. Considering that actors include the triple helix composed of university, government, and business, meaningful participation is required for developing a common language programme. Moreover, the tools referred to in work currently undertaken by the IMO Member States require new guidelines or a common methodology. A top-down approach or a soft law or a guideline would be beneficial to the industry. Finally, mechanisms need to foster synchronisation in technology, including closing gaps between the Global South and Global North and bridges that need to be built.

The current landscape of regulatory provisions is uneven and begs several questions. Among others, these conundrums, which are to be considered internal barriers to future development, include the following:

ELEMENTS WITHIN THE TECHNICAL REGULATORY ENVIRONMENT



Source: Markell, David L. and Glicksman, Robert L., Dynamic Governance in Theory and Application, Part I (2016) FSU College of Law, Public Law Research Paper No. 791; GWU Legal Studies Research Paper No. 2016-15 (Draft) published in 58 Arizona Law Review 563(2016).

Dr Johansson giving his comments at the IMO WMU Joint International Academic Conference, 12 October 2022, Malmö, Sweden.

- definition of remote inspection techniques and their difference from remote surveys
- close-up surveys
- variety and human element
- degree of autonomy
- safety
- data storage and data preservation
- liability
- time
- trustworthy product

Combining the internal barriers plus external barriers, they represent a considerable hindrance to future development.

6. TOWARDS FUTURE DEVELOPMENT

In tackling the barriers to future development, five strands supported by the provisions of the Stockholm Declaration deserve special attention:

Human Environment: Technology creates or helps to create the environment we desire. Preambular paragraph 1 of the Stockholm Declaration states that through science and technology, man has acquired the power to transform his environment.

Ecosystem: Trustworthy ecosystems are to be achieved while recalling that Principle 1 of the Stockholm Declaration calls for an environment of quality for future generations.

Synchronisation: Umbrella regulations should be preferred as they respond to Principle 25 of the Stockholm Declaration exhorting States to ensure that international organisations play a coordinated, efficient, and dynamic role.

Harmonisation: Bridges need to be built to close the gap between the Global South and the Global North. Principles 9 to 12 of the Stockholm Declaration place special emphasis on developing States.

Partnerships: We must move to integrate other organisations besides ISO and IACS. Principle 13 of the Stockholm Declaration provides for adopting an integrated and coordinated approach to development planning.

7. CONCLUDING REMARKS

We are witnessing a paradigm shift. As technology is not fully autonomous, on the day an autonomous drone strikes or injures someone, we may start assessing whether to call it a casualty, fatality, or an accident. Judges will not bend their arms and say that there are no rules on the autonomy of autonomous drones. Therefore, they will need to use regulatory provisions available today, which might be not enough. For this, there is an imperative need to continue addressing the regulation of current and emerging technologies, in which the endeavours of IMO need to be highlighted and strengthened.

16.4 REMARKS FROM COMMENTATOR

Thomas Klenum
Executive Vice President, The Liberian Registry

Mr Klenum highlighted Dr Johansson's data concerning underwater marine fouling on ships' hulls. He recalled that these initiatives fall into the IMO GHG Emission Reduction Strategy adopted in 2018, which came into effect on the 1 January of 2023. This framework includes the Carbon Intensity Indicator (CII) which is mainly based on the distance travelled within a calendar year and the corresponding fuel consumption. Applying underwater magnetic crawlers to the regular cleaning of the ship's underwater hull can improve the ship's performance by 25%, meaning a corresponding 25% reduction in fuel consumption. These new technologies thus have major positive environmental and operational consequences for the industry if they are widely applied.

More specifically, he noted this helps ships improve their rating format leading to full compliance with the CII requirements. Further, Mr Klenum stressed the 25% cost reduction gives an outstanding return on investment for the use of an underwater magnetic crawler to clean the hull. This is how technologies can offer a true win-win situation by contributing to environmental regulatory compliance and at the same time reducing costs. This also reinforces the importance of the theme from the IMO 2022 World Maritime Day 'New technologies for greener shipping'.

Moreover, in referring to the techno-regulatory legal framework, particularly the human element, he asked Dr Johansson about the basis for dissecting rules and requirements promulgated by IACS and how he can apply his findings in the human autonomy context.

Dr Johansson mentioned that all endeavours were based on pursuing a common methodology for a remote survey, including the inspection techniques. They first dissected and labelled every IACS rule and requirement, and then individual class society rules and requirements. The comparison between them helped to create a regulatory blueprint, which was further aided by interviews to look at the acceptance level of why some societies and service suppliers prefer remote inspection techniques as opposed to others. This blueprint aims to protect the environment while creating a level playing field from a horizontal policy perspective.

Mr Klenum referred to Dr Stöfen-O'Brien's presentation while emphasising her characterisation of plastic pollution as a reverse tragedy of the commons and the need for collective approaches to solving the problem. Then he asked about the best ways to ensure collective and pragmatic actions from all stakeholders.

Dr Stöfen-O'Brien commented that although there are different opinions regarding how to tackle the plastic pollution issue, there is an imperative need to allow these discussions to continue while being open to hearing from all stakeholders. Further, referring to individuals involved in the plastic treaty process, she encouraged undertaking a thorough assessment of the available national information so as to strengthen their State's position in the treaty negotiations. Finally, she recalled that a vast amount of information is available from the UNEP database.

Finally, referring to Dr Bridges' presentation, Mr Klenum noted that the navigation sector is working on decarbonising international shipping and environmental management. He asked Dr Bridges' opinion on how port infrastructure can support environmental management, particularly with a focus on the interface with the navigation sector.

Dr Bridges expressed the view that the navigation sector has the greatest capacity to influence climate adaptation on a broad scale. He noted that the United States has a navigation channel network 25,000 miles long where they dredge more than 200 million cubic metres of sediment every year. The vast amount of shoreline along rivers and coastline is where resilience from extreme floods as well as drought needs to be created. The beneficial use of these resources aids the creation and restoration of natural habitats while creating resilience for all communities.

16.5 KEY TAKEAWAYS

- **Nature-based solutions** are measures to conserve, restore, and engineer nature for the benefit of the people and nature. These are tools that can reduce the negative impacts of weather and climate disasters that climate change exacerbates.
- Managing **dredged sediments** can support natural systems' production of new habitats. This beneficial use can reduce waste production and the need for dumping in the ocean. Further, it can contribute to mitigating the adverse impacts of climate change and natural hazards.
- As the existing legal framework is insufficient to tackle the negative impact of **plastic pollution** on the environment and human health, effective and implementable measures to be shaped among all the relevant actors, including industry and civil society, are urgently required.
- Current international efforts to develop a **global agreement** to eliminate plastic pollution by 2024 have a strong focus on a multi-stakeholder dialogue. However, some challenges are posed by the necessity to integrate several other legal regimes, to pursue global interests rather than particular interests, and funding.
- In fulfilment of States' international duties related to the safety of life at sea and the protection of the marine environment, the **integration** of the growing use of robotic technologies with autonomous systems or remote inspection techniques deserves careful attention.
- The **techno-regulatory legal framework** led by IMO needs to be strengthened to address the regulation of current and emerging technologies while tackling the internal and external barriers that hinder the future development of the industry. Principles contained in the Stockholm Declaration are highly relevant to this aim.

Panel 8 Q&A section at the IMO WMU Joint International Academic Conference, 12 October 2022, Malmö, Sweden.

16.6 FURTHER INFORMATION AND MATERIAL

For further information and material from the Conference, please find the following documents at your disposal:

Summary of the Q&A Section

Also available here:
https://bit.ly/3YsIE2I

Conference Recording of Panel 8

Also available here:
https://bit.ly/47sJOOy

Post Conference material

Also available here:
https://bit.ly/3QxqF88

BUGWRIGHT2 Remote Inspection Techniques in Medium and Small-Sized Scandinavian Ports: Application, Advantage & Adversity

Aspasia Pastra[1], Tafsir Johansson[2], Herbert Francke[3] and Dimitrios Dalaklis[4]

Abstract: During the last few years, the utilization of Remote Inspection Techniques (RIT), including Unmanned Aerial Vehicles (UAVs) and Remote Operated Vehicles (ROVs), has gained significant momentum within the maritime sector. Today, RIT are rather extensively being exploited for ship inspection and maintenance purposes, thereby revolutionizing conventional practices and setting a new benchmark in the industry. In this context, these technologies are clearly emerging as indispensable tools in the modernisation of port operations. By effectively leveraging the capabilities of these technologies, ports can achieve remarkable strides in security, safety, efficiency, and sustainability.

This paper aims to examine the extent to which small and medium-sized ports in Scandinavia are using RIT for ground-based port operations and sea navigation. To this end, it is based on findings from a focus group discussion with seventeen (17) different Port Facility Security Officers (PFSOs) in Scandinavia that draw reference to the extent of use of these technologies in ports. Recommendations for the use of RIT in ports have been, thereupon, tabled considering the need for a review of the International Ship and Port Facility Security (ISPS) Code to address the application of UAVs in managing port security.

Keywords: Remote Inspection Techniques, drones, remotely operated vehicles, port security, port technology.

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[4] World Maritime University, Malmö, Sweden.

1. Introduction

The maritime industry, quite frequently viewed as the cornerstone of global trade, has witnessed significant technological advancements over the course of time and especially during the past few decades (WMU, 2019). Among various other advanced technology applications, it is the progression of autonomous technologies that stands to radically alter the landscape of maritime and port industries, promising an amalgamation of efficiency, safety, and economic viability. In this era of the fourth industrial revolution, Robotic and Autonomous Systems (RAS) in the maritime sector emerged after a cascade of Artificial Intelligence (AI) technological breakthroughs (Ichimura et al., 2022; Johansson, 2022). Within this tech-forward wave, remote inspection techniques (RIT), an offshoot of RAS, emerge as a vital trend, redefining inspection methods and ensuring vessel seaworthiness. RIT has been conceptualised as "… a means of a survey that enables examination of any part of the structure without the need for direct physical access of the surveyor" (IACS, 1997/Rev 2023). Currently, the mode of operation is termed "supervised autonomy," denoting the ongoing necessity for human surveyor oversight (Pastra et al., 2002).

Common types of industry-deployed RIT include unmanned aerial vehicles (UAVs) and remotely operated vehicles (ROVs). UAVs can be utilized in vessel surveys to inspect areas that may be dangerous or inaccessible to humans, thereby minimizing the relevant occupational hazards. Similarly, ROVs, which are submersible tethered robots employed in various underwater applications, can safely inspect parts of a ship that might be challenging, such as ship hulls, propellers, and submerged structures. RIT can facilitate more efficient and potentially safer survey and inspection methods. For instance, they can relieve tasks that are otherwise time-consuming, strenuous or fatal due to lack of oxygen or exposure to polluted vapors in confined spaces (Poggi et al., 2020, p. 881-882).

In the context of RIT, the EU project Bugwright2 aims at paving the way towards more effective utilisation of robotics for infrastructure inspection and maintenance by introducing a multi-robot survey team programmed to follow a pre-determined algorithmic pathway for visual and acoustic inspection of a vessel structure to detect corrosion patches, cracking and deteriorated coatings. The World Maritime University (WMU), a Bugwright2 consortium member and a United Nations academic institution founded by the International Maritime Organisation (IMO), has been assumed the task of conducting an in-depth analysis of the legal framework and prepare recommendations for the reform and progressive development of relevant norms concerning autonomous robotics regulation and standards.

The extent of utlisation of RIT and the challenges accompanying their use from Recognised Organisations (ROs), which have traditionally been responsible for the statutory survey of a vessel on behalf of the Flag Administration, have been addressed by WMU. Key challenges to consider for their widespread utilisation include: a) developing guidelines that will provide a uniform approach to conducting statutory remote surveys b) categorising the different "degrees of autonomy" c) forming a secure data governance framework to establish provisions and processes that could offer adequate protection to data-assets and d) delineating product safety and liability parameters to ensure high levels of safety and minimal risk of harm to users (Alexandropoulou et al., 2022; Johansson et al., 2021; Johansson et al., 2023; Pastra et al., 2022; Pastra et al., 2023).

However, the extent of the adoption of these technologies in small and medium-sized ports, along with the barriers to overcome for mass utilisation, remains unexamined. The aim of this paper is to identify the extent of use of these technologies by small and medium-sized ports and provide some relevant initial recommendations to policymakers and port authorities.

2. Ports and Ocean Technologies

Ports, essential hubs for global trade and transportation, have historically been at the forefront of adapting various technological innovations (Christodoulou et al., 2021a; Doelle et al., 2023) . The escalating demands on ports - spurred by burgeoning international trade and heightened environmental concerns- have necessitated the adoption of advanced ocean technologies, fundamentally transforming the landscape of port operations. The surge in automation is reshaping the port sector, influencing its finances, human capital, and operational cadence, thereby affecting productivity in terms of total traffic handled and maximum output obtainable using a given level of resources (Baskin and Swoboda 2023; Karnoji & Dwarakish, 2018; Talley, 2009).

In recent years, the term "smart ports" has gained significant prominence. Smart ports represent a natural evolution in the maritime industry, propelled by the convergence of technological innovation and the escalating demands of global trade. A smart port is an "intelligent digital port that can operate autonomously via the self-configured, self-protective, more adaptive, more secure, more responsive, and highly connected port system" (Min, 2022: 191). This "smartness "is realised through emerging technologies that boost connectivity, achieving horizontal and vertical integration across the entire port's ecosystem (Leclerc and Ircha 2023: 175). The ongoing advancement of Information and Communication Technology (ICT) facilitates an integrative environment between crew members, onshore officials, port officers and electronic equipment that engage synergistically in maritime operations (Dalaklis, 2020a; Ichimura et al., 2022).

Technologies shaping the future of smart ports include Artificial Intelligence (AI), the Internet of Things (IoT), Blockchain Technology, Big Data Analytics, 5G and Unmanned Aerial Vehicles (Ichimura et al., 2022) Artificial intelligence can optimize port operations through demand forecasting and decision-making automation and determine the best course/speed for each voyage (Dalaklis, 2020b). IoT devices that exchange information between people and equipment, and between equipment, such as sensors and cameras, enable for real-time cargo tracking, monitoring of ships and enhanced port security (Leclerc and Ircha 2023).

In addition, port authorities worldwide have increasingly embraced blockchain technology to boost service effectiveness, enhance cargo status updates, streamline the customs clearance process and facilitate the decision-making at every level in the supply chain (Wang 2021; Yang, 2019).

The domain of "Big Data Analytics" entails the scrupulous analysis of large data sets to elucidate concealed patterns, associations, and additional insights, such as market tendencies and consumer predilections, thereby facilitating business decision-making (Dalaklis et al., 2022).

5G technology promises to elevate the competitiveness and efficiency of ports, the bandwidth and speed required for large-scale implementation of automation. Automated cranes, self-driving container vehicles, and other robotic equipment can be seamlessly integrated and operated without lag. Major ports, such as Rotterdam, Singapore, and Hamburg, are progressively transforming into network developers (Johansson et al., 2023). Accordingly, 5G communication networks will enable the users to benefit from ocean technologies and RIT, contributing to sustainable development in various port areas (Cavalli et al. 2021). Beyond streamlining daily operations and global supply chains, 5G and smart ocean technologies can save valuable time and mitigate threats and vulnerabilities in port facilities, including armed robbery, bomb threat, cyberattacks, stowaways, smuggling of drugs, weapons, terrorism, and cargo theft (de la Peña Zarzuelo 2021; Ibrahim 2022; Rébé 2021).

UAVs can monitor illegal and accidental discharges, strengthening port state jurisdiction to prevent ship source pollution, reduce human labor requirements and eliminate human error (Argüello, 2023: Paddock & Crowell, 2021). In addition, the deployment of UAV systems in the port sector can counter maritime security threats and drug trafficking by sea, offering insights into potential criminal activities below the waterline (Ávila-Zúñiga-Nordfjeld et al., 2023).

3. Methodology

This study seeks to glean insights from subject matter experts in the port industry, utilizing focus group discussions as the primary qualitative research method. This approach fosters an environment where participants can interact and brainstorm about the potential use of RIT within their respective ports. The discussions were orchestrated during a two-day Annual Seminar for 17 Scandinavian Port Facility Security Officers (PFSOs), co-organized by the Nordic Crisis Management and the World Maritime University (WMU) on 18-19 April, 2023.

The session was facilitated by an academic faculty member of WMU who presented to the participants the Bugwright2 project and then guided the discussions using a pre-determined set of closed and open-ended questions. Fifteen out of the seventeen participants (88%) indicated that their port falls under the small EU taxonomy and manages an annual volume of goods below 10 million tonnes, whereas two of the participants (12%) confirmed that their port is medium size, managing an annual volume between 10 and 50 million tonnes.

4. Findings

4.1 Drones and ROVs: Utilisation, Benefits and Challenges

The PFSOs were asked to specify if they had set up a format risk assessment for drones based on a systematic approach from safety hazard identification to risk management and 47% responded affirmatively (Diagram 1).

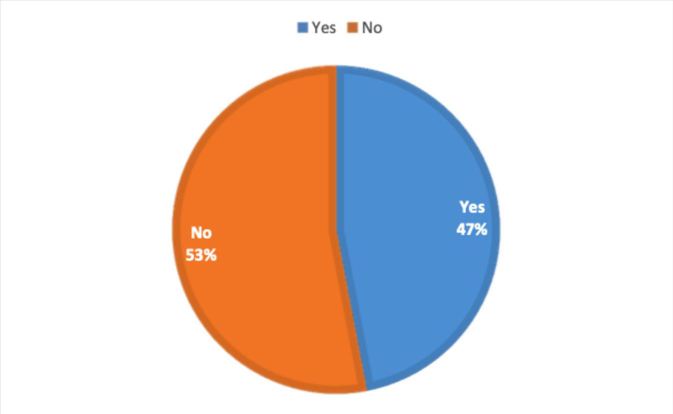

Diagram 1: Formal Risk Assessment for Drone Use

Despite that drones having a multitude of potential applications, small and medium-sized port authorities primarily utilise them for a) routine and on-demand equipment/infrastructure inspections, b) port construction projects, and c) vessel inspections. As noted by the participants, "there are so many ways to utilize them; we are only scratching the surface".

During the workshop, the principal benefits and challenges were thoroughly discussed. A pivotal benefit identified was the drone's capacity to reduce time lags from inspection to emergency response, facilitating swifter responses in scenarios necessitating immediate action, such as security breaches or infrastructure malfunctions. Furthermore, drones offer a comprehensive monitoring solution for extensive port areas, capable of navigating and inspecting locations that are either inaccessible or challenging for human inspectors, including towering cranes, cargo tops, or narrow waterways.

Regarding their challenges, the participants pinpointed technical, regulatory, security and financial hurdles. From a technical standpoint, the potential malfunctioning of drones raises concerns, especially in the harsh environments of ports characterized by saltwater exposure, high humidity, and strong winds. Addressing concerns surrounding navigation, communication interference, and weather resilience is critical in promoting the successful integration of drones into port operations. Technical damage of a drone and potential collision necessitates stringent safety protocols to safeguard both the human element and infrastructure.

Participants also highlighted the current lack of a regulatory framework and universally accepted standards governing drone operations in ports. Ports can leverage the full potential of drone technology, fostering safer, more efficient, and innovative operations with uniform standards for their operation, including safety protocols, privacy safeguards, and security measures.

Another considerable security challenge is distinguishing between friendly and potentially hostile drone activities. Drones could be misused for unauthorized surveillance, leading to possible industrial espionage and threats to port security. Therefore, a central challenge is the differentiation between drones used for legitimate operations and those piloted by malicious actors or inexperienced individuals. Moreover, stringent guidelines need to be set for flight paths and no-fly zones to ensure physical security. It is also vital to obtain consent from vessels and nearby industries, particularly when surveillance or inspection activities could infringe on their privacy or sensitive operations.

Financial considerations are not to be overlooked as high-quality drones for port operations often entail significant expenditures for port authorities, encompassing hardware, software, routine maintenance, and training investments.

Comparatively, the utilization of ROVs is less prevalent, with only 24% of ports adopting them, mainly for a) sub-surface port inspections to verify the integrity of moorings and other marine infrastructures—including quay wall structures, jetties, and breakwaters—and b) data collection from obscure areas, supporting managers in decision-making and accident prevention.

The primary benefits identified associated with ROV use include time-saving in inspecting ship hulls and underwater infrastructure due to the immediate feedback and reduced human intervention (Diagram 2). This technological transformative shift in port operations emphasizes not only the time-saving attributes of ROVs but also their critical contributions to enhancing security and safety within the port environment. On the one hand, remote techniques bolster the safety of the inspection process, mitigating accidents and potential loss of life during diving operations. On the other hand, ROVs can identify underwater threats or obstructions, explosive devices, hidden contraband or illicit goods, ensuring smoother port operations and rapid response to potential disruptions.

The primary challenges encountered with ROVs revolve around visibility constraints and the effects of currents and wind in port environments (Diagram 2). Ports, often situated in locations with constant ship traffic, frequently experience heightened turbidity, resulting from stirred-up sediment, creating murky conditions that hinder ROVs from capturing clear visual data. Additionally, strong water currents can impede ROV navigation, making it difficult to maintain a steady position, particularly during detailed inspections or delicate operations.

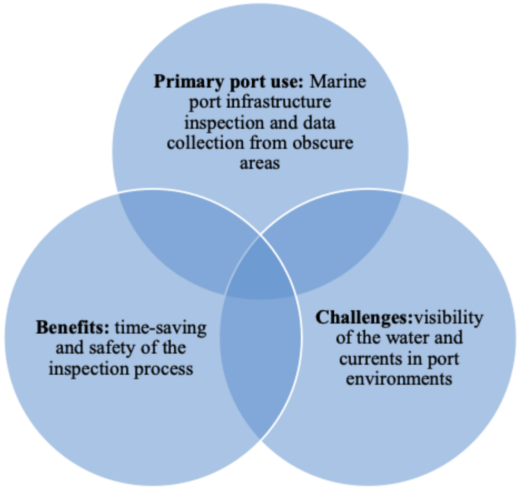

Diagram 2: Benefits and Challenges of ROVs

4.2 Paving the Future: Integrating RIT in Modern Port Operations

The discussion identified the level of trust of the PFSO in drones and ROVs by asking them if they consider these technologies trustworthy. Forty-one percent (41%) of the participants were neutral and thirty-five (35%) replied *rather yes* (Diagram 3).

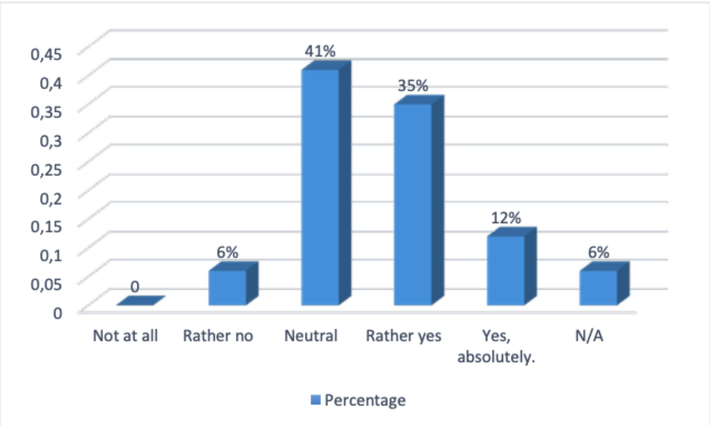

Diagram 3: Level of Trust in RIT

To increase their utilisation and trustworthiness even more, addressing several barriers to facilitate the mass utilization of RIT in port environments is imperative. These barriers encompass the following elements.

Firstly, all the participants agreed on the need for implementing a comprehensive global framework set by the IMO, which will play a pivotal role in orchestrating the use of RIT. The IMO should engage port authorities, shipping companies, drone manufacturers, and technology providers to understand challenges and collaboratively devise solutions that will lead to a set of standardized guidelines. A unified port training program could also be designed for port drone pilots specific to maritime operations that will encompass safety protocols, emergency responses, and security considerations.

Secondly, PFSOs underlined the need for an update of the International Ship and Port Facility Security (ISPS) of IMO as this is the ultimate tool for setting the measures aimed at enhancing the security of ships and port facilities, primarily targeting threats of terrorism. The participants pointed out that although the Code forms the basis for implementing remote airborne - and underwater technology, no substantial revisions have taken place in the past 20 years. While the ISPS Code was forward-thinking at its inception, it did not anticipate the exponential growth in drone technology and other digital innovations. The fact that the Code is quite broad in its requirements and descriptions implies that it is open to adaptations through IMO and national regulations. The Code offers the possibility of accommodating different interpretations and tailoring implementation to fit specific national circumstances. For instance, the 2005/65 EU directive for Enhanced Port Security is a good example of an attempt by the EU to extend the ISPS code. Other regulatory bodies such as MARSEC, EMSA, ENISA have also implemented supporting recommendations and guidelines. Although the provisions in sections B 15.3.5, 15.4.1, 15.7.31, and 15.16.5 acknowledge the need to address networks and computer systems, it is questionable whether these provisions adequately account for future development. The participants underlined that the possibility of updating the Code in the future requires stakeholder consultation and careful consideration of potential implications. Involving port authorities, shipping companies, technology providers, and security agencies could foster a multi-faceted perspective on possible integrations and enhancements, facilitating a comprehensive overhaul of the existing Code that is cognizant of potential future trajectories.

5. Conclusion

In light of the escalating digitization pervading global supply networks, it is imperative for ports to safeguard their pivotal positions as "nodes" within these chains by metamorphosing into digitally enhanced operational hubs or "digital nodes" (Dalaklis et al., 2022). In this context, robotics, such as drones and ROVs, signal a promising trajectory as they can be utilised not only within shipyards and ports, but also at sea or inland waterways, to serve very "niche" transport service needs (Dalaklis et al., 2022; Johansson et al., 2021).

This progressive step towards incorporating RIT into port operations heralds a new era of efficiency and safety in maritime operations. Small and medium-sized ports in Scandinavian have started utilising RIT, promising a blend of efficiency, safety, and sustainability. However, to unlock their full potential and facilitate seamless incorporation into existing systems, a cohesive and universal regulatory framework is indispensable. A well-structured framework from the IMO will not only address the immediate challenges but will also pave the way for future innovations in the domain of remote inspections. A regulatory framework in the form of a

Code of Conduct could certainly be a stepping stone in unveiling the grey areas, increasing the level of trust of port authorities in service robotics (Pastra et al., 2022).

In light of the escalating prevalence of organized criminal activities, it has become imperative to enhance port resilience (Bueger & Edmunds 2017). This necessitates advancing beyond the established guidelines delineated in the International Ship and Port Security (ISPS) Code, fostering a more robust framework through incorporating technological advancements and adequately addressing contemporary security challenges (Ibrahim, 2022). Integrating drones and other emergent technologies will bolster port security and ensure that the maritime industry remains resilient and efficient in the face of global challenges. Stakeholder consultation and careful consideration of potential implications are paramount before any amendment.

While the maritime and shipping sectors are frequently perceived as conservative and somewhat intransigent to transformative shifts, a plethora of forward-thinking ports globally have begun to incorporate highly innovative technologies, yielding distinct economic, operational, and environmental advantages (Dalaklis et al., 2022). The ports of the future will be smart, moving beyond obligatory regulatory mandates towards a comprehensive goal-oriented cooperation framework among the diverse port stakeholders, taking into account distinctive institutional circumstances and ownership structures along with the national, socio-economic-political system (Christodoulou et al., 2021b; Doelle et al., 2023). This transition signifies a paradigm shift, fostering a more resilient, efficient, and sustainable maritime industry, ready to meet the diverse demands of the modern socio-economic landscape, guided by informed and collaborative strategies.

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Addressing the hazards of remote inspection techniques: a safety-net for vessel surveys

Recto running head : LAW, INNOVATION AND TECHNOLOGY

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ABSTRACT

Emerging technologies and technologies with emerging applications are stark catalysts of transformation in the maritime industry. As the industry progressively shifts to remote inspection techniques (RIT), there is a growing need to identify and assess the potential hazards that exist within the breadth and scope of vessel surveys and inspections. Such an assessment is essential bearing in mind the limitations, drawbacks and negative externalities pertaining to robotic platforms that are being integrated into the traditional manual-driven system. Moving the RIT-agenda forward entails optimisation of the human-robotic interface (free from seen and unforeseen impacts) that remains a prerequisite to the conduct of classification and statutory surveys.

Drawing on findings from in-depth interviews with subject matter experts, this article makes recommendations for an RIT survey 'safety net' covering pre, ongoing and post operational aspects, and addressing data governance and psychosocial hazards as well as the hazards arising from the absence of a common legal liability framework.

KEYWORDS

- Hazards
- safety-net
- remote inspection techniques
- maritime policy
- drones
- remotely operated vehicles
- magnetic crawlers

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1. Introduction

From autonomous automotive technologies to autonomous vessels, the scale of Robotic and Autonomous Systems (RAS) influence in both land-based and maritime-based transportation is staggering. The genesis of RAS emerged after a cascade of Artificial Intelligence (AI) technological breakthroughs.[1] In retrospect, the velocity, breadth and depth, and systems' impact of what is in fact a fourth industrial revolution has led to a conflux of innovative advancements shaping the modern technological environment.[2] Commonly referred to as disruptive technology, remote inspection techniques (RIT), an offshoot of RAS, is best described as ' ... a means of survey that enables examination of any part of the structure without the need for direct physical access of the surveyor'.[3] But the absence of a human surveyor on-site does not preclude the need for oversight. This operational environment is known as the 'supervised autonomy' paradigm.

Common types of industry deployed RIT include unmanned aerial vehicles (UAV) or drones, remotely operated vehicles (ROV), and climbers or magnetic crawlers. The above possess the ability to comprise a multi-robot survey team programmed to follow a pre-determined algorithmic pathway for visual and acoustic inspection of a vessel structure to detect corrosion patches, buckling, cracking and deteriorated coatings. Notably, maritime industry and applicable government and organisational regulators have started adapting to the use of RIT for ship-outer-hull inspection, tank inspection, thickness measurement and cleaning.

Central to this multi-robot environment is *intentionality*. In the maritime context, it is significant to point out that the underlying intention of contemporary innovations, such as bridging the gap between current and potential capacities of RAS-led vessel inspections, is among other things, a part of classification surveys, as well as statutory survey criteria. Satisfying the regulatory goals and objectives with minimum effort while maintaining the highest safety standards is a unique aspect of the modern maritime technological environment.

Mass exploitation of RIT in the maritime sector cannot be achieved unless associated hazards are adequately controlled and regulated. To address safety issues in a satisfactory yet comprehensive manner, the topic of RIT demands a broader understanding of associated hazards throughout the ship inspection process. Observably, to date, there is a lack of homogeneity in understanding what RIT safety truly entails. This bleak situation is heightened by the existing dearth in literature that carves out the much-needed systematic review of all potential hazards that could emanate from the deployment of RIT either independently or when combined with human-centric survey and inspection at different stages. Ergo, this study aims to contribute to the ongoing international dialogue and discussions that aim to facilitate harmonised guidance that promotes user-friendly and liability-free RIT.

To this end, this article rigorously extracts and critically evaluates potential hazards inherent in the application of RIT across the entire process, from initiation to completion. The authors, subsequent to a thorough examination of pertinent theoretical frameworks and a critical evaluation of qualitative interview data, present a strategic framework. This framework holds the potential to provide valuable guidance to stakeholders including policymakers in identifying and mitigating hazards throughout the remote ship inspection process, ultimately reinforcing a justified paradigm shift towards RIT adoption within a specific yet significant maritime domain. The main purpose of this article is to discern the essential elements that can collectively establish a 'safety net' particularly in the absence of a unified legal framework. In pursuit of this objective, the concluding section delves into, yet another, exploratory research, building upon the foundational work laid out by Pastra et al. in their 2022 study on the 'trust ecosystem'.[4] This research then extends its focus to the domain of 'liability' – investigating the interrelationship between 'trust-safety-liability'. While contributing to the body of literature within the academic domain, this correlation represents a noteworthy aspect for consideration by policymakers and legislatures. The analyses could be instrumental in constructing arguments before courts adjudicating civil liability issues stemming from the utilisation of RIT.

The authors stress that a comprehensive governance framework for the implementation of RIT calls attention to a broader perspective that ventures beyond the examination of prospective liability systems. It is imperative to situate inquiries concerning legal liability within the broader context of risks and hazards. In doing so, it not only facilitates a more comprehensive understanding of the intricate relationships between technological deployment and potential consequences, but it also permits a nuanced assessment of the intricacies involved in determining legal liability. Legal liability, more often than not, cannot be examined in isolation, as it intersects with a spectrum of risks and hazards. Understanding those interconnections is vital to developing informed legal frameworks and policies that effectively address and mitigate issues that could, in turn, stifle innovation.

This article consists of six main sections and a concluding segment. The first section initiates discussions about hazards originating from RIT and underscores the importance of conducting comprehensive hazard analysis and risk assessments to ensure safety and mitigate potential risks. Following the contextual set-up, the article explains, in the second and third sections, the results obtained from hazard identification following a qualitative approach to quantify expert viewpoints concerning human-robotic interaction/interface occurring from the deployment of RIT. Section four then highlights the disparities between theory and real-world application, especially in the context of hazards like psychosocial risks, which have been relatively neglected in academic literature. The fifth section provides detailed recommendations with the goal of dissecting the specific components, e.g. the value of a trustworthy ecosystem, that combinedly constitute a protective framework for end-users. Subsequently, section six, enters the complex domain of 'liability' where light is cast on accountability from a common law perspective *inter alia*, the European Union approach to safety, liability and the 'burden of proof' paradigm with respect to digital technologies, the role of 'duty of care' in explaining 'burden of proof', and the linkages between 'duty of care' in both fault-based liability and strict-liability – offering valuable insights for the way forward. Finally, section seven ties together three important threads of the discussion, namely, trust, safety and liability before drawing concluding remarks.

2. 'Hazard' and 'safety' nexus in profile

Steady advancements and the introduction of innovative semi-autonomous systems have ameliorated the functioning of various industries. This includes the maritime sector where a surge in robotic-solution demands for survey, inspection and maintenance, especially during the COVID-19 pandemic, renders technology at the top of the pile.[5] These technologies offer substantial benefits when it comes to increasing operational safety, energy efficiency and reliability.[6] To be specific, adopting Robotics and Autonomous Systems (RAS) to carry out inspection and maintenance could lead to minimal downtime, cost efficiency, and enhancement of human safety through the minimisation of danger in tasks conducted in confined spaces.[7] In addition, evidence-based research indicates that the employment of RIT could improve overall ship-safety since human errors account for between 60 and 90% of the total number of accidents at sea. [8]

Despite the aforementioned benefits, the integration of RAS highlights conspicuous challenges on the margins of design and operation. In retrospect, a plethora of research projects have investigated human–robotic cooperation and the issues concerned with safety, performance and training of collaborative robots. [9] 'Robots have to be safe, but the question that prevails is '*how safe is safe enoughe*?', this being an aspect that is well documented.[10] Following the ISO/IEC Guide, safety has been conceptualised as ' ... freedom from risk which is not tolerable'.[11] Within this context, the term 'hazard' has been conceptualised as 'the conditions with the potential to compromise safety' and a 'potential source of harm'.[12] More precisely, in the case of human-robotic interaction, safety is defined as 'ensuring that only mild contusions may occur in worst case scenarios'.[13]

Indubitably, regulatory frameworks, tools and procedures are integral to RAS safety aspects whereby compliance and enforcement could mitigate risks that could otherwise impact stakeholders and the environment.[14] 'Risk', in general terms, can be defined as the combination of the probability of occurrence of harm and the severity of that harm.[15] Conversely, risk is calculated for identifying hazards and indicates 'the likelihood and consequences of a future hazard event in a given context'.[16] 'Harm', in tandem, has been defined as the 'injury or damage to the health of people, or damage to property or the environment'.[17] Taken together, the identification of hazards and determination of associated risks is the resultant of a risk management process.[18] In this process, it is crucial to consider 'individual' and 'societal' risk criteria to determine the safety and integrity requirements for the investigated system.[19] Relevantly, even though the hazards associated with RAS are well documented, in many cases the sources (of these hazards) are observed as being tied to the robotic platform, and not all hazards identified are common to all types of robots in relation to risk-level and potential-to-harm.[20]

Scholarly literature details the greater ramifications of human-robotic interactions, safety perceptions, benchmarking and measurements and, most importantly, the impending challenges.[21] A tacit agreement among authors is that robots have both positive and negative impacts on people, thus necessitating the need for furthering thorough research in this field. In other words, research on RAS safety should transcend the confined limits of physical impact, such as collision risks, and be expanded to capture other types and forms of hazards.

The emergence of new generation RAS with increased autonomous capabilities (through machine learning) and their physical interaction with humans has introduced novel hazards.[22] One of these so-called 'novel hazards' could occur during close-proximity and collaboration with the end-user resulting in 'bad synchronisation' and 'communication mishap with robot interface'.[23] Other forms of hazard include impacts from bugs in the software, technical glitches, latent damage and defects, and inadequate perception of the environment.[24]

Cyber security, for example, is a timely topic that borders on security threats and vulnerabilities – critical concerns that have garnered international attention more than the topic of physical injury from RAS.[25] Privacy and security hazards, in fact, exist due to their interconnectivity with multiple devices and cloud services.[26] The increased functions of interconnected devices and systems could weaken those systems thereby increasing the risk of system failure or malicious attacks.[27]

Mental-health is another issue that may stem from human-robotic interface.[28] The study of psychosocial influences in relation to RAS-safety has gained momentum quite recently. Studies stress that the looming effects of psychosocial influences include nervousness of the operator, stress and fear, to name a few.[29]

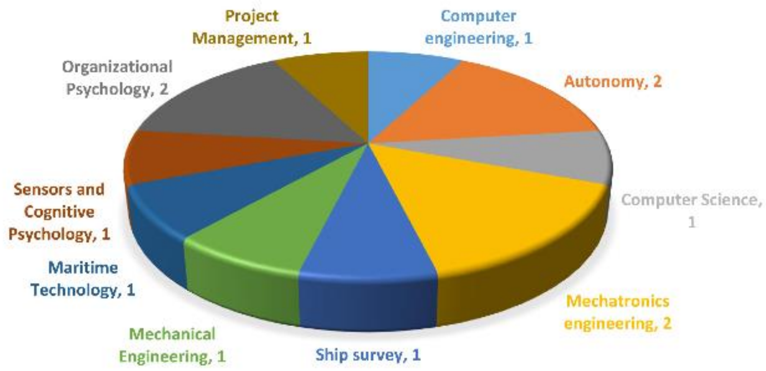
Finally, societal, and ethical issues, indeed, arise from the use of RAS. These include de-skilling, trust, security and deployment.[30] A public concern remains that robots might replace humans in high or low-skilled jobs, and the introduction of robots in the workplace might lead to duplicative efforts, which could result in passive behaviour or even depression.[31] This has a tendency to encourage social pressure in the sense that employees might feel a sense of insecurity about their work-future owing to the fear of being replaced.[32] Another issue that has been identified is the limited trust in the robots, which could lead to diametric challenges: acceptance and collaboration.[33]

Despite the aforementioned, promulgated guidelines that promote safety do not often focus on psychological and or behavioural factors.[34] In addition, the existing classical hazard analysis techniques are not well-suited to capture the complex interactions between humans and robots.[35] It is posited that ethical hazards such as liability, dehumanisation, and unemployment call for the conduct of an ethical risk assessment with a view to identifying and mitigating the ethical risks derived from human-robotic interactions.[36] It is evident that an exhaustive hazard analysis and risk assessment is needed to identify all the potential hazards associated with each type of service robot if the intention is to develop appropriate and adequate appropriate safeguards.[37] In a maritime context, RIT brings to the hazard-landscape a unique set of safety concerns; therefore, hazard recognition and mitigation is paramount to reduce workplace injuries, fatalities and social risks both projected and unforeseen.

3. Methods

Hazard-identification as the target objective, a qualitative approach was adopted to quantify expert opinion on human-robotic interaction/interface. Participant-observation was the principal research methodology that helped observe technical tasks and activities initiated and completed by the consortium members of the BUGWRIGHT2 project during a five-day integration week in November 2022 at the Perama Shipyard in Greece. The objective of the BUGWRIGHT2 integration week was to test drones, ROVs and magnetic crawlers in actual conditions at the pre-determined shipyard. The integration week presented itself with the opportunity to obtain first-hand data and information from service suppliers, engineers, classification society representatives, psychology analysts as well as academic counterparts. Thirteen (13) in-depth semi-structured interviews with subject matter experts were conducted at the testing site in the course of pre-deployment, during-deployment and post-deployment phases of RIT testing (Figure 1).

Figure 1. Interviewee's field of expertise.



4. Findings

Hazards identified from the participant-observation method coupled with in-depth discussions before, during and after the ship inspection processes are synthesised and presented in Figure 2 and subsequently analyzed in this section.

Figure 2. Main hazards during a multi-robot remote inspection.

4.1. RIT pre-survey hazards

The main hazard that stems from the usage of Unmanned Aerial Vehicles (UAV) is related to the poor familiarisation of the operator with the service robot. Inadequate training of inexperienced users operating complex systems could lead to 'crash' or operational-failure due to human error. Prior to the conduct of survey, the operator/service supplier should be certified based on UAV/aviation national safety policy. The certificate is evidence that the required standards of training and knowledge for safe operation have been met. Relevantly, a service supplier with the capacity and knowledge, and one that ensures that the desired safety management system is in place, is of utmost importance. It is noted that classification societies, such as Registro Italiano Navale (RINA), Bureau Vertias (BV) and Lloyds Register (LR) certify external companies with qualified operators as 'service providers' after they have successfully satisfied class criteria and tick-off items from respective prescribed verification-checklists.

Interview participants underscore that the lack of a comprehensive set-up of UAV navigational plan for UAV, which covers all the necessary inspection areas, could lead to damage of the technology, ship structure or personnel injury. The pre-inspection planning stage between the operator and surveyor is critical. It is also noted that in the case of multi-robot visual and acoustic inspections, the sequence of the service robot should be incorporated into the navigational plan.

Calibration, another vital aspect, should be carried out by adjusting various sensors on board the platform (i.e. compass calibration, gimbal calibration, inertial measurement unit-IMU-calibration or vision sensor) to maximise the accuracy and reliability of the operation. Localisation errors that originate from the relative geometry between transmitters and receivers should be alleviated by integrating approaches such as Global Positioning System (GPS) signals, UAV IMUs, Light Detection and Ranging (LIDAR), ultrasonic acoustic signals, 2D/3D cameras or laser range finders mounted onto the robot. Unsuccessful localisation and miscalibration could lead to an unsafe and unstable drone flight pathway.

Improper storage of batteries during the transportation of the UAV could also lead to fire/explosion and injury to operator. In addition, battery power capacity should be adequate to cover all the necessary inspection areas.

UAV pose various hazards to people on the ground and other aviation crafts, creating great challenges for law enforcement agencies. Non-regulatory compliance of UAV with national authorisations and guidelines, taking into account UAV's weight, specifications and the type of operation, could be considered as another type of hazard. Within the port area, UAV operators should ideally obtain the approval of port authorities and comply with the port's policy for permission to fly UAV.

Compared to UAV, remotely operated vehicles (ROV) encompass fewer hazards, and require much less pre-inspection and associated preparation time. The main concern revolves around their deployment, i.e. they should be lowered slowly from heights into the sea. For magnetic crawlers, special attention is required on the potential physical damage to the person carrying the crawler, as well as the potential damage to the robot, due to its significant heavy weight. The operator should be vigilant during the adhesion of the welding robots, as damage to the finger is highly possible.

4.2. RIT ongoing-survey hazards

During the survey process, a UAV may become a potential risk known as 'falling object' due to collision, battery failure, propeller failure or extreme weather conditions, causing severe damage to its equipment, on-site surveyors and the vessel itself. The risk of injury, especially from the UAV propellers that are attached to the motor, is high. During vessel dry dock of, everyone working in the near vicinity should be made aware that aware remote inspection using UAV is ongoing.

UAV loss-of-sight could also lead to damage and collision. Therefore, UAV Beyond Visual Line of Sight (BVLOS) operations should consider an advanced navigation system that enables them to make decisions, in line with airspace regulations, and automatically detect and avoid objects in their path. However, it should be noted that UAV utilised in a ship inspection process usually fly within Visual Line of Sight (VLOS) rules.

ROVs, under the current strand of discussion, include minimal hazards during vessel survey and inspection. Operators encounter the challenge of recovering and steering the robot if the cable is tangled or if it gets fastened to any parts of the ship; therefore, due attention should be given to tether-management. Tethers could be tangled during autonomous operations leading to the stumbling of human operators.

Finally, in terms of magnetic crawlers, loss of adhesion of a wall-climbing robot could lead to damage to the robot and injury to the operator during the inspection of large ship structures. If the robot reaches an area with impedance to the magnets, or if the wire-torque is too heavy for the crawler, then there is a high probability of injury-risks. Magnetic crawlers are equipped with a tether that transports a tube to transfer water at the interface between the sensor and surface with an electrical water pump. Lack of water supply to ensure adequate surface contact between the piezoelectric transducer and the hull could also affect the survey. Moreover, the absence of magnetic wheel protection may damage the hull's paint used for anticorrosion and antifouling.

4.3. RIT post-survey hazards

After completing a survey and inspection using RIT, the hazards that come into play include those that are tied to 'data quality' and 'data security'. It is posited that data quality, including videos, images and light detection and range (LiDAR) data, should be precise for a complete AND HOLISTIC understanding of the condition of the inspected area. Besides, the interpretation of multi-echo data in noisy environments resulting from metal extractions can also affect the UAV sensor and the data analysis results.

Effective mechanisms should be in place to secure data from unauthorised access and corruption. In the case of UAVs, sonar and radars on board a vessel may interfere with their operation, affecting the safety and security of sensitive data. Loss of data could also occur in tethered vehicles, such as ROV and magnetic crawlers, due to damage/loss of connection of the cable.

In the case of multi-robot inspection, there are serious concerns with regard to data integration. The complexity of multi-robot monitoring for operators and inconsistency of data observations from different types of robots pose challenges for the presentation of data in an optimised manner for human cognition. In the current stage, the absence of software and supportive technology that will enable the integration of ship inspection data raises challenges for effective data analysis. That being said, full automation of these technologies is expected to address the data integration issues in the future.

4.4. RIT psychosocial hazards

Potential occupational hazards that affect the psychological well-being of operators and surveyors were highlighted by respondents, in tandem. Identified psychological hazards include nervousness and stress of the surveyor working closely with a robotic agent, lack of control, over estimation and absence of social interaction. Respondents, within this frame of reference, observe a form of diametric impact. The first of this impact concerns the on-board surveyor. A growing psychological tendency among surveyors is that robotic systems may eventually replace manual-driven operations leading to the deduction that a surveyors' knowledge gathered over the years may become 'obsolete'. The latter observation concerns the remote pilot. Cognitive inattention and prolonged duration of the remote survey, according to the respondents, may lead to errors of judgment and negative fallouts.

An essential point to note is that several respondents highlighted that communication hazards between: a) human-human, b) human-robot and c) **[Q4]** robot-robot are critically evident. The level of communication and information exchange between humans will be reduced and 'feeling of solitude' may surface. Indeed, communication between humans and robots requires the need for upgrading a set of additional and out-of-the-box skills. The more autonomous the work, the higher the need for integration and communication between the service robots. From this integration, various effects may appear, ranging from increased stress for the operator, weak social interaction for the surveyor and the fear of potential replacement in tasks jobs performed by humans regardless of how onerous, dull, dirty and dangerous it may be.

The dangers of poor trust calibration were also raised by the interviewees. In a human–robot context, trust influences an operator's intentions, enables the surveyor to understand the robot's capabilities, and paves the way for mass deployment of these technologies. Trust calibration is needed to boost the trustworthiness and reliability of remote inspection tools.

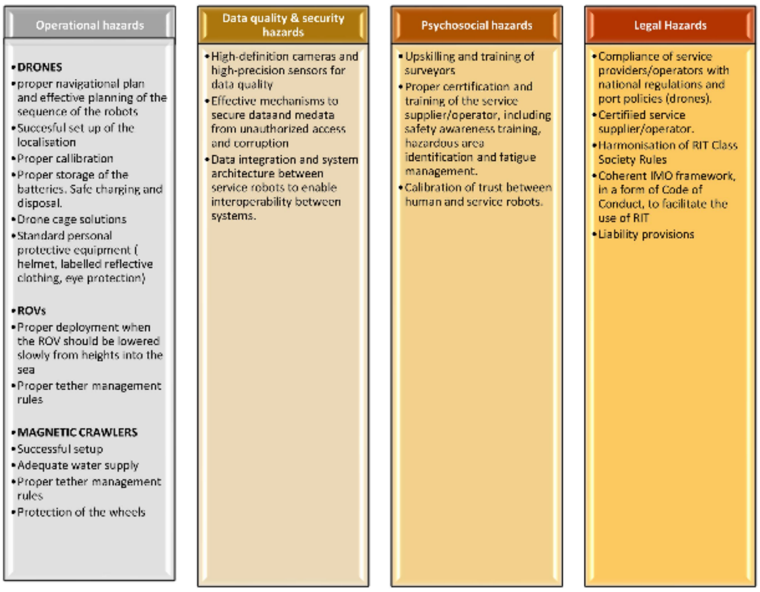
5. Recommendations for a safety-net for an RIT-survey

The overall findings confirmed that the RIT does concretely pave the way for safer inspections as they reduce the need for scaffolding and help surveyors reach dangerous and inaccessible areas. Notwithstanding, collateral issues, physical interaction, data management, social and legal hazards, *inter alia*, were unfolded by respondents in a non-linear order. In the absence of a common set of norms, this section seeks to proffer strategic recommendations based on:

- The three-part conceptual framework of 'dynamic governance' comprised of actors, mechanisms and tools – as propounded by David Markell and Robert Glicksman.[38] Markedly, the three-part proposition by the authors is viewed as instrumental in enabling policymakers to 'structure and administer' regulatory programmes when faced with institutional change or 'dynamic change', case-in-point, the integration of RIT;
- Three thematic strands of discussions for governance of emerging disruptive technologies: a) challenges of regulating emerging disruptive technologies; b) policy process and disruptive technologies; and c) regulatory responses to technological disruption [39]; and
- Pathways (from *de lege leta* to *de lege ferenda*) indicated by respondents to the participation-observation.

Taking all of the above into account, this section amalgamates findings and formalises the important elements for consideration (see Figure 3) under the following four specific headings: a) operational hazards in pre-survey and ongoing-survey phases, b) post-survey data quality & security hazards c) psychosocial hazards and d) legal hazards.

Figure 3. Mitigation framework of the main RIT hazards. Souce: Authors.



5.1. Addressing operational hazards in pre-survey and ongoing-survey phases

Patently, there are two types of main operational hazards before and during the ship inspection process: *hazards for technology* and *hazards for humans*. To address UAV-hazards, a navigational plan should be set up in a comprehensive manner to specify the inspection areas. In addition, the sequence of the robots should be specified and a chief inspection officer should be appointed for multi-robot surveys. The operation planning stage of the inspection is crucial whereby adjustment and coordination between the different operators (in case of multi-robot inspection) and between the 'operator' and 'surveyor' should be in order.

Special attention should be given to UAV-localisation, which should ideally be accurate and reliable to ensure the safety of participants and the effectiveness of the survey. Localisation can be achieved either through onboard sensors or with the help of a receiver that estimates its location based on a GPS or GPS-denied UAV technology. In the case of ROV, Underwater Positioning Systems (USBLs) can be utilised to detect the position of the ROV using acoustic positioning. Ultrasonic guided waves (UGWs) could provide accurate magnetic crawler localisation and structural feature mapping by relying on acoustic reflections in combination with the other systems.

The regular calibration of UAV, based on the manufacturer's instructions, is another measure of the effectiveness of the mission; thus, the operator needs to regularly and consistently re-calibrate the sensors of the UAV to ensure that it remains fit-for-service. Additionally, maintaining and storing batteries is integral to optimal UAV performance. Safe charging and safe disposal, therefore, are matters for consideration. It is important to stress that batteries must be stored at room temperature (for cooling purposes) and transported in specialised cases. UAV operators should carry extra battery packs during the inspection process so as to maintain continuous-flight momentum. At this point it should be noted that addressing the possible environmental hazards by energy consumption from the use of RIT could be mitigated by using renewable energy and zero-emission fuels; consequently, charging the batteries using renewable energy could lead to a zero-emission operation survey process.

In terms of explicit safety, UAV cage solutions could provide relief against physical injury and protect operators, surveyors and persons on land from physical injury from propellers and or the drone itself in case of a collision. Standard personnel protective equipment, such as helmets, labelled reflective clothing, and eye protection gears ought to be mandatory for survey participants.

For ROV, an issue noted earlier is the appropriate deployment of the ROV when it is lowered slowly into the waters. Although fully autonomous RIV may forgo tethers, until it reaches that stage, proper tether management for ROV and magnetic crawlers require the promulgation of niche organised rules so as to avoid dormant mishaps. Inadequate water supply should be ensured to enable the continuous operation of the magnetic crawler.

5.2. Addressing post-survey data quality and security hazards

Data obtained from RIT includes information from close-up surveys and gauging. During an RIT-survey programme, visual data, such as still images, live-stream and recorded video, are collected to examine the vessel's structural condition, ship's holds and tanks to discover corrosion and measure thickness. Inaccurate data or incomplete information about the condition of the ship could have serious consequences for her safety and maintenance.

For post-survey processes, data quality and data security are the two main concerns underlined by the respondents. According to Khatri and Brown data quality refers to data's capacity to accomplish their intended use through precision, timeliness, completeness, and credibility.[40] High-definition cameras and high-precision sensors are essential to address data quality risks.[41]

Apart from data quality, there are security risks also coined as hazards by respondents. According to the conclusions drawn by Johansson *et al.* data security and the effectiveness of data collection, data processing, and distribution of analysis-outputs need to be demonstrated if RAS platforms are to achieve the desired level of trust among the stakeholders of the business model. In this context, robust data encryption and access controls are crucial.[42] Metadata should also be stored in an appropriate manner.

'Control of data' provision of the International Association of Classification Societies (IACS) as embedded in s. 5.2.6 of IACS UR Z17 highlights the responsibilities of service suppliers in relation to computer software's ability to acquire, record, report, store, measure and monitor data.[43] While this does not conflict with laws on data protection, for example, the European Union's (EU) Regulation 2016/679 on the General Data Protection Regulation (GDRP), there is still the need to protect the data collected from a commercial asset (the vessel under inspection).[44] According to s. 16.8 of IACS UR Z17, operational procedures for handling/operating equipment and guidelines on the collection, validation and storage of data rests with the service suppliers, which begs the questions of who should retain the copyright (ownership) of data gathered from RIT; what are the main characteristics of data quality, how should data be shared between the key stakeholders, what provisions on data control and security should be considered, what responsibilities do each party have to the other regarding data control and data security, what is the duration of preservation of data and image from close-up and in-water surveys, should there be any safeguard mechanisms for service providers against third-party liability? It is self-evident that a trustworthy process built on adequate data management and security is in need of implementation. Fortunately, answers to some of the questions posed above can be found in guidelines developed by individual IACS classification society members, which should suffice during the initial reign of supervised-autonomy.

Highlighting the precautionary principle, it is asserted that further research on engineering and system architecture is needed to integrate data and metadata reported from the UAV, ROV and magnetic crawlers if the ultimate intention is to achieve a holistic understanding of structural integrity and precise localisation of defects.[45]

5.3. Addressing social and psychological hazards

Social and psychological hazards can adversely affect worker health and safety. Examples of these types of hazards include fatigue, stress, overload and absence of social interaction. Two conditions must be met to address the social and psychological hazards: a) the training of the surveyor/operator; and b) the calibration of trust to the technology.

5.3.1. Training

In order to strategically tackle future impacts, the issue of multi-skilled professionals must be confronted. The education and responsibility of operators should be strengthened through mandatory training, registration of UAV operators and a quality-based certification process. Suppliers of RIT, should have mandatory training requirements for their personnel, including safety awareness training, hazardous area identification and fatigue management.

Upskilling surveyors is essential to expanding abilities and minimising skill gaps. This can be achieved through continuous learning that entails the know-how of RIT operation as it moves forward in the autonomy-paradigm, capacity to analyze the findings from RIT and conceptualise 3D Models of the inspected area. The training schemes that will evolve over the years should be aligned to match the level of sophistication required to carry out services using individual RIT. Classification Societies have introduced 3D simulator training designed to train inspectors more effectively for raising safety levels.

In the not-so-distant future, it is projected that the operator could be replaced by the surveyor – an aspect duly noted by the respondents. Here, the surveyor's experience, skill and training should not be underestimated since the surveyor's professional judgment should not deviate from existing physical survey procedures.[46] Even if the world reaches a fully-autonomous phase free from the human element, regardless, a human should still retain vigilance so as to be able to intercept, if needed, to verify safety of survey operations.[47] It will still be important to uphold the relevant provision of IACS Recommendation 42: ' ... the results of the surveys by remote inspection techniques, when being used towards the crediting of surveys, are to be acceptable to the attending surveyor'.[48]

5.3.2. Trust

In literature, trust has been perceived as a psychological state with foundation dependent upon reciprocity, cooperation, and mutual concern.[49] Rochel underlined that conception of trust in this digital era should be enriched by addressing the responsibility of developers, the power relations between users and developers of AI systems and the benefits associated with the use of AI systems.[50]

Trust in artificial intelligence and digital technologies is a strategic priority for the European Member States as human workflows are increasingly intertwined with AI systems to support them. The European Commission makes it clear that trust is a prerequisite to ensure a human-centric approach to AI; thus, in this context, the trustworthiness of RIT should be ensured.[51]

Pastra *et al.* support that trust in RIT is a multi-dimensional concept that relates to a multifaceted interplay among specific work tasks, human dispositions, organisational and team settings, stakeholder needs and policies. The authors argue that to move inside the 'black box' of trustworthy RIT processes, the following elements should be considered:

- **a** technical robustness of the system without glitches or interruptions;
- **b** data quality and data security;
- **c** lawfulness of the system through the development of common standards;
- **d** skills and expertise of the surveyor; and
- **e** the lifecycle of the vessel.[52]

5.4. Addressing hazards arising from the absence of a common legal framework

The absence of a common framework for the use of RIT in the maritime sector creates a number of regulatory concerns. Those concerns and pathways forward will be addressed in the following sections.

5.4.1. Development of common safety standards

The International Maritime Organisation (IMO) and IACS, set the safety, environmental and security governance framework for shipping operations. IMO is the international governing body that sets a compliance and enforcement regulatory framework for the maritime sector. IACS, with its eleven member societies, is the technical standardisation body that contributes to the IMO framework through technical support and compliance verification. Member societies have, over the last several years, identified the main risks identified with the different varieties of RIT. Examples of this approach can be found in the different sets of requirements developed by RINA, the American Bureau of Shipping (ABS) and the China Classification Society (CCS). Guidance Notes developed by ABS include provisions on: explosion risks in hazardous areas, dropped object risks, collision risks (e.g. with other RIT), lost link risks (e.g. network compromise), other risks associated with high-risk working areas, and risks associated with parallel operations as well as emergency situations.[53] The other set of unique RIT operational standards are found in the Guidelines for Use of Unmanned Aerial Vehicles developed by the CCS which include: safety, operation performance, enduring capacity, data transmission and communication, data storage (e.g. video and image resolution and video and photo formats), as well as requirements for airborne cameras. Guidance notes for the use of RIT can also be found in RINA's Amendments to the 'RINA Rules for the Classification of Ships', outlining the requirements for data storage, cyber security, data protection and internet connectivity.[54]

Despite the provisions published by the respective classification societies, the international maritime RIT governance framework still remains fragmented as there are currently no agreed-upon standard procedures at the international level for statutory surveys.[55] Adopting a common methodological approach will also likely require developing operational common minimum requirements to harmonise categories of risk-assessments.

Given the urgent demand for guidance on remote surveys for the International Safety Management (ISM) Code audits and ISPS Code verifications, the Maritime Safety Committee, at its 104th session, considered developing guidance on assessments and applications of remote surveys. The term of 'remote survey' has been conceptualised as the "process of verifying that a ship and its equipment are in compliance with applicable statutory regulations or partially undertaken, without physical attendance on board the ship by a surveyor".[56] Although that this term is distinct from that of RIT, the authors support that these guidelines could serve as the basis for the development of guidance for RIT-based surveys. Some of the main topics addressed in the draft guidance on remote statutory surveys (i.e. digital quality, qualification of the surveyor and the risk assessment framework carried out by the flag State) can be applicable to the RIT context.

Therefore, it is recommended that a new output on the 'development of common safety standards for RIT' be added to the work programme of the Sub-Committee on Implementation of IMO Instruments. Hence, overcoming regulatory challenges associated with RIT is considered by the authors as the first step in facilitating remote performance transition, not only during global emergencies such as COVID-19, but also when a normal steady state prevails.

5.4.2. Proof of concept' via regulatory sandbox

Understandably, remote inspections conducted *off site* should be approved with the objective of achieving at least the equivalent results as *in situ* surveys, with 'safety' being the primary consideration, especially during *force majeure*. Beforehand, adequate tests should be carried out through joint collaborative efforts in a controlled environment allowing for the strategic development of both methodologies for remote classification inspection operations (on the external and the internal areas of a vessel) as well as necessary rules and requirements. Survey respondents deemed this as an important step for determining 'proof of concept' of the functionalities of remote RIT-surveys. Respondents also noted that flag states and classification societies could engage in extensive testing using the 'regulatory sandbox' methodology to establish 'proof of concept' for conducting RIT-surveys (with the possibility of a surveyor intervening as well as the possibility *without* a surveyor intervening) to ensure safer and even higher-quality evidence in the survey process offering optimum benefits to shipowners and operators.[57] The authors propose that the survey findings could serve as the impetus to initiate an international scoping exercise.

6. Liability

This section contains five important strands of discussion that contribute to the academic deliberations within an emerging field centred on liability stemming from RIT. We enter discussions by highlighting the extant regulatory challenges, particularly within the maritime sector, arising from the advent of novel and pertinent liability risks associated with RIT. Subsequently, the discourse delves into an examination of the conventional legal approach, highlighting the potential inadequacy of traditional liability norms in addressing the evolving landscape of digital technologies, with a particular emphasis on the doctrine of vicarious liability. The two subsequent sections shed light on the role of (proposed) European Union Directives in establishing a comprehensive civil liability framework for AI-related damages, and the 'burden of proof' paradigm. Finally, the authors undertake an evaluation of the efficacy of fault-based liability and strict liability, viewed through the lens of the 'duty of care', which emerges as a prominent theme stemming from the antecedent analyses.

6.1. RIT and the liability conundrum

A unified and well synchronised safety and liability approach can mitigate the hazards related to service robots.[58] Ultimately, RIT is an innovative and integrating such transformative product, such as service robots, into traditional human-driven tasks calls for a safety-net to guard against third-party liability. At present, IACS UR Z17 does not provide any caveats that prompt necessary pre-emptive steps from service providers, flag administrators or classification society members. The authors emphasise that quality assurance schemes for protection against liability are not generic either in scope or nature, and that the current legal regime only requires service suppliers ensure that these elements are in place. As previously discussed, *inspection and certification* fall under the conditional assessment programme that is a requirement of charterers and cargo owners. Through such assessment programmes shipowners can demonstrate 'operational reliability' to their clients.

New forms of RIT liability emanating from dropped object or collision risks, or even unseaworthiness of a vessel due to deterioration or corrosion from biofouling, may seem far-fetched since current routine options, such as reverting back to manual inspections and checks through periodical surveys remain readily available. Even so RIT does have the potential to create some new and unforeseen risks due to the introduction of multiple new actors during an RIT survey.[59] For example, input-material supplied by the asset owner to the service supplier prior to hull inspection (i.e. images, drawings and designs) could infringe on the copyright or other rights belonging to a third party. Hull survey data could be used for marketing by the service supplier without the prior approval of the asset owner. Therefore, the path forward should connect the RIT-survey regime to the liability laws of the flag state, referred to as a 'liability clause' in the texts of classification society member state requirements. An alternative is to follow the example set by Lloyd's Register by including a provision that requires end-users to maintain third-party liability insurance in case of accidents or incidents.[60]

In any event, these new risks go beyond and dissociate from the three-pronged concept of the vessel's seaworthiness, whose main aspect, in its narrow sense, refers to the physical stature of the vessel, being fit enough to perform the voyage safely. In this regard, 'unseaworthiness' signifies an attribute of the vessel which threatens the safety of the vessel or her cargo.[61]

6.2. The common law approach: accountability and the new legal paradigm

Traditionally, under England and Wales case law, classification societies have been discharged of liability whether in contract or under the tort law of negligence because 'the purpose of the classification certificate is not to guarantee safety',[62] but merely the vessel's compliance with the standards and rules set by the society and, policy issues oppose the imposition of liability on classification societies. By contrast, whereas it is the shipowner's absolute obligation, at common law, to provide a seaworthy vessel,[63] under the Hague-Visby Rules the carrier/shipowner's obligation is to exercise due diligence to make the ship seaworthy vessel before and at the beginning of the voyage (Hague-Visby Rules 1968, Art III rule 8), the latter being a non-delegable duty.[64]

However, this is not always the case in other jurisdictions. A classification society might be held liable where a marine casualty – resulting in damage or loss to property, personal injury or death is attributed to a wilful act or omission or gross negligence of its bodies, employees, agents or others who act on behalf of the classification society. In particular, where the classification society (RO) performs statutory surveys and issues certificates of compliance to the respective IMO Conventions, it acts as agent and on behalf of the administration, having been entrusted and delegated to exercise the said powers by the flag state in fulfilment of the latter's duties under Art.94, 217 UNCLOS (Appendix II of IMO Resolution A.739(18); IMO Instrument Implementation Code [III Code] (IMO, 2013a); Resolution MSC.349(92) (2013) Code for Recognised Organisations (RO Code)) acting on behalf of the administration in the event of a marine casualty causing loss, damage to property, injury or death where it is proven by a court of law to have been attributed to a wilful act or omission or gross negligence of the recognised organisation – its bodies, employees, agents or others who act on behalf of it-, liability with a requirement to compensate will be imposed on the administration which is entitled to claim compensation from the classification society.[65] While performing non-statutory surveys the classification society will be liable in contract and in tort as applicable to the relevant claim.

RIT surveys fall within the remit of semi – autonomous processes, still maintaining the human actor in the loop in combination with remote operated vehicles, complex digital technologies, dependent on data and interconnectivity, comprising semi- or autonomous systems with features specific to artificial intelligence (AI).

Under 5.2.3. Z17 IACS Req. 1997/Rev.172022 the service supplier of RIT surveys is defined as an independent contractor that undertakes to provide supervision for all services provided; so, it seems that liability rests with the service supplier in case of accident or incidents i.e. third party liability. Nevertheless, it could be argued that a classification society could be held liable under the extended theory of vicarious liability embraced by the case law, stepping out the established employer-employee relationship and encompassing such relationships not considered within the ambit of employment but akin to the latter.

The result of the above approach is that a relationship other than one of employment is, in principle, capable of giving rise to vicarious liability where harm is wrongfully done by an individual that conducts activities as an integral part of the business process carried out by a defendant and for its benefit (rather than his activities being entirely attributable to the conduct of a recognisably independent business of his own or of a third party), and where the commission of the wrongful act is a risk created by the defendant by assigning those activities to the individual in question.[66] Although vicarious liability is not meant to apply to independent contractors per se, the nomenclature is not significant for the designation of relationship, as it is judged on the facts of each case, it could be argued based on the above that a classification society could be held vicariously liable if the service provider acting on the instructions of the class surveyor and in particular, in terms of the method of performing the services and due to the fault of the former there is data disclosure, IP leakage etc. Under Z17, 16.10Verification – The supplier must have the surveyor's verification of each separate job, documented in the report by the attending Surveyor(s) signature. In any case, the suppliers' private contracts should be reviewed concerning the roles and responsibilities in respect of the data quality, storage, security, and sharing of information.[67] The accountability, i.e. liability of the actors participating in the RIT survey in terms of data flow, data storage and data processing, – apart from the personal data being subject to EU general data protection regulation, Regulation (EU) 2016/679 (GDPR), should be clearly defined.

However, the features of digital technologies, primarily their complexity, their dependence on data and their interconnectivity and in particular AI systems performing continuous adaptation through machine learning, entail opacity and limited predictability in their operation, rendering it difficult to trace the fault and identify the liable person. Thus, AI systems pose new risks and also challenges to the traditional regulatory liability regimes, which currently are under reform in most states for purposes of adapting to the requirements of emerging digital technologies, in particular AI. Henceforth, it is worth considering the liability regime introduced by the Commission's proposals for two complementary Directives to address liability arising out of damage caused by the digital technologies, including AI, potentially applicable to liability arising out of RIT surveys.

6.3. EU directives on AI safety and liability: a critical exposé

The EU Commission in its Report on the safety and liability implications of IoT, AI and robotics (2020), accompanying the White Paper on AI, identified new challenges and risks associated it with the uptake of AI and its uses in terms of product safety and liability, like connectivity, autonomy, data dependency, opacity, complexity of products and systems, software updates and more complex safety management and value chains.[68] In this regard, the Commission developed a coordinated horizontal, risk-based approach on AI systems – AI products or AI enabled services – in order to both promote the roll out and uptake of AI systems and address its risks in its'Proposal for a Regulation laying down harmonised rules on artificial intelligence, therein presenting a regulatory framework for operators that design, develop or use AI systems which aims at safety and prevention of harm caused by AI systems and the protection of fundamental rights, indicating prohibited AI uses and establishing an hierarchy of AI comprising 'high risk' AI systems to the health and safety or fundamental rights of natural persons, up to 'non risk' AI systems.[69] The proposal contains specific rules applicable to the design and development, in particular, of the 'high risk' AI systems before they are placed on the market, thereby being subject to compliance with certain mandatory requirements and an ex-ante conformity assessment.

Considering that a safety-centric regulatory framework is effectively reinforced through the establishment of an efficient redress mechanism in case of the former's violation, safety and liability are essentially the two sides of the same coin. At the EU level, member states' non-harmonised fault-based, non-contractual/ tort liability rules, are not suited to handling liability claims for damage caused by AI-enabled products and services since the claimant is required to prove a negligent or intentionally damaging act or omission ('fault') by the person potentially liable/ wrongdoer, as well as a causal link between that fault and the respective damage.

Where AI is interposed between the act or omission of a person and the damage, the specific characteristics of certain AI systems, such as complexity, autonomous behaviour and opacity (the so-called 'black box' effect), may render it excessively difficult, if not impossible or prohibitively expensive for the victim to meet this burden of proof, identify the liable person and prove the facts for a plausible liability claim, in particular that a specific input by the potentially liable person caused a specific AI system output that led to the respective damage. To this effect, a harmonised liability/redress regulatory system is currently underway in the EU to counterbalance harm caused by AI. In line with the above, the Commission takes a holistic approach in its AI policy to liability by proposing adaptations to the producer's liability for defective products under the Product Liability Directive as well as the targeted harmonisation under the AI Liability Directive.[70] These two policy initiatives are closely linked and form a package, as claims falling within their scope deal with different types of liability.

The Product Liability Directive covers producer's no-fault liability for defective products, leading to compensation for certain types of damages, mainly suffered by individuals whereas the AI Liability Directive covers national liability claims mainly based on the fault of any person with a view of compensating any type of damage and any type of victim, legal entities included. They complement one another to form an overall effective civil liability system, based on, in certain circumstances, on the presumption of causality or defectiveness.

Hence, the Commission's proposals focus on the following elements:

The *Directive on Liability for Defective Products* which revises the existing EU harmonised regime on the no fault-based – liability of the manufacturer/producer/designer/developer of defective products and possibly the further economic operators related to them (importer and the distributor), providing for the right to compensation of natural persons for the damage suffered by defective products, (**[Q5]** physical injury/ death, psychological damage, property damage or data loss not used exclusively for professional purposes. The definition of 'product' is expanded to include software, digital manufacturing files and AI enabled products while a product shall be considered defective if it does not provide the safety the public at large is entitled to expect, in particular where the product safety requirements and regulations whether national or EU are not complied with, taking into account all the circumstances, amongst others, the effect on the product the ability to continue to learn after deployment. A claimant with a plausible claim can seek an order for a defendant to disclose relevant evidence whereas failure to comply results in a presumption of the defect. However, if a claimant faces excessive difficulties in proving the defect and/or causation due to technical or scientific complexity, then the defect / causation can be presumed on the basis of sufficiently relevant evidence (Art.8, 9).

The *Directive on Adapting Non-Contractual Civil Liability Rules to Artificial Intelligence* (AI Liability Directive) aims to lay down common rules towards alleviating the burden of proof of the claimant (natural person or legal entity) in non-contractual/tort fault-based civil law claims for damages pursued under the national fault-based liability regimes for any harm caused by AI systems, in particular by an output of an AI system or the failure of such a system to produce an output where such an output should have been produced (Art.2). In consistency with the AI Act, the AI Liability Directive maintains the same definitions as the AI Act, the distinction between high-risk/non-high-risk AI, the documentation and transparency requirements of the AI Act (Art.4 (2)) through the right to disclosure of information, and it incentivises providers/users of AI-systems to comply with their obligations under the AI Act. Nonetheless, the Directive is meant to be the least possible interventionist; it does not affect national rules determining which party has the burden of proof, which degree of certainty is required as regards the standard of proof, or how fault is defined (Art.1), other than the introduction of rebuttable presumptions provided for in Articles 3 and 4.

The *AI Liability Directive* alleviates the victim's/ claimant's burden of proof by introducing the rebuttable 'presumption of causality' (Art.4) – where the claimant has demonstrated or the court has presumed the fault of the defendant – or of a person for whose behaviour the defendant is responsible – consisting in the non-compliance with a relevant duty of care laid down in EU or national law directly intended to protect against the damage that occurred due to the defendant having failed to comply with a national court's order to disclose or to preserve evidence pursuant to Article 3(5), and it can be considered reasonably likely, based on the circumstances of the case, that the fault has influenced the output produced by the AI system or the failure of the AI system to produce an output gave rise to the damage. If a claimant presents facts and sufficient evidence to support the plausibility of a claim in damages suspected to have been caused by a 'high risk' AI system, Article 3 of the *AI Liability Directive* grants to the claimant the right to request disclosure of evidence at the provider's or user's disposal about the high risk AI system (subject to the principle of proportionality taking into account confidential information, like trade secrets) in order to assist a claimant identify potentially liable defendants. If the defendant fails to comply with a court order to disclose or preserve evidence in a claim for damages, there is a rebuttable presumption that the defendant breached the relevant duty of care (Art.3 (5)).

6.4. EU jurisprudence on the burden of proof

By contrast, the rebuttable presumption does not apply to 'high risk' AI systems where sufficient evidence and expertise is reasonably accessible (Recitals p.28, through technical documentation and logging requirements pursuant to the AI Act) for the claimant to prove a causal link (Art.4 (4)) whereas with regard to non-high risk AI systems it only applies where it is excessively difficult for the claimant to prove the causal link (Art.4 (5)). Where it concerns a damage-claim against a 'high risk' AI system provider, a breach of duty is only established if considering the 'high risk' management AI system's results, the provider breached their obligations according to the AIA, in particular the AI system was not designed and developed in a way that allows for an effective human oversight, or to meet transparency requirements or to achieve an appropriate level of, accuracy, robustness and cybersecurity, or the provider failed to take corrective actions to remedy another breach or withdraw / recall a 'high risk' AI system. Similarly, a breach of duty of care is established in damages claim against a 'high risk' AI system user if the latter breached its obligation to use / monitor the AI system in accordance with accompanying instructions of use or, where appropriate, suspend or interrupt its use or exposed the AI system to input data under its control to data not relevant in view of the system's intended purpose (Art. 3).

The abovementioned approach does not ensue a reversal of the burden of proof, whereby the claimant no longer bears the burden of proof but rather it is for the defendant to prove that the conditions of liability are not fulfilled. The Commission discards such a reversal of the burden of proof to avoid exposing providers, operators and users of AI systems to higher liability risks, which could hamper innovation in AI-enabled products and services.

Nevertheless, it is noteworthy to mention that the easing of the burden of proof based on the presumptions is not readily acceptable by the EUCJ. The Court in its judgement of 21 June 2017 on the preliminary ruling concerning the interpretation of Article 4 of Council Directive 85/374/EEC rejected the establishment of a presumption of causality between damage and defect or defectiveness of the product. The Court ruled that Article 4 of Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the member states concerning liability for defective products must be interpreted as not precluding national evidentiary rules such as those at issue in the main proceedings. National courts must, however, ensure that their specific application of those evidentiary rules does not result in the burden of proof introduced by Article 4 being disregarded or the effectiveness of the system of liability introduced by that directive being undermined. Article 4 of Directive 85/374 must be interpreted as precluding evidentiary rules based on presumptions according to which, where research neither establishes nor rules out the existence of a link, the existence of a causal link between the defect and the damage suffered by the victim will always be considered to be established when certain predetermined causation-related factual evidence is presented.

In particular, *national courts must, however, ensure that their specific application of those evidentiary rules does not result in the burden of proof introduced by Article 4 being disregarded or the effectiveness of the system of liability introduced by that directive being undermined* (para 43*). A presumption could undermine the burden of proof set out under Art. 4* (in the revised Directive Art.9) whereby the injured person is required to prove the damage, the defect and the causal relationship between defect and damage. *However, in laying down rules of and evidence applying to cases within this Directive, the procedural autonomy of Member States is not unlimited. The combined effect of national rules of proof and evidence must respect the principles of equivalence and effectiveness* (para 24) [...] *In particular, national rules of proof and evidence that unduly hamper the national court's ability to assess 'sufficiently relevant evidence' (para 14) or that are not sufficiently rigorous so that they in practice result in a reversal of the burden of proof, would not be consistent with the principle of effectiveness (para 25).*

It will be interesting to follow the development of EUCJ jurisprudence in the context of the new liability mechanism introduced by the abovementioned Directives and whether it will have an impact on liability in the context of RIT surveys.

An evaluation and targeted review of the AI Liability Directive's application shall take place five years after the end of the transposition period through a monitoring programme established by the Commission which will present a report to the European Parliament, to the Council and to the European Economic and Social Committee, examining the effects of Articles 3 and 4 on achieving the objectives pursued and evaluate the appropriateness of strict no-fault liability rules for claims against the operators of certain AI systems, as long as not already covered by other Union liability rules, and the need for insurance coverage, while taking into account the effect and impact on the roll-out and uptake of AI systems.

6.5. Fault-based liability v. strict liability

The authors, in deciding between fault-based liability and strict liability, turn to the doctrine of 'duty of care' – a concept particularly relevant in areas such as tort law, environmental law, and administrative law within the EU.

In the context of fault-based liability, manufacturers/producers/designers/developers are under a 'duty of care' to inform their customers about potential risks and exercise prudent diligence to mitigate any potential harm arising from errors in the manufacturing and programming procedures.[71] Accordingly, if manufacturers/producers/designers/developers have prudently undertaken appropriate measures, there will be no violation of 'duty of care', even in cases where the RIT has caused damage. In such instances, there would indeed be an absence of fault, rendering fault-based liability principles inapplicable and inadmissible. 'Duty of care', according to the authors, is intrinsically tied to the 'precautionary principle' in so far as the 'duty' involves taking appropriate 'precautions' to ensure the safety and well-being of others. That being stated, it will be necessary to establish a 'causal nexus' between the 'duty of care' and the 'damages' – a process that could potentially complicate the legal proceedings and result in delayed compensation for the injured party. This is because causal-nexus pertains not only to the cause-and-effect relationship characterised by a factual link, it also delves into the examination of whether this factual link is immediate rather than distant or remote.[72]

What is preferred, is a system based on strict liability. In a system of strict liability, it is automatically assumed that the manufacturer or distributor possesses an innate obligation to ensure the safety of their product for its intended use, without the necessity of proving negligence or fault on their part. Within this framework, a breach of 'duty of care' transpires upon the introduction of a defective product into the stream of commerce. Therefore, there is 'absolute' liability on the part of manufacturer, which gives the injured party direct access to prompt compensation without going through the need for establishing causal nexus through direct or distant factual linkages.[73] The above is supported by Andrea Bertolini: ' ... preference should be given to strict liability rules that clearly identify the party who is to be deemed responsible, as the one who benefits from the use or commercialisation of the technology and is in control of the risks posed by it, being best positioned to manage them'.[74] The manufacturing company is likely to obtain insurance (*ex ante* a number of costs) and spread the costs throughout the value chain. This will result in the completion of the liability loop for RIT.[75]

7. Correlation between trust-safety-liability

An effective safety culture develops from the systematic monitoring of safety and by updating the system in accordance with the experiences of both the operator and the industry. However, this updating process is dependent on the open reporting of safety incidents, which is facilitated by trust.[76] Trust in organisations has been studied in different ways to address positive outcomes on organisational phenomena, such as positive impact on safety culture and safety performance.[77] Therefore, the key aspect of building safety culture is the level of openness and trust and access to information that may indicate compromising of safety. James Reason argues that the safety culture is based on an underlying element of trust through the development of three subcomponents: a reporting culture, a just culture, and a learning culture that interact to create a safety culture.[78] Research shows that high levels of trust in relationships contributes to high levels of safety in high-risk enterprises; the shipping industry is considered a high-risk industry.[79]

Similarly, trust acts as the central mechanism through which other drivers impact AI acceptance. It is important, therefore, to understand what influences trust in AI systems. A global study in 2023 examines four distinct 'pathways to trust' their comparative importance in predicting trust – the institutional drivers: the belief that current laws, rules and governance are sufficient to ensure AI use is safe and confidence in government and technology/commercial organisations to develop, use and govern AI, motivational drivers concerning the perceived benefits of AI, uncertainty reduction drivers regarding the perceived risks of AI, and subjective knowledge: the extent to which people feel they understand AI, and tech efficacy.[80]

Transparency in respect of AI systems' use and the way AI systems operate is important for AI to become commonly accepted. Furthermore, the use of risk management in the AI systems' lifecycle as well as the documentation can improve the AI systems' transparency ensuing an organisation's accountability and consequently liability.[81]

Transparency and traceability as well as accountability are fundamental factors in building trust in AI. Mechanisms should be put in place to ensure responsibility and accountability for AI systems and their outcomes, both before and after their implementation. Auditability of AI systems is key in this regard, as the assessment of AI systems by internal and external auditors, and the availability of such evaluation reports, strongly contributes to the trustworthiness of the technology.[82]

In its White Paper on Artificial Intelligence, the Commission stressed that AI systems – and certainly high-risk AI applications – must be technically robust and accurate in order to be trustworthy. That means that such systems need to be developed in a responsible manner and with an ex-ante due and proper consideration of the risks that they may generate. Their development and functioning must be such to ensure that AI systems behave reliably as intended. All reasonable measures should be taken to minimise the risk of harm being caused.

8. Conclusion

RIT or ICT-fused inspections and surveys are not an aberration but an amelioration towards a likely safer future of fully autonomous RAS. RIT can provide better and perhaps safer modes of conducting surveys and inspections. For example, after being integrated, RIT can provide relief from tasks that are otherwise time-consuming, strenuous and in some instances, fatal due to lack of oxygen or polluted vapours in confined spaces of tanks and holds.[83]

Despite the many benefits of remote inspection technologies, some hazards are still evident. Hazard recognition of robotics in the workplace is a prerequisite for their massive exploitation and use if they are to make an impact in reducing the number of injuries and fatalities. The hazards identified in our study include a) operational hazards that emerge during the physical interaction with the service robots b) data quality and security hazards c) social hazards and d) legal hazards.

International regulations for RIT, or top-down rules and requirements, if developed the right way, could help provide guidance and avoid a plethora of hazards for a system marked by multiple echelons and diverse stakeholders. The law is part of a general normative framework, which substantially affects the type of technology being developed and brought to society, securing the trustworthiness of an AI system.[84] Common procedural rules covering data management, liability, and operational standards, will all have a crucial bearing on the types of technology that will emerge in the not-so-distant-future. Transition from UAVs to hybrid Unmanned Aerial Underwater Vehicles (UAUV) capable of navigating and operating in both air and underwater water environments is in the making, and they will soon be deployed in the offshore industry.[85] This will further raise RAS-governance questions as both aviation and admiralty stakeholders will need to unravel complex layers to set new industry-based standards.

Moving to the niche liability domain, it is anticipated that the proposed liability framework shall engender confidence in AI technologies and facilitate access to a proficient judicial apparatus by ensuring accountability/culpability and adequate reparation for individuals (natural or legal) and entities adversely impacted by AI systems. This framework delineates a foundational level of protection for victims, aiming to both redress harm and incentivize proactive measures to avert such harm. The envisaged reforms, seeking convergence in fault-based, non-contractual liability regulations among member states, are poised to dissipate legal ambiguities surrounding the elucidation and application of extant national liability statutes in cases involving AI, thereby striving for equitable outcomes for the affected parties through consistent legal interpretation. Enhanced societal trust is a corollary of these reforms, yielding benefits for all stakeholders within the AI-value chain, affording them the ability to evaluate and mitigate their liability exposure, notably those engaged in cross-jurisdictional trade within the EU, thereby forestalling distortions of competition within the internal market. Thus, the harmonisation of the AI Liability framework emerges as a stabilising force and a prerequisite for the widespread adoption of AI technologies.

A governance structure in the form of a framework for cooperation of national competent authorities, classification societies and relevant stakeholders is imperative. This structure is indispensable for averting the disintegration of responsibilities, amplifying testing and certification capabilities for AI-infused products and services, and maintaining coherence within the industry. Control in the assignment of such authority is needed in order to promote uniformity of inspections and surveys and maintain established standards.

In light of the liability package proposed in this article, a fault-based liability paradigm emerges as fitting, wherein AI interposes between an individual's act or omission and resultant damage. Conversely, a strict, non-fault liability model, reminiscent of liability regimes applicable to defective products, is recommended, further fortified by mandatory insurance coverage. This augmentation aligns with the evolving nature of RIT survey processes, transitioning from human intervention to autonomous and automated modalities. In order to avoid further regulatory fragmentation uniform industry standards as to RIT surveys must be elaborated and established through review processes, relying both on transparent procedural and qualitative criteria while being able to adapt to the AI systems' development. A governance structure should serve as a forum for a regular exchange of updated information and best practices, identifying emerging trends, advising on standardisation and on certification, thus facilitating the implementation of the legal framework. To that effect, it should rely on a network of national authorities, as well as sectorial networks and regulatory authorities, at national, EU and international level.

The writers further contend that the maritime industry and applicable government and organisational regulators will need to adapt to technological transformation. For that transformation to be triumphant – consensus-based methodologically-sound all-embracing guidelines mitigating much-needed liability concerns are indispensable.[86] Hazard and liability aspects will need to be appraised with due diligence at any given stage of development of international guidance on the topic. If carefully structured, the international guidance will enable the maritime industry to unleash the full potential of RAS in the face of current and future global emergencies.

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80 Nicole Gillespie and others 'Trust in Artificial Intelligence: A Global Study' 2023 <https://espace.library.uq.edu.au/view/UQ:00d3c94> accessed 10 October 2023 (The University of Queensland and KPMG Australia).

81 OECD, 'Artificial Intelligence in Society', 2019 <https://doi.org/10.1787/eedfee77-en> accessed 19 September 2023. (OECD Publishing, Paris).

82 Commission, 'Building Trust in Human-Centric Artificial Intelligence' (Communication) COM (2019) 168 final

83 See Poggi and others (n 6).

84 See Rochel (n 50).

85 Kin Hey Chu and others, 'Techno-regulatory challenges for Remote Inspection Techniques (RIT): The Role of Classification Societies' in Tafsir Johansson' et al. (eds), *Smart Ports & Robotic Systems: Navigating the Waves of Techno-regulation & Governance* (Palgrave Macmillan 2023). See also Anastasios Kartsimadakis, 'Remote Inspections Scheme on Tanker Vessels during Covid-19 Pandemic' in Tafsir Johansson' et al. (eds), *Smart Ports & Robotic Systems: Navigating the Waves of Techno-regulation & Governance* (Palgrave Macmillan 2023). See also David Knukkel, 'Remote Inspection Schemes: Past, Present & Future' in Tafsir Johansson et al. (eds), *Smart Ports & Robotic Systems: Navigating the Waves of Techno-regulation & Governance* (Palgrave Macmillan 2023).

86 See Kartsimadakis (n 85).

Disclosure statement

No potential conflict of interest was reported by the author(s **[Q6]**).

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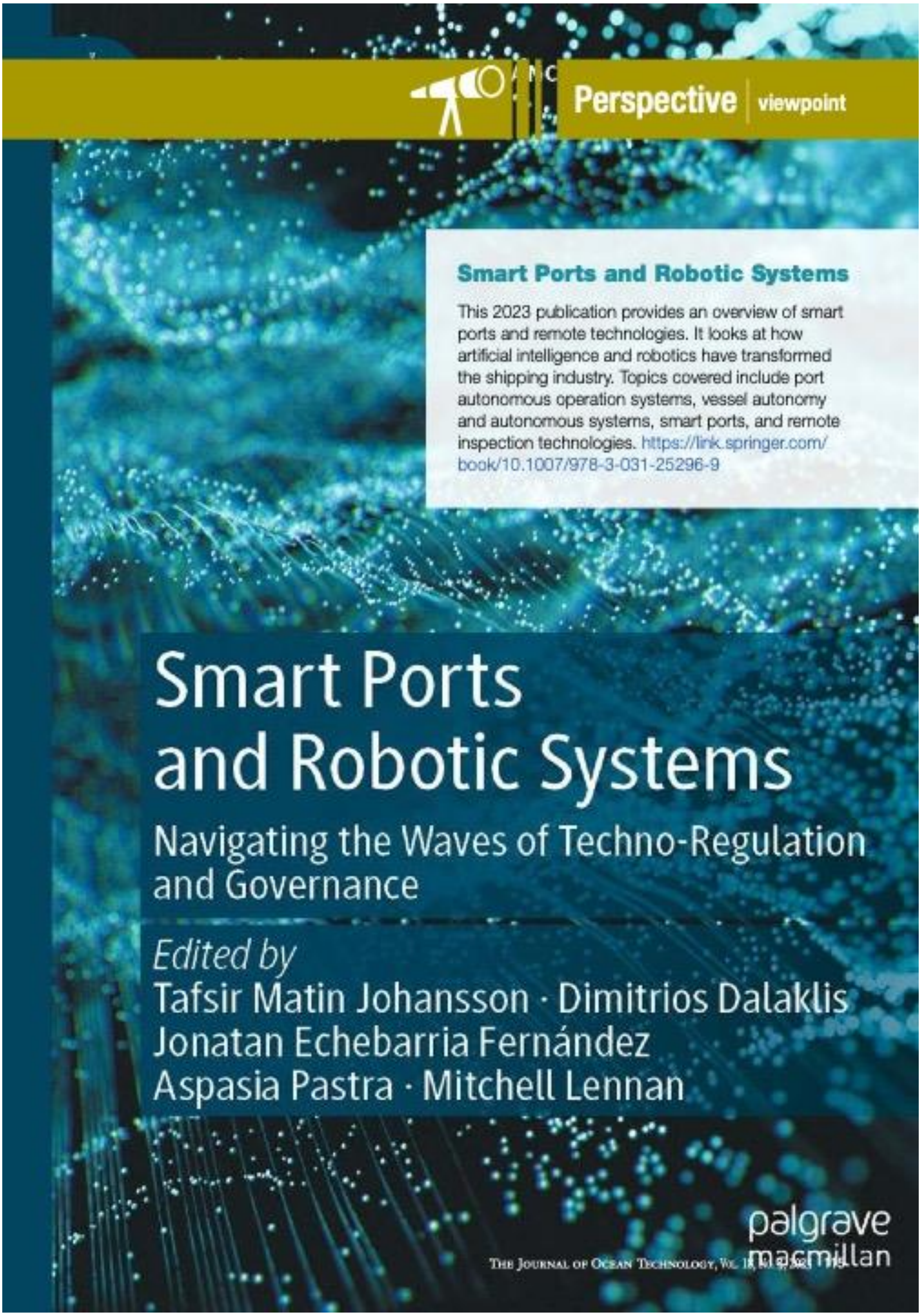
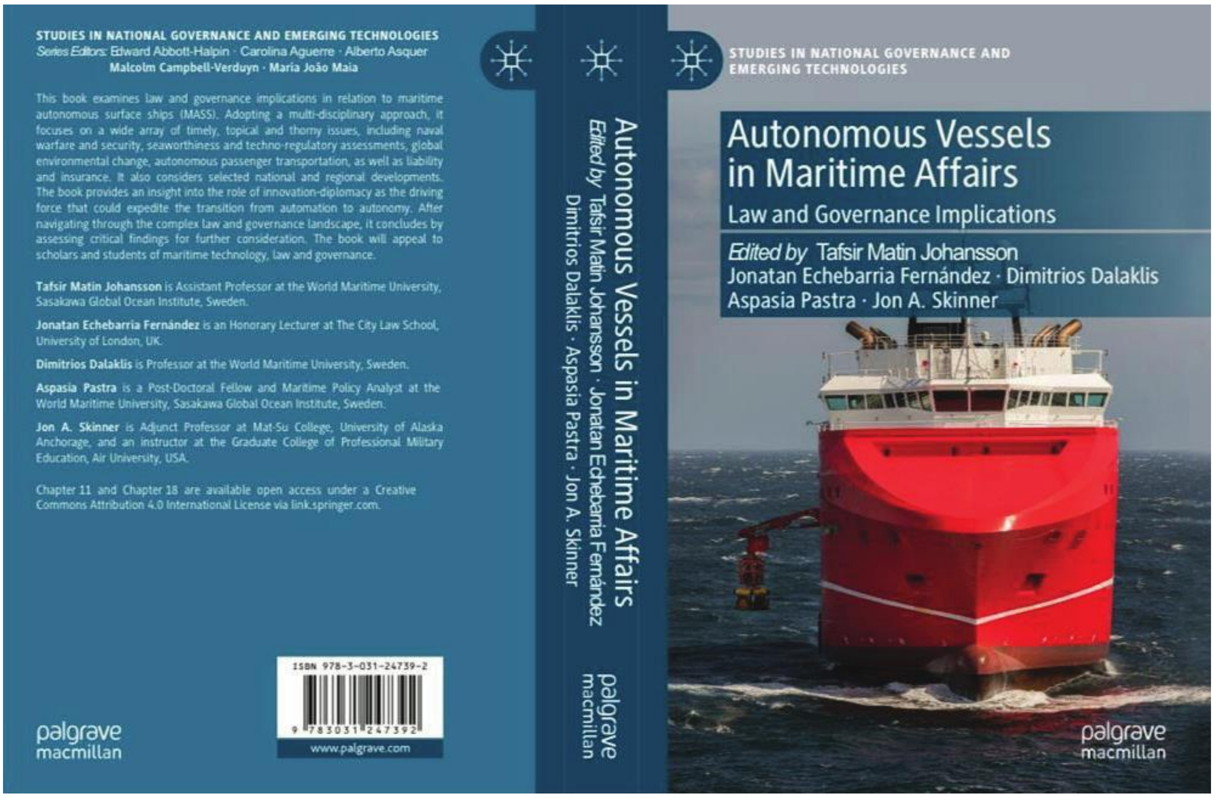

Perspective
viewpoint
Smart Ports and Robotic Systems
This 2023 publication provides an overview of smart ports and remote technologies. It looks at how artificial intelligence and robotics have transformed the shipping industry. Topics covered include port autonomous operation systems, vessel autonomy and autonomous systems, smart ports, and remote inspection technologies. https://link.springer.com/book/10.1007/978-3-031-25296-9
Smart Ports and Robotic Systems
Navigating the Waves of Techno-Regulation and Governance
Edited by
Tafsir Matin Johansson · Dimitrios Dalaklis
Jonatan Echebarria Fernández
Aspasia Pastra · Mitchell Lennan
palgrave macmillan
The Journal of Ocean Technology

Perspective | viewpoint



Autonomous Vessels in Maritime Affairs

This book examines law and governance implications in relation to maritime autonomous surface ships. Adopting a multi-disciplinary approach, it focuses on a wide array of timely, topical, and thorny issues, including naval warfare and security, seaworthiness and techno-regulatory assessments, global environmental change, autonomous passenger transportation, as well as liability and insurance. It also considers selected national and regional developments. The book provides an insight into the role of innovation diplomacy as the driving force that could expedite the transition from automation to autonomy. After navigating through the complex law and governance landscape, it concludes by assessing critical findings for further consideration. The book will appeal to scholars and students of maritime technology, law, and governance.

D. Exploitation & Dissemination Activities: (2020 – 2024) for Task 10.5

This section contains an overview of events participated with a view to exploiting and disseminating findings from research reports pertaining to Tasks 1.4 and 10.4.

It is important to note that "exploitation", in this context, refers to marketing the value of remote inspection technologies maintaining both benefits and regulatory barriers, and creating the value of services so rendered in the process of vessel statutory and classification inspection and monitoring. "Dissemination" on the other hand, in its simple form, refers to sharing research results with all potential users of remote inspection technologies.

Table 1 Overview of World Maritime University's Exploitation and Dissemination Activities

Event	Type	Date	Hosted by	Participants	Focus of Event	Link to Presentation/Event
Webinar	Virtual	4 December 2020	World Maritime University	24 participants: World Maritime University Ph.D. candidates, BUGWRIGHT2 Consortium members as well as respondents interviewed between August and November 2020	International Landscape	Presentation: click here Event: click here Brochure: click here
Conference: European Union Law Forum Annual Conference	Virtual	8-10 September 2021	University of Bournemouth	NA	Addressing Uncertainties in RAS Integration for Ships' Hull Inspection and Maintenance: Through the Prism of International Environmental Law	Session Info: click here Video Presentation: click here

Abstract (above): The effective integration and further improvement of the capabilities offered by numerous Robotic and Autonomous Systems (RAS), as a result of advanced and clearly innovative technical applications, can fundamentally change certain elements of operations within the maritime sector. Albeit, the advantages of utilizing RAS are manifold, considering crucial statutory and classification tasks connected to major carriers of the world fleet that are between the range of 0 to +25 years with (approximately) 9,734 large ships and (approximately) 4,759 very large ships over the age of 5 years. From a maritime standpoint, state-of-the-art technologies, such as Multi-Aerial Vehicles (MAVs), Remotely Operated Vehicles (ROVs) and Magnetic Crawlers, inter alia, has the potential to conduct close-up surveys and thickness measurement in a timely manner and contribute to the mitigation of hull fouling or biofouling, as well as increase vessels' energy efficiency and reduce fuel consumption. Patently, a certain number of manufacturers and service providers assert that RAS can achieve the above effectively and efficiently by replacing the current inspection manual-driven rudimentary system that is time consuming to say the least. There are clear indicators that the paradigm shift has already begun. National flag State authorities, classification societies and ship owners are slowly but steadily adapting to RAS applications that will, in turn, have vital regulatory applications in the context of control, enforcement and compliance, as well as in meeting requirements under environmental, climate and shipping regulation. In retrospect, RAS has garnered widespread attention in the regulatory and policy communities, especially considering the novel aspect of their application that corresponds to optimum performance along with climate change mitigation benefits derived from hulls with a better environmental footprint. However, from a horizontal policy perspective, the international RAS governance framework remains fragmented and shrouded with uneven areas that are grey areas - deemed to impede the seamless integration of RAS alternatives within the maritime domain. For effective integration, the barriers need to come down and uncertainties need to be removed. Against this backdrop, this presentation grapples with a twofold discussion founded on the notion of "environing technology" observing the pathways of good environmental stewardship utilizing emerging applications of progressive technologies. The discussion relates to a brief synthesis of the international RAS arrangements focusing on the UN Framework Convention on Climate Change, the International Maritime Organization (IMO) treaty regime as well as international standards that act as important prerequisites for introducing new technologies in niche areas of shipping. Subsequently, discussions segue into an expository overview of the implications of those technologies on the Law of the Sea governance framework pertaining to safety and environmental protection, followed by a first-hand insight into the regulatory blueprint that provides ways forward in relation to the thorny issues developed by the World Maritime University under the auspices of the European Union Horizon 2020 project BUGWRIGHT2: Autonomous Robotic Inspection and Maintenance on Ship Hulls. Concluding remarks are drawn with reference to policy harmonization considering nine thematic strands for facilitating seamless integration, and with a view to ameliorating RAS' influence with regards to environmental protection.

Conference: World Maritime Day 2021; *Seafarers at the Core of Shipping's Future*	Virtual	30 September 2021	Hellenic Marine Environment Protection Association	120+ participants	Remote Inspection Technologies and the Human Element	Event: click here
Webinar	Virtual	6 October 2021	In Extenso Innovation Croissance (Stakeholder Meeting)	30+ participants	Breaking the RIT Barriers through Regulatory Standards	Presentation: click here
Webinar	Virtual	14 October 2021	Dalarna Science Park, Sweden	30+ participants: officials of Economic Development and Department of Natural Resources, Investment Promotion Bureau, Innovation Centre from Shenzhen, China	World Maritime University: Overcoming Regulatory Barriers for Service Robotics in an Ocean Industry Context	Presentation: click here
Conference: 2021 Global Ocean Regime Conference, *Technological Innovation and the Role of the Law of the Sea*	Virtual	24 November 2021	Ministry of Oceans and Fisheries & Korea Maritime institute	Estimated 150+ participants	Overcoming International Regulatory Barriers for Remote Inspection Technology in an Ocean Industry Context	Presentation: click here Event: click here & here
Webinar: *International, Maritime Organization Ocean Webinar series*	Virtual	1 December 2021	International Maritime Organization & World Maritime University	123 participants	EU Horizon 2020 BUGWRIGHT2: Overcoming Regulatory Barriers for Service Robotics in an Ocean Industry	Presentations: click here Flyer: click here
Workshop: InterAct Kick-off Workshop	Virtual	4 March 2022	University of Copenhagen	30 participants	Trust Ecosystem and Dynamic Governance in Vessel Class Survey	
Conference: 45th Annual Conference on Oceans Law and Policy: UNCLOS at 40	Virtual	17 March 2022	Stockton Center for International Law (SCIL) at the United States Naval War College and the Maritime Institute of Malaysia (MIMA), co-sponsored by the Embassy of Japan in Malaysia, World Maritime University (WMU)-Sasakawa Global Ocean Institute (GOI) and the Korea Maritime Institute (KMI), with additional generous support from the Centre for International Law (CIL NUS), the	100+ participants	Law of the Sea and Class Techno-regulatory Dynamic Governance	Flyer: click here Agenda: click here Presentation: click here

			National Center for the Sea and Maritime Law (DEHUKAM) (Turkey), and the Japan Institute of International Affairs (JIIA).			
Webinar	Virtual	24 March 2022	World Maritime University	88 participants	Optimizing Vessel Operations and Environmental Compliance through Emerging Technologies	Flyer: click here
High-level Seminar: 1st Senior Advisory Group Meeting	Virtual	12 April 2022	World Maritime University	25 participants	International Arrangements, National Comparative Analysis and EU Regional Analysis	Programme and Bio Booklet: click here
Seminar: (at) POSIDONIA 2022 international maritime trade fair	Physical	6 – 10 June 2022	BUGWRIGHT2 Consortium partner: Glafcos Marine	50 participants	BUGWRIGHT2: Overcoming Regulatory Barriers for Service Robotics in an Ocean Industry	NA
Seminar: at Digital Transition and Cybersecurity Awareness in Shipping	Virtual	21 June 2022	Hellenic Marine Environment Protection Association	50 participants	Progressive Autonomy and the Law of the Sea	Presentation: click here
Conference: United Nations Ocean Conference	Physical	27 June 2022	World Maritime University	170 participants	BUGWRIGHT2: Overcoming Regulatory Barriers for Service Robotics in an Ocean Industry Context	Presentation: click here
Conference: 32nd European Safety and Reliability Conference (ESREL 2022)	Physical	28 August 2022	European Safety and Reliability Association	-	Towards a Harmonized Framework for Vessel Inspection via Remote Techniques	Presentation: click here

Abstract (above): Remote inspection techniques (RIT) for performing inspections on the steel structure of ships are changing the landscape of ship inspection and hull cleaning. Patently, unmanned aerial vehicles (UAV) perform global visual inspections, ultrasonic thickness measurements and close-up surveys for ships undergoing intermediate and renewal surveys; magnetic crawlers can conduct ultrasonic thickness measurements and perform hull cleaning; remotely operated vehicles (ROV) can perform underwater surveys. Moving forward, efforts to maintain good environmental stewardship, especially at the European Union (EU) level will require not only the seamless integration of RIT, but also a guarantee that all techno-regulatory elements vital the semi-autonomous platform are streamlined into a cohesive policy framework materialized through multi-stakeholder cooperation. The aim of this extended abstract is to present some of the findings from research conducted by the World Maritime University-Sasakawa Global Ocean Institute (GOI) within the framework of the European Union H2020 BUGWRIGHT2 project. The findings mirrored through this piece derives from research pertaining to: the qualitative assessment of international regime related to ship's safety, environmental control of pollution and survey standards; and comparative analysis from case studies regarding the regulation of robotics covering six leading maritime nations. To this end, discussed herewith are the techno-regulatory elements --- those that bolster support to a harmonized regulatory blueprint for semi-autonomous platforms in the maritime domain.

Keywords: Remote Inspection Techniques, Ship inspection, Maritime Policy, Drones, Remote Operated Vehicles, Magnetic Crawlers.

Seminar	Virtual	20 September 2022	Dalarna Science Park, Sweden	The presentation was attended by 47 participants from Shenzhen, China. Participants included Maritime professors, researchers, decision	(International Ocean Governance) BUGWRIGHT2: Overcoming Regulatory Barriers for	Presentation: click here

				makers from such as: Shenzhen University, Department of City Planning, Business development bureau, Environmental protection department, Department of Natural resourcing, Shenzhen Institute of Advanced Technology, China Academy of Sciences, Tsinghua University (Shenzhen), Shenzhen Maozhou River Basin Administration Center, Shenzhen Maritime Safety Administration of the People's Republic of China, Shenzhen Customs Office of Postal Supervision, Agriculture, Rural and Marine Fisheries Bureau of Shenshan Special Cooperation Zone, Harbin University, Southern University of Science and Technology, Shenzhen Marine Comprehensive Law Enforcement Detachment etc.	Service Robotics in an Ocean Industry Context	
Seminar: Annual seminar for Scandinavian Port State Officers	Physical	28-29 September (presentation made on 29 September)	World Maritime University & Nordic Crisis Management	16 participants	BUGWRIGHT2: Remote Inspection Technologies & Port State Control	Newsfeed: click here Agenda: click here Presentation: click here
Conference: IMO-WMU Conference on the 50th anniversaries of the London Convention and Stockholm Declaration	Virtual	13 October 2022	International Maritime Organization & World Maritime University	600 participants	Reconnoitering Techno-regulatory Dimensions of the Human Environment in Maritime Robotics & Autonomous Systems	Presentation: click here
Conference: 7th International Conference on Ocean Law and Policy	Virtual	14 October 2022	City Law School, London and National Taiwan Ocean University	NA	Deployment of Remote Inspection Techniques Maintaining Dynamic Governance: Umbrella Regulation or Self-Regulation?	Presentation: click here
Conference: VI Conference of the Brazilian Institute for the Law of the Sea	Virtual	28 October 2022	Brazilian Institute for the Law of the Sea	NA	Regulating Emerging Technologies for Vessel Hull Inspection and Maintenance: Rec	Presentation: click here

					ommendations for Reform	
Teaching (2 hours)	Physical	09 March 2023	World Maritime University	Students of *Maritime Safety and Environmental Administration* specialization (MSS 601/week 4)	Towards a Harmonized Framework for Vessel Inspection via Remote Inspection Techniques	Presentation: click here
Special Lecture (45 minutes)	Physical	16 March 2023	World Maritime University	Before the Honorable Executive Board Members of the World Maritime University (click here to view list of members)	WMU Horizon 2020 BUGWRIGHT2 Project Overcoming Regulatory Barriers for Service Robotics in an Ocean Industry Context (Thematic Area: Autonomous Robotic Inspection and Maintenance on Ship Hulls)	Brochure: click here Presentation: click here
Special Lecture (45 minutes)	Physical	30 March 2023	World Maritime University	Mario Girard, CEO Quebec Port Authority; Hugues Paris, Vice President Infrastructure & Environment, Quebec Port Authority; Patrick Robitaille, Vice President Business Development and Innovation, Quebec Port Authority; Jacques Tanguay, CEO Group Ocean; and Jean-Philippe brunet, Executive Vice President – Corporate Affairs and Partnerships	BUGWRIGHT2: Overcoming Regulatory Barriers for Service Robotics in an Ocean Industry Context	Presentation: click here
Webinar (50 minutes)	Virtual	5 April 2023	Hellenic Marine Environment Protection Association (Digital Transition and Cybersecurity Awareness in Shipping)	136 participants: Second Officers, Third Officers, Electrotechnical Officers, Apprentice Officers, Masters, Chief Officers	Progressive Autonomy and the Law of the Sea	Brochure: click here
Seminar	Physical	19 April 2023	Nordic Crisis Management	Scandinavian Port Security Facility Officers (22 Participants)	Remote Inspection Techniques	NA
International High-level Executive Forum	Physical	26-29 April 2023	Delphi Economic Forum	Upon acceptance of the World Maritime University's panel submission, the panel proceeded with a 55-minute discussion. The Forum for 2023 received major news circulation across the globe.	Enhancing Oceanic Affairs with Emerging Technologies	Brochure: click here

Summary of the Delphi Economic Forum & Panel:

The event drew almost 1,000 speakers from 71 countries, including heads of state, national leaders, EU Commissioners, and heads of international organizations.

The event witnessed physical participation from:

- Honorable Excellency Katerina Sakellaropoulou; President, Hellenic Republic;
- Honorable Excellency Kyriakos Mitsotakis; Prime Minister of the Hellenic Republic;
- Alexis Tsipras; Leader of the Main Opposition party, Syriza, Greece;
- Honorable Excellency Rumen Radev; President, Republic of Bulgaria;
- Honorable Excellency Nikos Christodoulides; President, Republic of Cyprus, Cyprus;
- Karl Nehammer; Federal Chancellor, Republic of Austria;
- Edi Rama; Prime Minister, Republic of Albania; and
- Mathias Cormann; Secretary-General, Organization for Economic Co-operation and Development (OECD), France.

The panel developed by the World Maritime University was comprised of:

- (Moderator & Organizer) Dr. Aspasia Pastra; Associate Research Officer, World Maritime University-Sasakawa Global Ocean Institute, World Maritime University, Sweden;
- Mr. Steven Geoffrey Keating; Assistant General Counsel, National Geospatial-Intelligence Agency, US; United States Observer to the Advisory Board on the Law of the Sea at International Hydrographic Organization;
- (Speaker & Organizer) Dr. Tafsir Matin Johansson; Assistant Professor, at the World Maritime University-Sasakawa Global Ocean Institute, World Maritime University, Sweden;
- Captain Yoss Leclerc; President and CEO - Logistro Consulting International Expert Adviser Port Operations - Quebec Port Authority, Canada, Former President - International Harbour Masters Association (IHMA);
- Mr. Panos Zachariadis; Fleet Technical Director, Atlantic Bulk Carriers Management, Member of the IMO Greek Delegation, Greece;
- Mr. Thomas Aschert; Global Marine & Offshore Remote Operations Manager, Lloyd's Register, Germany; and
- John Gikopoulos; Chief Innovation Officer & Head of Applied Intelligence, Qualco Group, Greece.

It is important to note that other than large-scale (hundreds of) physical and online participants --- the World Maritime University BUGWRIGHT2 took the opportunity to engage with over 150 participants including ship-owners (those are the principal end-users), foreign dignitaries, aerospace engineers, politicians and academics to discuss remote inspection techniques with a focus on BUGWRIGHT2. They were made aware of the project, the European Union Horizon 2020 programme, and the mission and vision of the project. In addition, both Dr. Tafsir Johansson and Dr. Aspasia Pastra shared the BUGWRIGHT2 website with many of the participants. This, according to the World Maritime University, is presumably the extensive and most far-reaching dissemination work conducted thus far with highest number of international dignitaries, industry and other relevant stakeholders.

Workshop (Sustainability at Sea: Environmental Dimensions to Ocean Governance)	Physical	17 May 2023	World Maritime University	International participants from the National University of Singapore	Technology Supporting Sustainability and	Brochure: click here
International Event: Maritime Safety Committee (MSC 107)	Physical	31 may – 2 June 2023	International Maritime Organization	1300-member state delegates attended MSC 107. The objective of participation was twofold: 1. To observe top-down regulatory developments of Goal-based standards for maritime autonomous surface ships (31 May – 2 June 2023 (all day events)); and 2. Conduct interview with Executive Vice President of Liberian Registry for critical insights on Goal-based standards (five-tiered approach) and potential collaboration for	MASS Code Development	Agenda: click here

				forthcoming WMU-GOI workshop that serves as a deliverable for WP 10.5 (3 June 2023: 11:00 – 15:00; 18:00 – 20:00)		
North Atlantic Treaty Organization NATO Maritime Interdiction Operational Training Centre 14th Annual Conference	Physical	7th – 8th June 2023	NATO Maritime Interdiction Operational Training Centre	120 NATO as well as EU security high-Officers (name list under strict confidentiality)	Joint Presentation with WMU colleague Professor Dimitrios Dalaklis titled: "Protecting Critical Maritime Infrastructures via Robotic and Autonomous Systems (RAS): Harmonized Techno-Regulatory Dynamics in Profile"	Agenda: click here
Abstract (above): Remote inspection techniques (RIT) for performing inspections on the steel structure of ships are changing the landscape of ship inspection and hull cleaning. Patently, unmanned aerial vehicles (UAV) perform global visual inspections, ultrasonic thickness measurements and close-up surveys for ships undergoing intermediate and renewal surveys; magnetic crawlers can conduct ultrasonic thickness measurements and perform hull cleaning; remotely operated vehicles (ROV) can perform underwater surveys. Moving forward, efforts to maintain good environmental stewardship, especially at the European Union (EU) level will require not only the seamless integration of RIT, but also a guarantee that all techno-regulatory elements vital the semi-autonomous platform are streamlined into a cohesive policy framework materialized through multi-stakeholder cooperation. The aim of this extended abstract is to present some of the findings from research conducted by the World Maritime University-Sasakawa Global Ocean Institute (GOI) within the framework of the European Union H2020 BUGWRIGHT2 project. The findings mirrored through this piece derives from research pertaining to: the qualitative assessment of international regime related to ship's safety, environmental control of pollution and survey standards; and comparative analysis from case studies regarding the regulation of robotics covering six leading maritime nations. To this end, discussed herewith are the techno-regulatory elements --- those that bolster support to a harmonized regulatory blueprint for semi-autonomous platforms in the maritime domain. **Keywords:** Remote Inspection Techniques, Ship inspection, Maritime Policy, Drones, Remote Operated Vehicles, Magnetic Crawlers.						
NAFTEMPORIKI 7th Shipping Conference: The big dilemmas	Physical	14 June 2023	NAFTEMPORIKI	Approximately 500 participants attend the conference. The event received broad nation-wide attention through the media, especially from ship owners, P&I clubs as well as environmental activities.	Dr. Aspasia Pastra acted as moderator of panel titled "The new "face" of human resources in shipping". Dr. Tafsir Johansson acted as a panel member in the panel titled: "How can technology contribute to the goal of decarbonization?"	Agenda: click here
International Event: Maritime Environmental Protection Committee (MEPC 80)	Physical	3-7 July 2023 International Maritime Organization	International Maritime Organization	1500-member state delegates attended MEPC 107. The objective of participation was threefold: 1. To disseminate BUGWRIGHT2 findings to member State Working Group attendees of GHG and biofouling; 2. Obtain critical information relevant to Biofouling management	Tackling climate change - cutting GHG emissions from ships - Including adoption of the revised IMO GHG Strategy; and Biofouling Management	Agenda: click here

				- revised Guidelines; and 3. Obtaining first hand insights on the how to proceed with goal-based standards (N.B. standards form the central element of WMU's work under BUGWRIGHT2)		
46th Annual Conference on Oceans Law and Policy (COLP 46)	Physical	20-22 September 2023	Türkiye, Istanbul	60 + participants. The event was co-organized by Ankara University National Center for the Sea and Maritime Law (DEHUKAM), US Naval War College, World Maritime University, ANCORS University of Wollongong, Gujrat Maritime University, Nippon Foundation, Korea Maritime Institute, The Japan Institute of International Affairs, Republic of Türkiye Ministry of Culture and Tourism, and Turkish chamber of Shipping.	The first of the two presentations were done by Dr. Aspasia Pastra under the panel called "sustainable shipping". Dr. Pastra's presentation titled "Optimizing the Vessel Inspection Domain via Robotic Systems: The "Human Element" Conundrum". Here Dr. Pastra highlighted where the work of the human ends and when the work of the service robots begins through a detailed understanding of the status quo human-robot interface in the maritime sector. This was followed by a separate presentation titled "Standards in Decarbonization and Techno-regulation (NP): Transcending Prescriptive Boundaries" under the panel titled "Protection of the Marine Environment". This was a joint presentation with Executive Vice President of the Liberian Registry, Mr. Thomas Klenum. The Presentation revolved around the nexus between decarbonization and techno-regulation "new paradigm! (np).	Program: Click Here
DEVPORT 2023: Quelle Place Pour Lea Ports Territoriaux Dans Le Systeme Maritime De Demain?	Physical	4-5 October, 2023	Le Havre, France	Over 100 participants	Join paper presentation (Aspasia Pastra) with Mr. Herbert Francke on the topic: "BUGWRIGHT2 Remote Inspection Techniques in Medium and Small-Sized Scandinavian Ports: Application, Advantage & Adversity"	Agenda: Click here

<table>
<tr><td colspan="7">Abstract (above): Robotic and autonomous systems (RAS) are byproducts of a cascade of innovative applications and have the potential to relieve the human element from tasks that are dull and onerous. Drones, remotely operated vehicles and magnetic crawlers, and the likes, commonly known as remote inspection techniques (RIT), are designed to conduct close-up surveys, ship maintenance and thickness measurements. RIT, especially drones, have become an increasingly popular tool in large ports to enhance port security and safety. These can be used for surveillance, inspection of cargo and ships for contraband and monitoring of vessels' movements.

The aim of this paper is twofold. Firstly, to present the major findings from BUGWRIGHT2—a collaborative project co-funded by the European Union's Horizon 2020 Research and Innovation program that aims to change the European vessel-structure maintenance landscape. Secondly, to examine the extent to which small and medium-sized ports in Scandinavia use RIT for ground-based port operations and sea navigation. To this end, this article documents findings from interviews with Master Harbors and Port Security Officers in Scandinavia that draw reference to the extent of use of these technologies in ports. Recommendations for the use of RIT in ports have been, thereupon, tabled considering the need for a review of the International Ship and Port Facility Security (ISPS) Code) to address the application of unmanned aerial vehicles in managing port security.</td></tr>
<tr><td>11th Advisory Board on the Law of the Sea (ABLOS)</td><td>Physical</td><td>11-12 October, 2023</td><td>Monaco</td><td>(approximately) 50 participants (closed event)</td><td>Paper presentation (by Tafsir Johansson): “Dynamic Governance in the Application of Maritime Remote Inspection Techniques: Recommendations for Reform”</td><td>Agenda: click here</td></tr>
<tr><td colspan="7">Abstract (above): Artificial Intelligence integrated robotic technologies provide innovative, perhaps even revolutionary new solutions under the auspices of the fourth industrial revolution. A cascade of innovations has led to state-of-the-art solutions by allowing the completion of tasks that are otherwise time consuming, risky and onerous. Among these innovations, remote inspection techniques (RIT), including unmanned aerial vehicles (UAVs), remotely operated vehicles (ROVs), and magnetic crawlers, have gained significant traction, particularly in response to the challenges posed by the COVID-19 pandemic. These alternatives have been embraced by classification societies due to their ability to navigate restrictive conditions. By capturing intricate data through real-time visual imagery, RIT boasts the capability to deliver inspection services with enhanced safety and efficiency, thereby driving the transformative digitization of the "ship survey" landscape. The groundwork for a paradigm shift has been laid. In this scope, the multi-robot (ship-hull) survey platforms currently explored have the potential to alter the manner in which massive structures are currently being inspected and maintained. This transformative shift stands to enhance the competitiveness of the shipping industry, opening avenues for improved regulations, standards, and environmental conservation. This transformative shift stands to enhance the competitiveness of the shipping industry, opening avenues for improved regulations, standards, and environmental conservation. However, while the existing framework based on international common minimum standards is commendable, it raises several challenging concerns that might emerge post-implementation of available techniques. Considering those thorny issues, this presentation underscores pivotal components that collectively chart a course toward overcoming potential market growth barriers that could otherwise hinder progress in this techno-regulatory paradigm shift. Subsequently, the presentation offers an in-depth look into the qualitative regulatory blueprint, which has been developed by researchers at the World Maritime University under the European Union Horizon 2020 project “BUGWRIGHT2: Autonomous Robotic Inspection and Maintenance on Ship Hulls”.</td></tr>
<tr><td>World Maritime University: Ocean Sustainability, Governance & Management Specialization</td><td>Physical</td><td>31 January 2024</td><td>Sweden, WMU HQ</td><td>17 students</td><td>Course lecture titled: Marine Technology, Autonomation & Data Acquisition

WMU is pleased to inform that BUGWRIGHT2 findings have been integrated into course lecture, which shall be delivered on an annual basis.</td><td>NA</td></tr>
<tr><td>ESG Shipping Awards Best Practices Workshop</td><td>Physical</td><td>13 February 2024</td><td>Athens, Greece</td><td>(approximately) 70+ participants (closed event)</td><td>Panel discussions on topic “Ocean Technologies and the Human Element” by Dr. Aspasia Pastra</td><td>Agenda Timeline: click here</td></tr>
<tr><td>WMU-GOI-BUGWRIGHT2 Event</td><td>Physical and online</td><td>16 February 2024</td><td>Piraeus, Greece</td><td>70 physical participants; 270 online participants</td><td>See Agenda (Row to the right)</td><td>Agenda: click here</td></tr>
</table>

Please find transcribed in s. 7 of this report						Biographies: click here
World Maritime University: Ocean Sustainability, Governance & Management Specialization	Physical	4 March 2024	Sweden, WMU HQ	30 students	Course lecture titled: Governance of Marine & Remote Inspection Technologies WMU is pleased to inform that BUGWRIGHT2 findings have been integrated into course lecture, which shall be delivered on an annual basis.	NA

E. ANNEX: PRINCIPAL RESEARCH REPORT (2020 – 2024) FOR TASK 10.5

This section contains the original texts produced by the World Maritime University based on raw data and information. In other words, this section contains foundation-research imbricated with desktop research findings, raw data, raw-data analysis, results from primary and secondary source examination, and findings from inquiry and strategic exploration. It is important to note that the World Maritime University has finalized this report (May-October 2023) taking into account all general and specific comments provided by the following members of the Senior Advisory Group:

1. Mr. Thomas Klenum; Executive, Vice President, Liberian Registry, Washington, Germany;
2. Ms. Mona Swoboda; Program Manager, Inter-American Committee on Ports (CIP) Organization of American States;
3. Ms. Vera Alexandropoulou; Lawyer & Solicitor and Vice President, Thalassa Foundation;
4. Ms. Marina Papaiouanou; Training Manager, Det norske Veritas;
5. Captain Yoss LeClerc; President & CEO at Logistro Consulting International Inc.; President, International Harbour Masters Association;
6. Mr. Andrew Baskin; Vice President, Global Policy and Trade, General Counsel, HudsonAnalytix, Inc.;
7. Mr. David Knukkel; CEO at GDI and RIMS BV, Global Drone Inspection (GDI) of Robotics in Maintenance Strategies (RIMS), the Netherlands;
8. Mr. George Giazlas; Operations Manager DIVING STATUS Underwater Services; and
9. Mr. Thomas Aschert; Senior Principal Surveyor, Lloyd's Register, Netherlands.

1. INTRODUCTION

1.1 Setting the Scene

1.2 Objectives

The objectives of this report are aligned with the objectives found in *Annex 1 to the Grant Agreement (Description of Action) Part B* s. 2.1.3 (pp. 29) entitled "regulatory barriers and policy framework inputs".

Objectives (Strand 1): Review of Origins, Types and Status of International, European, And National Norms, Regulations and Standards in Relation to Autonomous Robotics

The aim of this report is to review the origins, types and status of international, European, and national norms, regulations and standards in relation to autonomous robotics. Specifically, the main objective is to examine the origins and status of norms and regulations on artificial intelligence; safety, and cybersecurity

The connection between autonomous robotics and artificial intelligence (AI) is a profound and dynamic one, with significant implications for safety and cybersecurity. As autonomous robotic systems become more advanced and prevalent --- their reliance on AI technologies becomes increasingly crucial. Autonomous robots are able to interact with humans and adapt to complex tasks and environments using sensors, machine learning algorithms, and sophisticated programming. AI, merging with machine learning (ML) and deep learning (DL) capabilities, plays an increasingly important role in the development of intelligent robots which perceive and understand their environment in a way that is similar to how humans' function (Soori et al., 2023).

In the same vein, ensuring the safety and cybersecurity aspects of these systems becomes an essential consideration. Following the ISO/IEC Guide (2014, 3.14), safety has been conceptualized as "… freedom from risk which is not tolerable". In the case of human-robot interaction, safety can ensure that only mild contusions may occur in worst-case scenarios (Haddadin and Croft, 2016). The safety of autonomous systems is the cornerstone in cultivating trust in robotics and contributes to the complex interplay between and among specific work tasks, human dispositions, organizational and team settings, stakeholder needs and policies (Pastra et al., 2022). Ensuring the safety of robotics systems involves rigorous testing, validation, and adherence to strict regulations in a setting that AI algorithms are thoroughly trained and evaluated to minimize the risk of unintended behavior or accidents.

Cybersecurity, in that continuum, also emerges as a critical concern in the context of autonomous robotics since the more connected and integrated into larger networks these systems are --- the more prone they are to cyber threats (Pastra et al., 2022). Malicious actors could exploit vulnerabilities in AI algorithms or gain unauthorized access to control systems, potentially leading to significant damage, privacy breaches, or even physical harm. The increased functions of interconnectivity with multiple devices and cloud services could weaken autonomous systems, thereby increasing the risk of system failure or malicious attacks (Martinetti et. al., 2021; Michels and Walden, 2018). Therefore, robust cybersecurity measures, including encryption, authentication protocols, and intrusion detection systems, are crucial to safeguarding autonomous robotics systems from cyber-attacks.

Objectives (Strand 2): A Methodology for the Evaluation of Existing Norms and Standards

As the realm of robotic technologies expands, the need to critically evaluate and adapt existing norms and standards becomes increasingly pertinent. This report outlines a proposed methodology with four key elements to be used for the evaluation of existing norms and standards in robotic technologies.

a) Evaluation of the Existing Regulatory Framework through a Socio-Legal Approach;
b) Evaluation of Hazards and Mitigation Frameworks to enable international harmonized rules;
c) Establishment of human-centric and ethical principles; and
d) Regulatory sandboxes and Living Labs: a synergistic approach to adaptable regulation.

The four elements provide for a comprehensive and forward-looking approach that, not only assesses the current regulatory landscape but also focuses on risk mitigation, ethical innovation, and the synergistic use of regulatory sandboxes and living labs.

Objectives (Strand 3): Advance Understanding Whether New Regulatory Approaches or Self-regulation is Best for the Future Development of Robot-technologies for Automatic Robotic Guidance and Inspection Systems

The aim of this strand is to advance understanding whether new regulatory approaches or self-regulation is best for the future development of robot-technologies for automatic robotic guidance and inspection systems

Objectives (Strand 4): Make Recommendations for Reform and Enhancement of a Regulatory Blueprint in consultation with European and International Organizations

The aim is to create distinctive and state-of-the-art regulatory and policy blueprint, which can be used by the various regulatory bodies. It suggests that basic selected strands of influence that have the potential to bolster support in conceiving international harmonized rules.

Objectives (Strand 5): Develop Guidelines for the Regulation of Autonomous Robotic Inspection and Guidance Systems

To develop guidelines that specify acceptance criteria for utilizing the capabilities of a Remote Inspection Technique System (RITS) toward the credit of surveys as required by flag States.

1.3 Methodology

Methodology (Strand 1) Used to Review origins, types and status of international, European, and national norms, regulations and standards in relation to autonomous robotics

For the analysis of the AI, safety and cybersecurity origins and norms, the methodology deployed includes analysis of data collected through primary and secondary sources of information. Secondary sources encompass scholarly materials developed by legal experts, publicly available governmental documents, legal directories, and policy documents provided by maritime administrations. Primary data collected to satisfy the aims of work package 1.4 has been also utilized in this report. Moreover, researchers turned to the in-depth semi-structured interviews conducted between March and July 2021 with sixty (60) international subject matter experts --- results which, to date, serve as important benchmarks of the current study.

Methodology (Strand 2) Used in the Process of Developing a Methodology for the Evaluation of Existing Norms and Standards

This strand is developed taking into account both qualitative and quantitative methods. Reference is also made to the methods utilized in the development of the BUGWRIGHT2 regulatory blueprint (see report deliverable for work package 1.4).

Methodology (Strand 3) Used to Advance Understanding Whether New Regulatory Approaches of Self-regulation is Best for the Future Development of Robot-technologies for Automatic Robotic Guidance and Inspection Systems

The methodology deployed for reviewing selected national arrangements include analysis of data collected through primary and secondary sources of information. Secondary sources included scholarly materials written by legal experts, governmental publicly available documents, and scholarly sources. Primary data was collected through in-depth semi-structured interviews between March and July 2021 for the aims of the BUGWRIGHT2 WP10.4.

Methodology (Strand 4) Used to Make Recommendations for Reform and Enhancement of a Regulatory Blueprint in consultation with European and International Organizations

Findings have been extracted based on exposition of legal texts, international instruments, relevant scholarly literature, academic and professional journals containing legal opinions and expert commentaries, industry standards, procedures, requirements and the likes. In addition, qualitative findings from thirty-three structured interviews conducted during the Covid-19 pandemic has helped underscore the pre-requisites, including the identification and removal processes of some particular difficult issues for transition.

Methodology (Strand 5) Used to Develop Guidelines for the Regulation of Autonomous Robotic Inspection and Guidance Systems

All elements of the guidelines have been carefully extracted based on exposition of legal texts, international instruments, relevant scholarly literature, academic and professional journals containing legal opinions and expert commentaries, industry standards, procedures, requirements and the likes. All previous scholarly outputs (developed under the auspices of the BUGWRIGHT2 project) provided a foundation for the main elements that should be incorporated into the guidelines for end-users. These publications bridge potential policy gaps through cooperation-based strategic techno-regulatory governance founded on critical safety, security, quality, performance, and efficiency standards with regards to maritime semi-autonomous platforms (see Annex I). Besides, the discussions that took place at the IMO Headquarters during the a) 107th session of the IMO's Maritime Safety Committee from 31 May to 9 June 2023 and b) the 80th Marine Environment Protection Committee from 3-7 July 2023 contributed significantly to the development of the guidelines (see Annex II).

Acronyms

AI	Artificial Intelligence
AILD	Artificial Intelligence Liability Directive
AI HLEG	European Union High-Level Expert Group on Artificial Intelligence
AIDA	Artificial Intelligence and Data Act
CAC	Cyberspace Administration of China
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CSIRTs	Computer Security Incident Response Teams
DL	Deep Learning
DSA	Digital Services Act
DSP	Digital service providers
DMA	Digital Market Act
DSPs	Digital service providers
ECCC	European Cybersecurity Competence Center
ECCG	European Cybersecurity Certification Group
ENISA	The European Union Agency for Cybersecurity
ETSI	European Telecommunications Standards Institute
EU	European Union
GDPR	General Data Protection Regulations
GPSD	Directive 2001/95/EC of the European Parliament and of the Council of 3 December 2001 on general product safety
IC	Intelligence Community
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
IT	Information Technology
IEC	International Electrotechnical Commission

ML	Machine Learning
MSR	Decision No 768/2008/EC of the European Parliament and of the Council of 9 July 2008 on a common framework for the marketing of products
NAIIA	National Artificial Intelligence Initiative Act of 2020
NAII	National Artificial Intelligence Initiative
NCCs	Network of National Coordination Centres
NIS	Network and Information Security Directive
NIS2	Network and Information Security Directive2
NIST	National Institute of Standards and Technology
NSTC	National Science and Technology Council
OES	Operators of essential services
OSTP	Office of Science and Technology Policy
PIPL	Personal Information Protection Law of China
RAPEX	EU's Community Rapid Information System
R&D	Research and Development
Select Committee	Select Committee on Artificial Intelligence
TEC	Treaty establishing the European Community
TFEU	Treaty on the Functioning of the European Union
US	United States

2.1 Initiatives for the Regulation of AI

Over the past seven years, AI has been the new subject of large-scale regulation to ensure that its design, deployment, and use is framed safely, responsibly, and ethically. The European Union (EU), United States of America (US), China, and Canada have participated in policy initiatives to become global AI leaders and balance socio-economic priorities with the tremendous pace of innovation in robotics and artificial intelligence applications (Miailhe and Lannquist, 2020). As AI continues to advance and permeate various aspects of society, there is a growing recognition of the need for global cooperation and coordination in regulating this transformative technology.

2.1.1 The Evolution of AI Regulatory Initiatives in Europe

A European Union High-Level Expert Group on Artificial Intelligence (AI HLEG) was formed by the European Commission in June 2018 to provide advice on artificial intelligence and generic aspects. This unique effort has led to three crucial policymaking initiatives taken by the Commission and its Member States:

- Communication on Building Trust in Human Centric Artificial Intelligence (European Commission, 2019) sets seven key requirements for trustworthy AI: Human agency and oversight, Technical Robustness & Safety, Privacy and Data Governance, Transparency of AI systems, Fairness, Societal/environmental well-being and Accountability;
- White Paper on Artificial Intelligence: a European approach to excellence and trust (European Commission, 2020a) presents policy options to enable the trustworthy development of AI and analyses strengths, weaknesses, and opportunities for Member States in the global market of AI; and
- Updated Coordinated Plan on AI (European Commission, 2021a) includes actions for four policy strands: a) set enabling conditions for AI development, b) make the EU the place where excellence thrives from the lab to market, c) ensure that AI technologies work for people and d) build strategic leadership in high impact sectors.

In 2021 the European Parliament and the Council laid out a Proposal for a Regulation Laying Down Harmonized Rules on Artificial Intelligence (Artificial Intelligence Act), amending Certain Union Legislative Acts. Upon its adoption, the Act will be the world's first law to regulate artificial intelligence, ensuring a human-centric approach for safe, transparent, and environmentally friendly AI systems. The Act aims to address the risks of AI by categorizing them into four levels: unacceptable risk, minimal risk, limited risk, and high risk. The Act has the potential to become a global standard, providing the best standardized approach in classifying AI systems according to risk and establishing obligations for providers and users. After the implementation of the Act, a European Artificial Intelligence Board will be developed, ensuring its uniform application across the EU. Article 3(1) narrows down the definition of AI systems to those developed through machine learning techniques, knowledge-based approaches and search and optimization methods. The proposal sets the basis for a horizontal foundation for AI through the establishment of a trustful network between the manufacturer and end-user, high-risk AI systems requirements and harmonized rules before placing the product on the market.

In addition, other AI-related rules have recently been adopted, such as the Digital Services Act (DSA) and the Digital Market Act (DMA) that have the potential to enhance the safety of digital services and foster innovation. DSA came into force on 16th November 2022 and imposed new obligations on platforms, such as disclosure requirements to regulators about the operation of algorithms. Within that context, on 28th September 2022, the Commission released a Proposal for an Artificial Intelligence Liability Directive (AILD) to improve the functioning of the internal market by specifying uniform rules for certain aspects of non-contractual civil liability for damage caused by the involvement of AI systems.

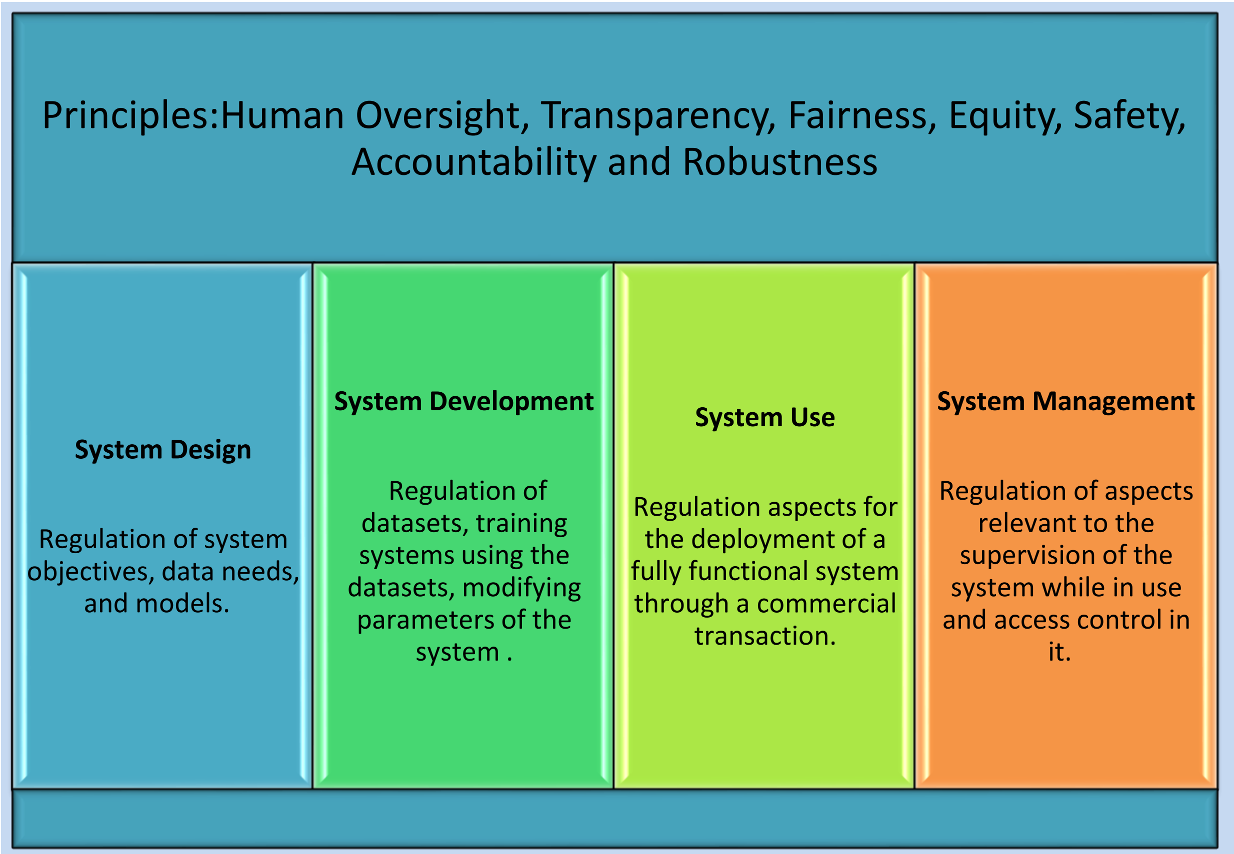
Another important initiative in 2021 emanated from the European Standardization Organizations through the *Strategy 2030* of the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC). The Strategy supports the implementation of the EU law and proposes the formulation of advanced and innovative standards in the field of AI.

2.1.2 The Evolution of AI Regulatory Initiatives in Canada

IMO, a UN specialized agency and a standard-setting organization conscientiously operates within the UNCLOS framework in the development of regulations. Canada is another leading AI country that has contributed significantly to AI technology since the 1970s. Its network comprises of 850 start-up companies, 20 public research labs, 75 incubators and accelerators, and 60 groups of investors from across the country (Government of Canada, 2020).

In 2017, Canada was the first country in the world to develop a national strategy for AI, namely the *Pan-Canadian Artificial Intelligence Strategy*. In June 2022, the Government of Canada drafted a new regulatory framework for AI innovation known as the *Artificial Intelligence and Data Act* (AIDA). AIDA is included in Bill C-27, the Digital Charter Implementation Act, 2022, to ensure a trustful ecosystem of digital technologies for Canadians and Canadian businesses that mitigate risks and address discriminatory outcomes. This new regulation has been made in cooperation with key stakeholders and international partners – such as the EU, the United Kingdom, and the U.S. The content of AIDA aligns with the EU Artificial Intelligence Act as it specifies criteria for high-impact systems similar to those that use biometric data for personal identification or other autonomous systems critical to health and safety (Government of Canada, 2022). AIDA, like the European AI framework, is guided by the principles of Human Oversight, Transparency, Fairness and Equity, Safety, Accountability and Robustness so as to regulate system's design, development, use and management (see Figure 1).

Figure 1: Policy Measures for Each Stage of the Lifecycle of an AI System



Source: Adapted from the Government of Canada, 2022

2.1.3 The Evolution of AI Regulatory Initiatives in China

Within the maritime policy context, classification societies play an indispensable role in the regulation and safety of the maritime sector. China in the last few years has rapidly developed its artificial intelligence (AI) capabilities and invested heavily in AI research. China State Council issued a seminal document in 2017 titled *A Next Generation Artificial Intelligence Development Plan* (State Council Document No. 35) with ambitious plans to make AI the main driving force for economic transformation. The Plan includes strategic goals, research & development, talent development through education and skills acquisition as well as ethical norms and aims to make the country the leading AI power by 2030 in production segments, social governance, national security, and defense (The State Council of the People's Republic of China, 2017). The Plan asks for fostering "local industry and innovation chains focused on AI" and the establishment of "AI industrial clusters". Local governments across the nation have launched similar initiatives and the Beijing region, already home to many major businesses and research institutes, supports the best examples in the context of China. In addition to the *Next Generation Artificial Intelligence Development Plan*, the government has passed other policies, such as *Made in China 2025* (The People's Republic of China, 2015) and *Action Outline for Promoting the Development of Big Data* for the development of AI (State Council, 2015). These policies aim to motivate different stakeholders on the ground that AI is a field that is being backed by the government and is worth investing in (Li, Tong and Xiao, 2021).

In 2016, China enacted the Cybersecurity Law of the People's Republic of China, which came into force on 1st of June 2017, to regulate the country's cyber networks and protect citizens' and organizations' lawful rights and interests (Wagner, 2017).

One of the most crucial policies is the *AI Security Standardization White Paper*, released in 2019 by the National Information Security Standardization Technical Committee. This provides guidelines for the development and use of AI systems in various industries, with a focus on ensuring the security of data and protecting the rights of individuals (CSET, 2019).

In 2021 China's Ministry of Science and Technology published the *Ethical Norms for New Generation Artificial Intelligence* to underline the full decision-making power of humans over machines and integrate moral parameters into the entire lifecycle. The guidelines are based on the following principles: controllable and trustworthy systems, human well-being, fairness and justice, protection of privacy and safety, and ethical literacy.

China Personal Information Protection Law (PIPL) that entered into force on 1 November 2021 (The National People's Congress of the People's Republic of China, 2021) enhances the Chinese legal framework for data security and bears similar markings to the European Union's General Data Protection Regulations (GDPR) that limit the use of personal data by businesses and protect user's rights. The law addressed many of the data misuses that have plagued Chinese consumers for years and applies to organizations and individuals who process personal information in China and those who process data of China citizens outside the country.

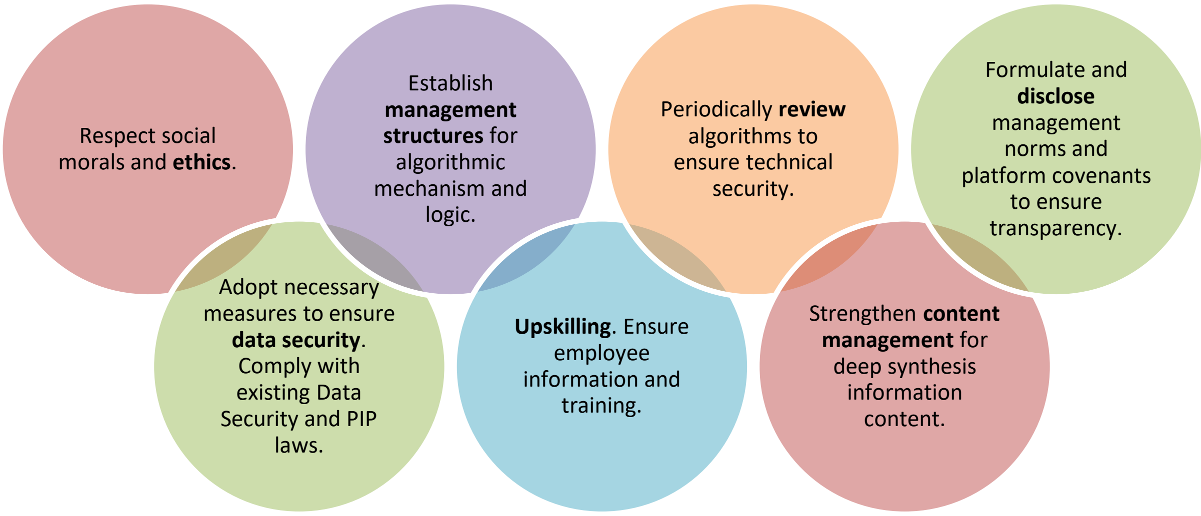
PILP, along with the *Data Security Law* (The National People's Congress of the People's Republic of China, 2021) and *Cybersecurity Law* (Standing Committee of the National People's Congress, 2016), have a profound impact on all enterprises that employ networks or information systems in their operations and impose technical alterations on IT infrastructure and system application and design.

On 11th April 2023, the draft law *Administrative Measures for Generative Artificial Intelligence* Services developed by the Cyberspace Administration of China (CAC), requiring organizations to submit security assessments to authorities before launching their offerings. The draft law addresses issues such as content moderation, algorithmic transparency and protection of the Rights of End Users.

China's *Deep Synthesis Provisions* came into force on 10th of January 2023 as part of the Chinese government's efforts to strengthen its supervision over deep synthesis technologies (Cyberspace Administration of China, 2022). These technologies include the use of generative algorithms with deep learning and virtual reality to produce text, images, sound and video functions. The provisions include a number of obligations of organizations providing deep synthesis services or providing technical support to these services (see Figure 2).

It should also be noted that the level of AI and the implementation of the national strategy varies from region to region. There are regions such as Shanghai and Shenzhen that have built robust infrastructure for new AI companies, whereas other regions are still in the process of exploring AI systems. Shenzhen policymakers have drafted local regulations for AI in June 2021 on the Promotion of Artificial Intelligence Industry of Shenzhen Special Economic Zone to the local People's Congress for review. The Regulations aim to establish a framework in order to govern the approval of AI products and services, AI usage ethics and residents' data privacy rights. This initiative may pave the way for the development of similar standards at the national level.

Figure 2: Policy measures for each stage of the lifecycle of an AI system



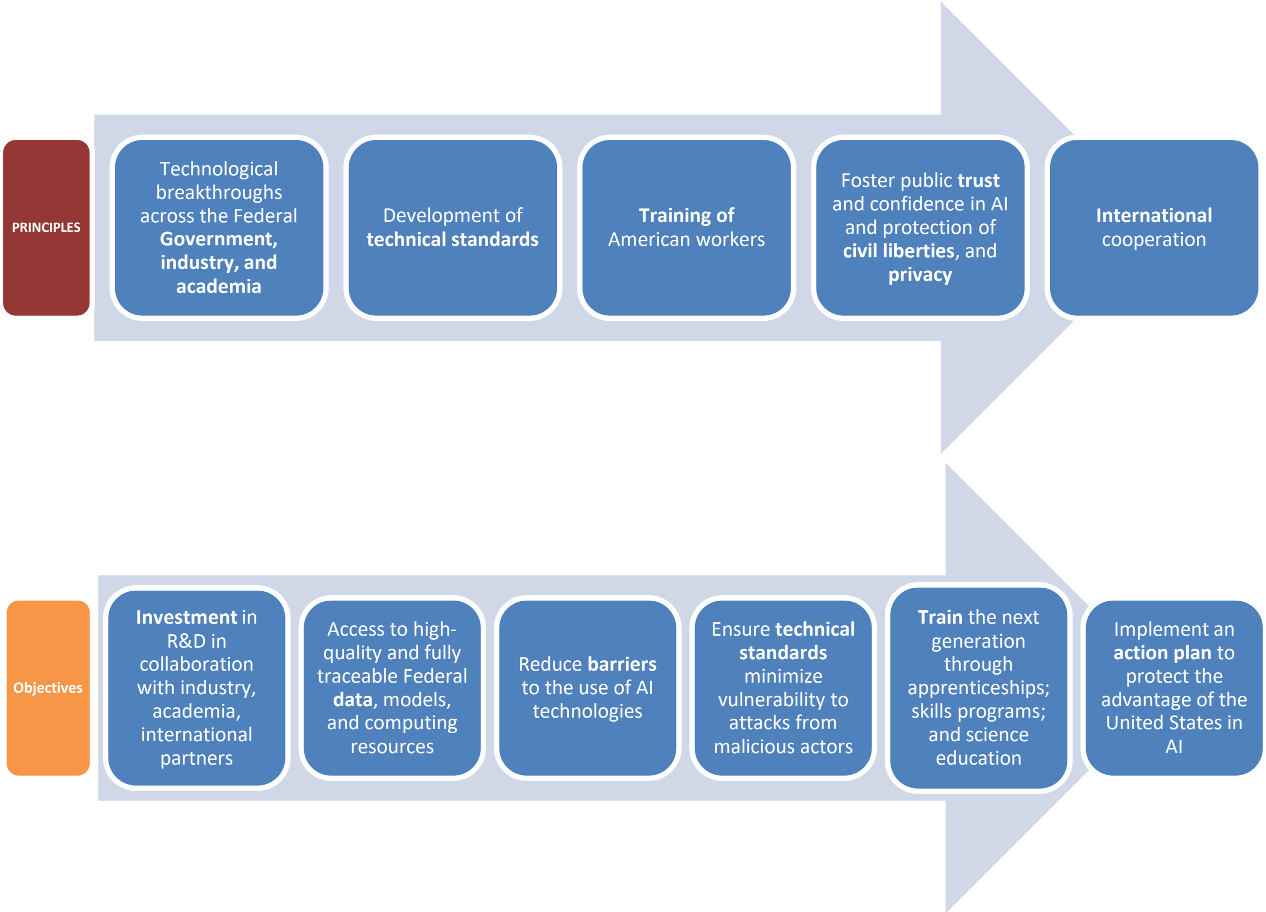
Source: Adapted from China's Deep Synthesis Provisions

2.1.4 The Evolution of AI Regulatory Initiatives in the USA

In the US --- the national strategy on AI is defined through legislation and Executive Orders. The current framework is an amalgam of legislation, Executive Orders and existing rules covering product liability, data privacy, intellectual property, unfair treatment and discrimination.

On 11 February 2019, the US President launched the American Artificial Intelligence Initiative, the Nation's strategy for promoting American leadership in AI, by signing Executive Order 13859: *Maintaining American Leadership in Artificial Intelligence* (The Federal Register, 2019). The aim of the Executive Order is to enhance the scientific, technological, and economic leadership position of the U.S. through a coordinated Federal Government strategy. The American AI Initiative (coordinated Federal Government strategy) is based on five principles: AI research funding, unleashing Federal AI computing and data resources, setting AI technical standards, nurturing America's AI workforce and fostering international partnerships (Figure 3). The Initiative is coordinated by the National Science and Technology Council (NSTC) Select Committee on Artificial Intelligence (Select Committee).

Figure 3: Principles and Objectives of the Executive Order 13859



Source: Adapted from Executive Order

Furthermore, in February 2020, one year after the AI Initiative, the First Annual Report of the American Artificial Intelligence Initiative was published to assess the progress toward achieving the national strategy's objectives (Executive Office of the President of the United States, 2020). Among others, the country was urged to eliminate impediments to the safe development and testing of AI technologies. This should be accomplished primarily by appropriate guidance that is compatible with the Nation's values and technical standards for AI.

Consistent with Executive Order 13859, the Office of Management and Budget (OMB), in cooperation with the Office of Science and Technology Policy (OSTP), issued in November 2020 a Memorandum for the Heads of Executive Departments and Agencies with guidelines governing how federal agencies should develop and use AI technologies (Office of Management and Budget/ Exec. Office of the President, 2020).

The memorandum establishes ten Principles for good Stewardship in relation to AI Applications that agencies should take into account before enforcing regulation (see Table 2).

Table 2: Proper Development and Use of AI

No.	Proper Development and Use of AI
1.	Public Trust through the promotion of reliable, robust, and trustworthy AI applications.
2.	Public Participation in all the phases of the policymaking process.
3.	Scientific Integrity and Information Quality throughout the rulemaking process.
4.	Risk Assessment and risk management for regulatory and non-regulatory approaches to AI across various agencies and various technologies.
5.	Benefits and Costs assessment before considering regulations related to the development of AI applications.
6.	Flexible approaches that can be adapted easily to technological changes.
7.	Fairness and Non-Discrimination with respect to outcomes produced by the AI application.
8.	Disclosure and Transparency for addressing questions about how the application impacts human end-users.
9.	Safety and Security methods and approaches for the development of AI systems that guarantee systemic resilience and prevent malicious actions and exploitations of AI system weaknesses.
10.	Interagency Coordination for consistency and predictability of AI-related policies.

Source: Adapted by the Office of Management and Budget, 2020

According to the Memorandum, all Federal Agencies are encouraged to consider using existing statutory authority to issue non-regulatory policy statements and guidelines to encourage AI innovation in their respective sector. For example, the US Department of Defense has adopted ethical principles for using the AI application responsibly when applying testing and fielding standards for technology innovations. In addition, the *Principles of Artificial Intelligence (AI) Ethics for the Intelligence Community (IC)* released in July 2020 intends to guide the personnel on how they should develop and use AI and include machine learning (see Figure 4).

Figure 4: Artificial Intelligence Ethics for the Intelligence Community

Source: Adapted by the Artificial Intelligence Ethics for the Intelligence Community (Office of the Director of National Intelligence, n.d.)

The Principles and Objectives of the Executive Order 13859 were codified into law by the *National Artificial Intelligence Initiative* (NAII) which was established by the National Artificial Intelligence Initiative Act of 2020 (NAIIA) enacted on January 2021, as part of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (Congress.gov, 2020a). The Initiative aims to ensure continued U.S. leadership in AI R&D and the use of trustworthy systems in the public and private sectors. The National AI Initiative Office is the body that has been established by The Office of Science and Technology Policy (OSTP) to carry out the responsibilities described in this bill. The Initiative is based on multiple networks of actors to support AI Research and Development, education and coordination (see Table 3). At the first level, the NAIIA directs the President, acting through the NAII Office, to plan and coordinate the relevant initiatives.

Table 3: Actors and Initiatives of the National Artificial Intelligence Initiative (NAII)

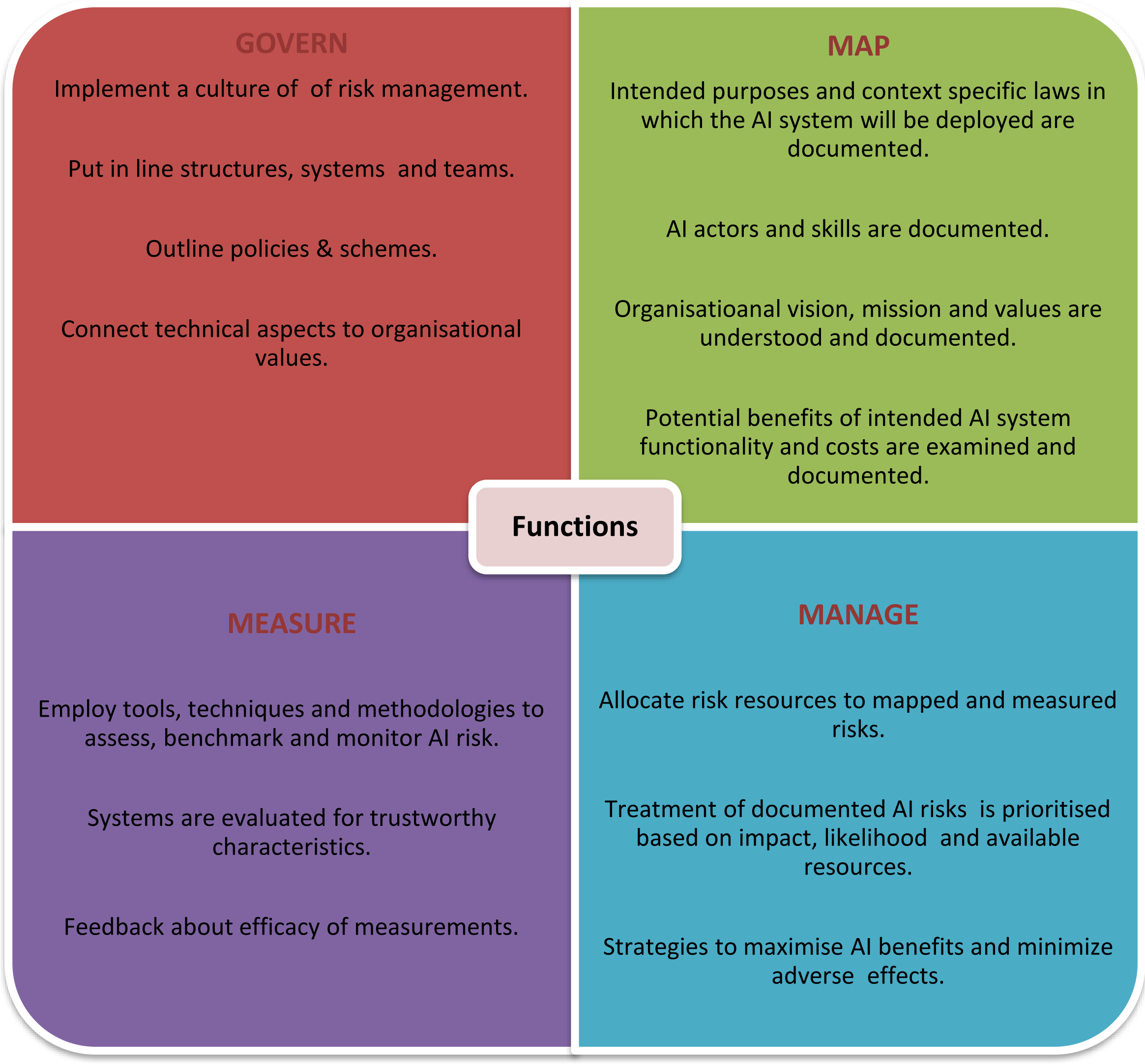
Actor	Initiatives
The President, acting through the Initiative Office	Support for: artificial intelligence research and development through grants, cooperative agreements, testbeds, and access to data and computing resources-K-12 education-training programs for students and researchers-Outreach to diverse stakeholders.
National Artificial Intelligence Initiative Office	Provide technical and administrative support to the Interagency Committee and the Advisory Committee and serve as the point of contact on Federal artificial intelligence activities for public and private sector
Interagency Committee	Coordinate Federal programs and activities in support of the Initiative and develop a strategic plan for artificial intelligence.
National Artificial Intelligence Advisory Committee	Advise the President and the Initiative Office on the current state of US competitiveness and AI science and opportunities for international cooperation.
National Research Council	Conduct a study of the current and future impact of artificial intelligence on the workforce of the United States across sectors.
National AI Research Resource Task Force	Develop a coordinated roadmap and implementation plan for creating and sustaining a National Artificial Intelligence Research Resource.
National Artificial Intelligence Research Institute	Focus on a particular economic or social sector and addresses the ethical, societal, safety, and security implications relevant to the application of AI in that sector.
National Institute of Standards and Technology	Advance collaborative frameworks, guidelines, risk-mitigation frameworks, technical standards and associated methods and techniques for artificial intelligence.
National Oceanic and Atmospheric Administration Center for AI	Coordinate the scientific and technological efforts across the National Oceanic and Atmospheric Administration.
National Science Foundation	Fund research and education activities in artificial intelligence systems.
Department of Energy AI Research Program	Advance artificial intelligence tools, systems, capabilities, and workforce needs and improve large-scale simulations of natural and other phenomena.
Anti-Money Laundering Division	Improve coordination among the agencies tasked with administering anti-money laundering.

Source: Adapted by the National Artificial Intelligence Initiative, 2020

The use of Artificial Intelligence by governmental agencies is supported by the *AI in Government Act of 2020 and the Executive Order 13960 on Promoting the Use of Trustworthy AI in the Federal Govern*ment signed by President Donald J. Trump in December 2020 (Congress.gov, 2020b). According to the Act, the "AI Center of Excellence" shall facilitate the adoption of AI technologies in Federal Agencies and assist them to apply Federal policies regarding the management and use of data in artificial intelligence applications.

On 26 of January 2023, the National Institute of Standards and Technology (NIST), which participates in developing technical standards, released its Artificial Intelligence Risk Management Framework 1.0 to assist companies in addressing and mitigating risks when designing and using AI systems. (National Institute of Standards and Technology/ US Department of Commerce, 2023). The Framework, with its four core "functions" of *Govern, Map, Measure, and Manage* includes organizational actions and outcomes to manage AI risks and responsibly develop trustworthy AI systems (see Figure 5).

Figure 5: Core Organizational Functions to Manage AI Risks



Source: Adapted from NIST’s Artificial Intelligence Risk Management Framework 1.0

2.2 Summary of the AI Regulatory Initiatives

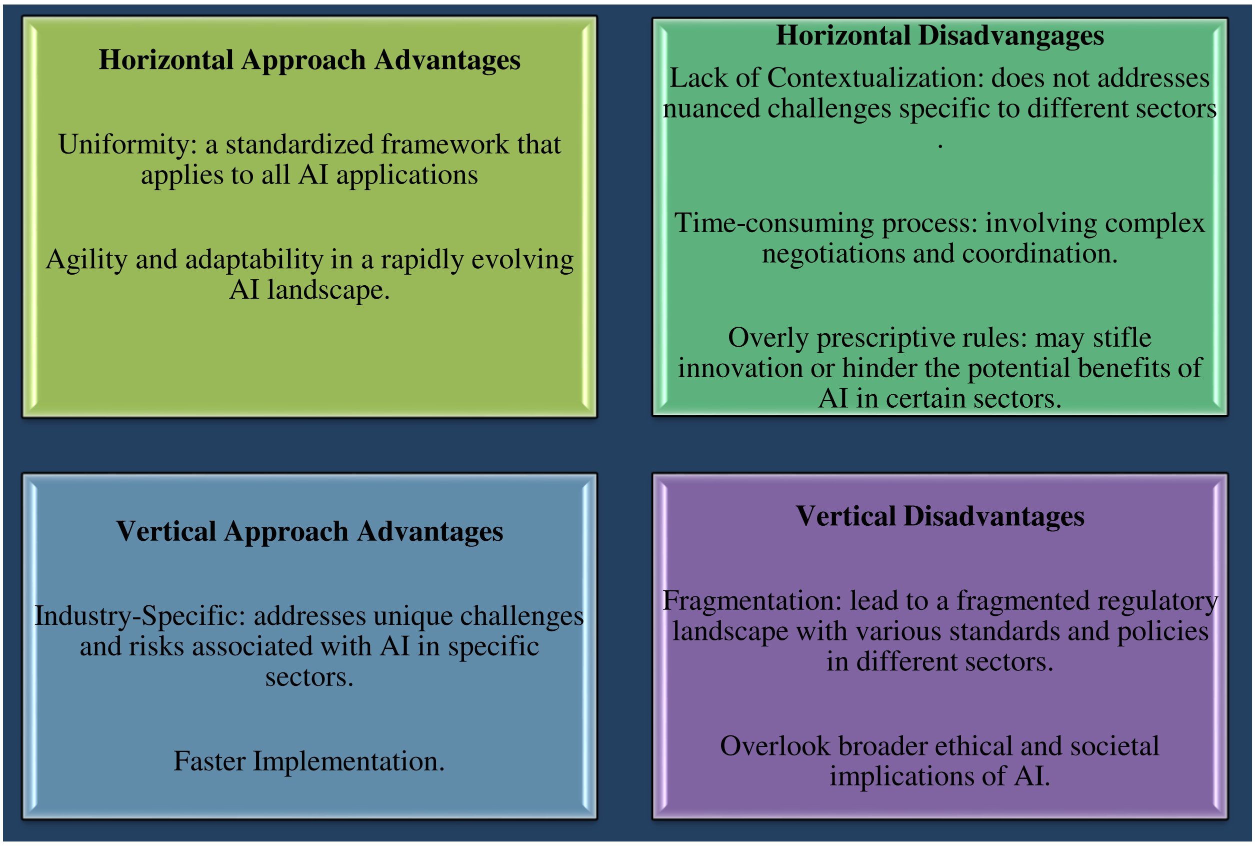
Government regulators in the EU, Canada, the U.S. and China are involved in the last six years in the mitigation of AI tools before capitalizing on the opportunities (see Figure 6).

Figure 6: Global Policy Initiatives for Artificial Intelligence

Source: Authors' Original Contribution

In the context of law-making for AI, two key approaches are often employed: the horizontal approach and the vertical approach (Kop, 2021). The horizontal approach involves enacting overarching legislation that applies across various sectors and applications of AI. European Commission's Proposal for a Regulation on Artificial Intelligence and Canada's regulatory approach poses a horizontal regulatory framework in which AI are subject to the same risk-assessment criteria and legal requirements. A risk framework is utilized to categorize risks and set obligations associated with high-risk deployments and applications deemed to pose an "unacceptable risk" to safety or human rights are banned. The vertical approach, in contrast, involves sector-specific regulations that address the unique challenges and risks associated with AI in particular domains. This top-down approach embraced by the U.S. recognizes that different sectors may require tailored regulations due to varying technological complexities, ethical concerns, or societal impacts. By combining these approaches strategically, lawmakers can create a comprehensive legal framework for AI that balances general principles with sector-specific considerations, promoting the responsible and ethical deployment of AI technologies (see Figure 7).

Figure 7: Advantages and Disadvantages of Horizontal and Vertical Regulation for Artificial Intelligence



Source: Authors' Original Contribution

2.3 The Evolution of the EU Safety Framework

Product safety has been at the forefront of policy debates in the U.S. and EU since 1960 but fragmentation has prevailed to the present day due to the pace of innovation and the conflicting interests between consumers and manufacturers (Ruohonen, 2022).

In the EU, product safety has been considered as the earliest case of a risk-based approach to regulation and since 1990s, safety regulations have relied on a precautionary principle (Ruohonen, 2022: 347). The precautionary principal rests on the understanding that the government should regulate potential dangers to health and the environment even before scientific data proves that the danger poses an absolute risk, requiring a risk management approach that entails scientific agreement before policymaking (Sciascia, 2006).

The Treaty on the *Functioning of the European Union* (TFEU) entered into force on 1 December of 2009 was the output of the Treaty establishing the European Community (TEC or EC Treaty), as was put in place by the ambitious Treaty of Maastricht that created the European Union. TFEU article 26 sets a general safety goal by stating that consumer protection requirements shall be considered when defining and implementing other Union policies and activities. Article 169 makes provisions about the critical role of the Union in protecting the health, safety, and economic interests of consumers, as well as promoting their right to information Official Journal of the European Union, 2016).

The evolvement of the EU regulatory framework gave a New Approach to regulation because it was not framed around specific products; instead, it was framed around four strategic pillars: fair trading, public health, public controls, and consumer information, unified by standardization (Howells, 2000; Ruohonen, 2022). The outcome of the New Approach was *Council Directive 92/59/EEC of 29 June 1992 on general product safety* centered on a broadly-based, legislative framework of a horizontal nature. The framework obliged producers to place only safe products on the market and give all the relevant information to consumers that will enable them to assess the risks inherent in a product (Council of the European Union, 1992).

The policymaking in the 1990s and the cumulative experience with the safety of products led to *Directive 2001/95/EC of the European Parliament and of the Council of 3 December 2001* on general product safety (GPSD), specifying that a product is safe if it meets all statutory safety requirements under European or national law (European Parliament, Council of the European Union, 2001). The Directive clarified some of the provisions of Directive 92/59/EEC and requested Member States' market surveillance authorities to act against dangerous products and exchange information through the "EU's Community Rapid Information System (RAPEX)". GPSD underlined the need for European standards by European standardization bodies. It was underlined that in the absence of specific regulations- and when the European standards are not available- the safety of products should be assessed considering national or international standards, codes of conduct and the state of the art. The Directive created a crucial 'safety net' for consumers and a common legislative framework that minimizes disparities between Member States.

For more rigorous market surveillance of dangerous products, *Decision No 768/2008/EC of the European Parliament and of the Council of 9 July 2008 on a common framework for the marketing of products* (hereafter, MSR), came into force (Official Journal of the European Union, 2008a). According to the provisions specific product legislation should limit itself to the expression of essential requirements and recourse to technical standards adopted following Directive 98/34/EC. *Regulation No 765/2008 on the requirements for accreditation relating to the marketing of products* (Official Journal of the European Union, 2008b), along with Decision No 768/2008, have established an umbrella framework for the market surveillance of products and services. In this framework, the EU has been allocated the coordinating and information exchange roles with the national authorities undertaking administrative responsibilities. However, some product categories from chemicals to pharmaceuticals, are subject to specific product requirements, risk assessments and rigorous laboratory testing.

GPSD and the MSR comprise essential elements of the safety framework and their principles are based on the precautionary approach, enabling policymakers to take action to prevent the risk of serious harm, in situations where there is scientific uncertainty. Nonetheless, new challenges arose in the last decade stemming from the online sale of products, artificial intelligence, and cybersecurity. Therefore, a Proposal for a *Regulation of the European Parliament and the Council on General Safety* was adopted by the European Parliament on 30 March 2023 (European Commission, 2021a). The proposal amends Regulation (EU) No 1025/2012 and repeals Directive 87/357/EEC and Directive 2001/95/EC. The Two important definitions of product and safe product, as per Article 3, are presented below:

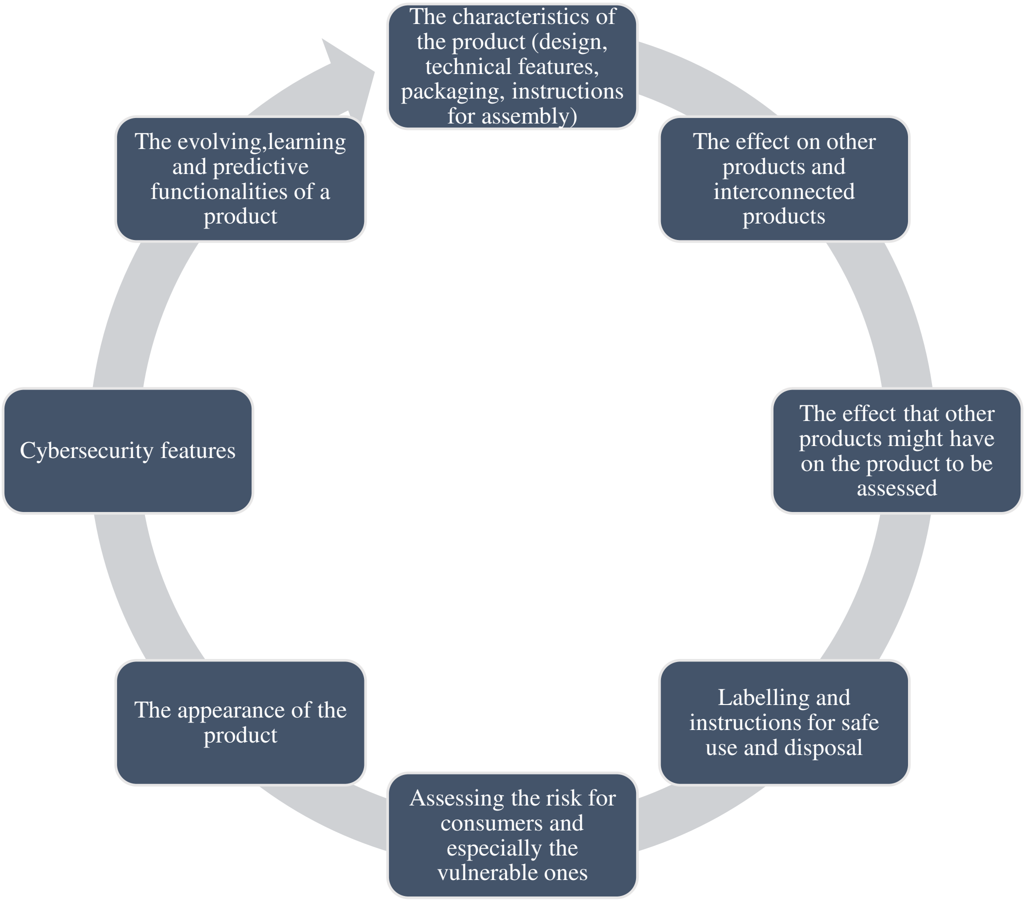
- Product' means any item, interconnected or not to other items supplied or made available, whether for consideration or not, including in the context of providing a service – which is intended for consumers or is likely, under reasonably foreseeable conditions, to be used by consumers even if not intended for them (Article 3.1 of the proposal for Regulation of the European Parliament and of the Council on general product safety); and
- Safe product' means any product which, under normal or reasonably foreseeable conditions of use, including the actual duration of use, does not present any risk or only the minimum risks compatible with the product's use, considered acceptable and consistent with a high level of protection of health and safety of consumers; (Article 3.3 of the proposal for Regulation of the European Parliament and of the Council on general product safety)

The proposed Regulation provides continuity with the GPSD requiring that consumer products be safe and that the development of standards is ensured. In addition, it:

- Addresses the safety risks linked to new technologies and online sales;
- Includes obligations to undertake risk assessments prior to placing products in the market;
- Removes promptly dangerous products from the market;
- Protects vulnerable consumers, such as children;
- Sets stricter standards for manufacturers, authorized representatives, importers, and distributors;
- Provides mandatory obligations on manufacturers to notify the authorities via Safety Gate if there is "an accident caused by a product; and
- Includes provisions for businesses' compliance requirements.

In Article 5 the aspects for assessing the safety of products should be taken into consideration by economic operators before they make their products available, including product characteristics and the interconnectivity with other products. The main elements of assessment are presented in Figure 8.

Figure 8: Aspects for Assessing the Safety of Products



Source: Adapted from the Proposal - *Regulation of the European Parliament and the Council on General Safety*

According to Article 6, a product shall conform to the general safety requirement laid down in Article 5 if it complies with relevant European standards or national provisions as far as the risks covered by those standards are concerned. Article 7 clarifies that in cases where the presumption of safety under Article 6 does not apply, then international standards, voluntary certification schemes, recognized scientific bodies and codes of good practice should be taken into consideration to ensure the safe assessment of the product.

Another important instrument of the safety framework is Regulation (EU) *2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance and compliance of products* (Official Journal of the European Union, 2019) that amended Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011. The Regulation strengthens the market surveillance of all non-food products, such as medical devices, machinery, toys, electronics, clothing, and footwear, ensuring that only compliant products that fulfil health and safety standards will be available on the EU e-commerce and physical marketplaces. It lays out specific procedures for economic operators and establishes a mechanism for their cooperation with supervisory authorities.

Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery (Official Journal of the European Union, 2006) is the EU's regulatory framework covering the mechanical engineering industry, including provisions for the free market circulation of machinery and the protection of users. The Machinery Directive has evolved through the years with its original version dating from 1989 (89/392/EEC). On 21 of April 2021, to address the safety risks posed by novel technologies and direct human-robot collaboration, the Commission put forward a new proposal for a regulation on machinery products as part of the wider 'AI package' (European Commission, 2021d). The new Machinery Regulation will ensure that machinery consumer products, industrial autonomous machines and collaborative robots will be safely placed in the EU market. It creates proportionate rules for all member states and increases legal certainty for manufacturers who shall ensure that machinery products have been designed in accordance with the essential health and safety requirements. The administrative burden and costs for manufacturers are lessened, whereas their legal certainty is increased due to clarifying issues related to definitions, essential requirements, and conformity assessment procedures.

To facilitate the consistent application of the general safety requirements, the European Union (EU) has promoted the development of tailor-made standards for products operated by RAS through the work of the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC) and the European Telecommunications Standards Institute (ETSI) (Alexandropoulou et al., 2021). Regulation (EU) 1025/2012 provides a legal basis to use European standards for products and services, identify ICT technical specifications, and finance the European standardization process. It also sets an obligation for European standardization organizations (CEN, CENELEC and ETSI) and national standardization bodies on transparency and participation (Official Journal of the European Union, 2012).

The liability framework that accompanies the safety regime is in existence since 1985 based on Council Directive 85/374/EEC (Council Directive, 1985) ensures a regime of strict liability for defective products and a fair balance between the interests of consumers and producers which created EU is in the process of revising these rules and applies in the context of IT Technologies as well, revised though and in some instances with reversed "burden of proof" since it is currently based on a de facto negligence liability system where the injured person is required to prove the damage, the defect and the causal relationship between defect and damage (Alexadropoulou et al., 2021). The Report on the safety and liability implications of Artificial Intelligence, the Internet of Things and robotics of the Commission to the European Parliament (European Commission, 2020b) underlines that digital technologies like AI challenge aspects of Union and national liability frameworks and could reduce the effectiveness of EU and national liability frameworks. Therefore, the provisions of the Liability Directive should be further clarified to ensure compensation for damage caused by products that are defective because of software or other digital features. However, the framework has also suffered from fragmentation and incoherence as it is difficult to legislate consumer goods and services with this unprecedented pace of sectoral changes and technological progress (Ruohonen, 2022). The Report outlined the main steps that must be considered for the update of the existing technology-neutral framework. The new framework should include explicit provisions for a) human oversight throughout the lifecycle of the AI products b) producers of AI humanoid robots c) cooperation between the economic operators in the supply chain d) manufacturers/software developers and e) compensation for damage caused by products that are defective due to software.

Overall, software and autonomous applications are tangible products although the information embedded within the software medium is intangible (Alexandropoulou et al., 2021; Alheit 2001; Ozturk 2021). Taking into account this view, autonomous systems indeed fall under the category of "product" in the context of Directive 85/374/EEC (Alexandropoulou et al., 2021). The safety framework of these products is broad-based of a horizontal nature that provides a general safety requirement for any product placed on the market and intended for consumers, including electronic selling. The safety framework for products in the EU is a comprehensive legislative system structured around key elements such as the General Product Safety Directive (GPSD), specific regulations for certain product categories, the responsibility of distributors, and the management of product recalls and withdrawals. The existing "Union product safety legislation or framework includes:

- Consumer Safety Network as established in Directive 2001/95/EC on general product safety (GPSD) which states that only safe products may be placed on the market;
- Decision No 768/2008/EC on a common framework for the marketing of products in the EU;
- Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery which aims at the free market circulation of machinery and the protection of users; and
- Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for effective products.

2.4 The Evolution of EU Cybersecurity Framework

The European Union's commitment to strengthening cybersecurity led in 2016 to the implementation of the first piece of EU-wide legislation on cybersecurity *Directive 2016/1148 concerning measures for a high common level of security of network and information systems* across the Union (Network and Information Security-NIS Directive). The NIS Directive was focused on protecting critical infrastructure and established the NIS Cooperation Group, and the network of Computer Security Incident Response Teams (CSIRTs) to enhance cooperation on specific cybersecurity threats with the EU.

NIS Directive included provisions for the implementation of appropriate non-technical security measures for the operators of essential services (OES) and digital service providers (DSPs). OES included critical sectors such as energy, transportation, finance, and healthcare, whereas DSPs encompassed online marketplaces, cloud computing services, and search engines. The NIS Directive outlined incident reporting obligations for OES and DSPs in the event of significant cybersecurity incidents. It also emphasized cooperation and information sharing among Member States to facilitate a coordinated response.

The increasing prevalence of cyber threats has necessitated the European Union (EU) to update its legal framework to ensure an effective response to cybersecurity challenges; thus, the EU cybersecurity rules introduced in 2016 were replaced by *Directive (EU) 2022/2555* (NIS2 Directive). The Directive expands the scope of its predecessor by including additional sectors, such as cloud services, telecoms, social media platforms and the public administration for a more comprehensive approach to cybersecurity (see Table 4). The Directive places increased emphasis on incident reporting, ensuring that organizations promptly notify relevant authorities in the event of a significant cybersecurity incident. It also strengthens cooperation and information sharing between Member States to enable a more coordinated response to cross-border cyber threats. To bolster the EU's cybersecurity capabilities, the NIS2 Directive establishes the European Cybersecurity Competence Center (ECCC), working together with a Network of National Coordination Centres (NCCs) to enhance research, innovation, and knowledge sharing within the EU.

Table 4: The Differences between NIS and NIS2

	NIS	NIS2
Sectors	Healthcare, Transport, Banking, Digital Infrastructure, Water Supply, Energy, Digital Service Providers	Digital services such as social networking services and providers of public electronic communication networks, space, water management, manufacturing of certain critical products (i.e., medical), public administration, food, postal services, PROVIDERS OF PUBLIC
Capabilities	The first step for EU Members is to improve their cybersecurity capabilities.	Sanctions for breach of the cybersecurity risk management and reporting obligations.
Cooperation	Cooperative network between the Member States.	Increased information sharing. Establishment of the European Cyber Crises Liaison Organisation Network (EU- CyCLONe) to support coordinated management of large-scale incidents.
Risk Management	Operators of Essential Services (OES) and Digital Service Providers (DSP) have to adopt risk management practices and notify significant incidents to their national authorities.	Strengthened list of measures: incident handling and crisis management, vulnerability handling and disclosure, policies to assess the effectiveness of cybersecurity risk management measures, cybersecurity training, effective use of cryptography.

Source: European Commission (2023)

In addition, the Cyber Security Act (*Regulation (EU) 2019/881 of the European Parliament and of the Council of 17 April 2019 on ENISA and on information and communications technology cybersecurity certification and repealing Regulation (EU) No 526/2013*) was proposed in 2017 as part of a wide-ranging set of measures to deal with cyber-attacks, is the tool that sets a harmonized EU cybersecurity certification framework for ICT products, ensuring through a comprehensive set of rules and technical standards, that cybersecurity products and services meet specified security requirements, thus increasing trust and confidence in digital technologies. The Act establishes the ENISA to undertake the tasks assigned to it for the purpose of contributing to a high level of network and information security within the Union. ENISA has the critical role in setting up and maintaining the European cybersecurity certification framework for products and services. The Act also establishes the Stakeholder Cybersecurity Certification Group and the European Cybersecurity Certification Group ECCG which coordinates and monitors the EU's cybersecurity certification framework (see Figure 9).

Figure 9: Main elements of Cyber Security Act

Source: Adapted from Cyber Security Act

Therefore, the current EU Cybersecurity framework is based on:

- Directive on measures for a high common level of cybersecurity across the Union (NIS2 Directive) entered into force in 2023; and
- Regulation (EU) 2019/881 of the European Parliament and of the Council of 17 April 2019 on ENISA (the European Union Agency for Cybersecurity) and on information and communications technology cybersecurity certification and repealing Regulation (EU) No 526/2013 (Cybersecurity Act) (Text with EEA relevance)

2.4 Concluding Remarks: Implications for BUGWRIGHT2 Stakeholders

The connection between autonomous robotics and artificial intelligence is deeply intertwined, with AI serving as the driving force behind the capabilities of autonomous robots. However, as these systems become increasingly complex and interconnected, the issues of safety and cybersecurity become crucial. Striking the right balance between innovation and precaution is crucial to harnessing the full potential of autonomous robotics while safeguarding against potential risks.

In the context of law-making two key approaches are often employed: the horizontal approach and the vertical approach. However, for AI applications, a hybrid approach could provide a comprehensive, contextualized, and adaptable framework that addresses industry-specific concerns while safeguarding AI's ethical and societal implications. Such a balanced approach paves the way for responsible and effective governance of AI in an ever-evolving technological landscape. AI policymaking and governance must be anchored in current global governance realities and be flexible to the changing power dynamics, especially the growing influence of transnational actors and the private sector (Miailhe and Lannquist, 2020).

Therefore, a coherent combination of "soft" and "hard" law is the way to orient new technologies toward broad societal benefit.

The policymaking efforts will continue in the following years, with the technical standardization organizations such as the IEEE and ISO, and national agencies like the NIST in the U.S., and the CEN, CENELEC in Europe, taking the lead in the development of standards. Stakeholders involved in the field of technological development primarily rely on standards published by organizations that have the mandate to implement four distinct categories of standards: national, regional, international and informal (European Commission, 2013). The principal difference between regulations and standards is that while the former is legally binding in nature and subject to sanctions, the latter is voluntary in nature with no legal obligations for compliance (European Commission, 2013).

For the application of technical standards, policymakers along with key stakeholders such as software developers, academia and industry should get involved in a "polycentric" style of governance, with many different actors and mechanisms for safe and equitable development, deployment and use of innovative AI applications. Within this context, the US and the EU should work together using ongoing multi-stakeholder negotiations and joint research projects in order to ensure the safeguarding of liberal democratic values and ethical principles as well as the development of soft law mechanisms.

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3. Analysis of Strand 2: A Methodology for the Evaluation of Existing Norms and Standards

Acronyms

AI	Artificial Intelligence
EU	European Union

3.1 Evaluation of the Existing Regulatory Framework: The Socio-Legal Approach

3.1.1 Conceptualization of the Socio-Legal Approach

The first step in the process is to fully assess all existing norms, regulations, and standards for robotic technologies in order to identify relevant gaps. For the best assessment of the current regulatory framework, norms and standards, a socio-legal methodological approach should be embraced to examine how the law operates in society and the effects it has on social institutions, individual behavior, and social change. Socio-legal studies emerged as a potent interdisciplinary approach, aiming to interrogate the relationship between law and society. Socio-legal research is the examination of how law and legal phenomena occur in the world, interact with each other and affect those who are touched by them (Webley 2020). It rests on the premise that legal phenomena are deeply intertwined with societal variables, underscoring the requirement for diverse methodologies that can accommodate this complexity (Banakar & Travers, 2005).

The socio-legal methodology is effective due to its capacity to consider the law in its sociocultural, political, environmental economic contexts (Lange, 2017; Cotterrell, 2014). The socio-legal methodological approach offers a multidimensional lens through which legal researchers can examine the complex interplay between law and society as they are inherently intertwined, with legal systems reflecting and responding to social realities and values. This approach recognizes the reciprocal relationship between legal institutions, norms, and social structures, and aims to uncover the sociological, political, and cultural factors that shape legal processes and outcomes.

The legal research of a socio-legal approach can pursue different types of research objectives (see Table 5) and these include: descriptive, classifying, comparative, theory-building, explanatory, evaluative and recommendatory research objectives (Kestemont, 2018). In the context of objectives, comparative research plays an essential role in the regulation of service robotics, providing differences and similarities between the legal systems of different jurisdictions. Comparative research is an important aspect of understanding global jurisprudence, playing a critical role in law reform and legal harmonization.

Table 5: Objectives of Legal Research

Descriptive	Describing the law. To analyze legal constructs in all their components in order to present them in an accurate manner.
Classifying	To classify legal phenomena in the existing legal system.
Comparative	Comparison can be internal, historical and external comparison. *Internal:* to compare two or more legal constructs in order to uncover their similarities and differences. *External:* Cross-Jurisdiction: comparison between jurisdictions. *Historical:* Comparison of legal constructs from different periods in time.
Theory Building	To identify patterns from a set of legal rules or cases in order to develop a model or a theory (legal doctrines).
Explanatory	To explain 'why something is as it is'.
Evaluative	To assess whether a legal construct attains its goals or solves a specific problem, whether it is in compliance with a general principle of law, whether it violates a supranational legal norm, etc.
Recommendatory	To determine how the law should be.

Sources: Kestemont, L. (2018)

At its core, the social aspect of the socio-legal approach calls for a deeper understanding of law's functioning beyond the formal legal texts. It urges us to examine how the law is impacted by social structures, attitudes, and interactions. The socio-legal methodological approach encompasses a range of research methods and techniques dependent upon the objective and the research questions of the study. The relationship between legal dogmatics and sociology of law is presented in Table 6.

Table 6: The relationship between legal dogmatics and sociology of law

	Legal dogmatics	**Sociology of law**
Target	Rules	Factual behaviour, practices and institutions
Perspective	The participant's	The observer's
Method	Text hermeneutics	Social sciences' methods
Analysis	Interpretation and classification	Analysis of empirical material
Approach	Law as an autonomous system	Law in its social context
Perception of law	Formal law	Formal and informal law
Goal	To create coherence within the legal system	To explain and examine critically social processes related to law

Source: Ervasti, 2008

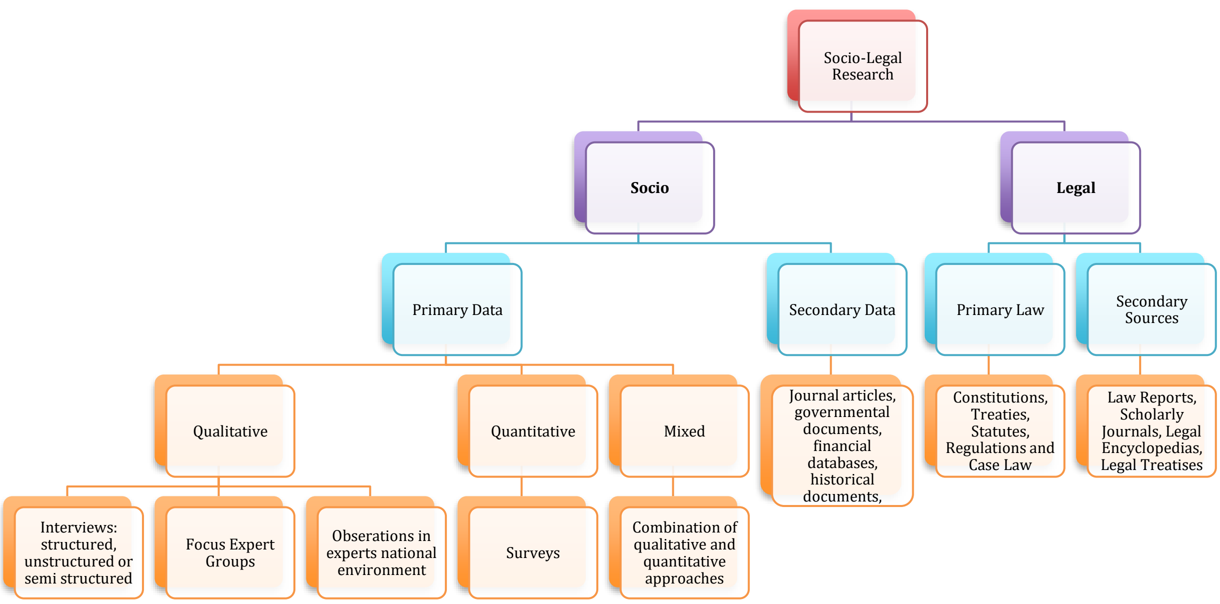
3.1.2 Data Collection for a Socio-Legal Approach

In a socio-legal approach, social and legal data is collected (Figure 10). Regarding the legal data, a comprehensive examination of legal texts is performed including legislative material and international legal instruments, also often referred to as "black-letter law". Exposition of legal texts in the research process includes international instruments, relevant scholarly literature such as textbooks, academic and professional journals containing legal opinions and expert commentaries, industry standards, procedures and requirements. Researchers investigate not only what the law says, but how it is interpreted and applied, and what impact it has on different stakeholders. It is used to analyze the extant law (de lege lata) pointing out its drawbacks and deficiencies. It must be thoroughly understood to determine what the law should be in the future (de lege ferenda). This approach highlights the continuum of past, present and future in terms of the progress of the law. In summary, legal data can be collected from primary law such as constitutions, treaties, statutes, regulations and case law or secondary sources such as law reports, scholarly journals, legal encyclopaedias, and legal treatises.

The social analysis component of socio-legal research explores the social, cultural, and economic factors that influence the law. A socio-analysis can be made either through primary or secondary data. The primary approaches for collecting social data are qualitative and quantitative methods. The qualitative method seeks to gather in-depth information through interviews, observations, and diary techniques to establish new theories. Conversely, the quantitative method employs stringent processes to test and confirm hypotheses and predict the likelihood of a certain result. Qualitative research, while providing a rich variety of procedures and yielding diverse findings, is limited by the researcher's cognitive information processing capacity to accurately depict participant behavior (Currall et al. 1999). Extensive debate exists regarding the blending of qualitative and quantitative methods, spanning from broad methodological concerns to practical advice for integrating these methods and models into a single research design. Certain management researchers recommend the use of a mixed-methods approach (Currall et al. 1999; Edmondson and McManus, 2007) to enhance the methodological exactness of the research and generate superior results. Secondary data for social science can be collected through various sources such as public records, government statistics, historical documents, financial databases, media content, and previous research data (Boslaugh, 2007).

Based on the approach that will be utilized, different data analysis methods and software (i.e. SPSS, NIVO) should be employed (Denzin and Lincoln, 2000; Gibbs, 2007). There are traditions about the different ways in which one may analyze qualitative (narrative) and quantitative (numbers, statistical) data, although there is a great overlap between some of these too (Epstein and Martin, 2010; Webley 2020).

Figure 10: Socio Legal Research: Data Collection



Source: Authors' original contribution

3.1.3 Socio-Legal Approach in the BUGWRIGHT2 Project

For the aims of the WP1.4 for the development of a regulatory blueprint, a socio-legal approach was undertaken to review the international, European and national norms, standards and regulations.

For the legal research, an in-depth detailed examination of international, regional and national legal instruments, often referred to as “black-letter law”, was performed. Exposition of legal texts in the research process included, as well, international instruments, policy documents provided by maritime administrations, scholarly literature such as textbooks, academic and professional journals containing legal opinions and expert commentaries, industry standards, procedures and requirements.

Findings from legal research have been confirmed with 65 interviews of subject matter experts during 2020-2021 from the United States of America (US), the Netherlands, Canada, Norway, China and Singapore. This comparative approach facilitated the comparison of different contexts to reveal insightful technological trends and the enhancement of our understanding of the current stage and future of autonomous robotics systems.

For the identification of subject matter experts, a stakeholder analysis was performed to identify the individuals and groups who have a vested interest or influence over autonomy-related matters. Stakeholder analysis offers a robust methodology for this purpose, facilitating the inclusion of key voices in a wide array of robotics and contributing to the development of more informed, effective, and sustainable technological solutions. Our sample included experts from maritime administrations, classification societies, autonomous systems and artificial intelligence (AI) companies and universities. The respondents offered strategic and critical views pertaining to how selected jurisdictions are paving the way to autonomous operations, more specifically hull inspections and cleaning, through technological advancements. The information so gathered helped mark out strategic actions for the regulatory and policy blueprint considering the state-of-the-art as well as gaps and drawbacks, which can be used by the concerned regulatory bodies when developing new regulations or reforming existing laws and policies.

3.2 Evaluation of Hazards and Mitigation Frameworks to Enable International Harmonized Rules

The second step of the process involves identifying the risks associated with the examined application of robotics and underscores the necessity of comprehensive assessments to optimally leverage robotics for societal benefit, while minimizing potential adverse consequences. Mass exploitation of robotics cannot be achieved unless associated hazards are adequately controlled and regulated. Risks and mitigation frameworks can be identified through in-depth interviews with subject matter experts. Besides, participant observation stands as a robust methodology in qualitative research, offering in-depth, context-rich data that allows researchers to immerse themselves in the testing environment of robotic systems and observe the behaviors, interactions, and social processes that occur naturally within that setting.

Hazard recognition of robotics in the workplace is a prerequisite for their massive exploitation and use if they are to make an impact in reducing the number of injuries and fatalities. As depicted in Figure 11, the hazards that should be taken into consideration include a) operational hazards that emerge during the physical interaction with the service robots, b) data quality and security hazards, c) social and psychological hazards such as inadequate training of the human element, absence of trust; and d) Legal hazards such as liability aspects.

Figure 11: Hazard recognition of robotics

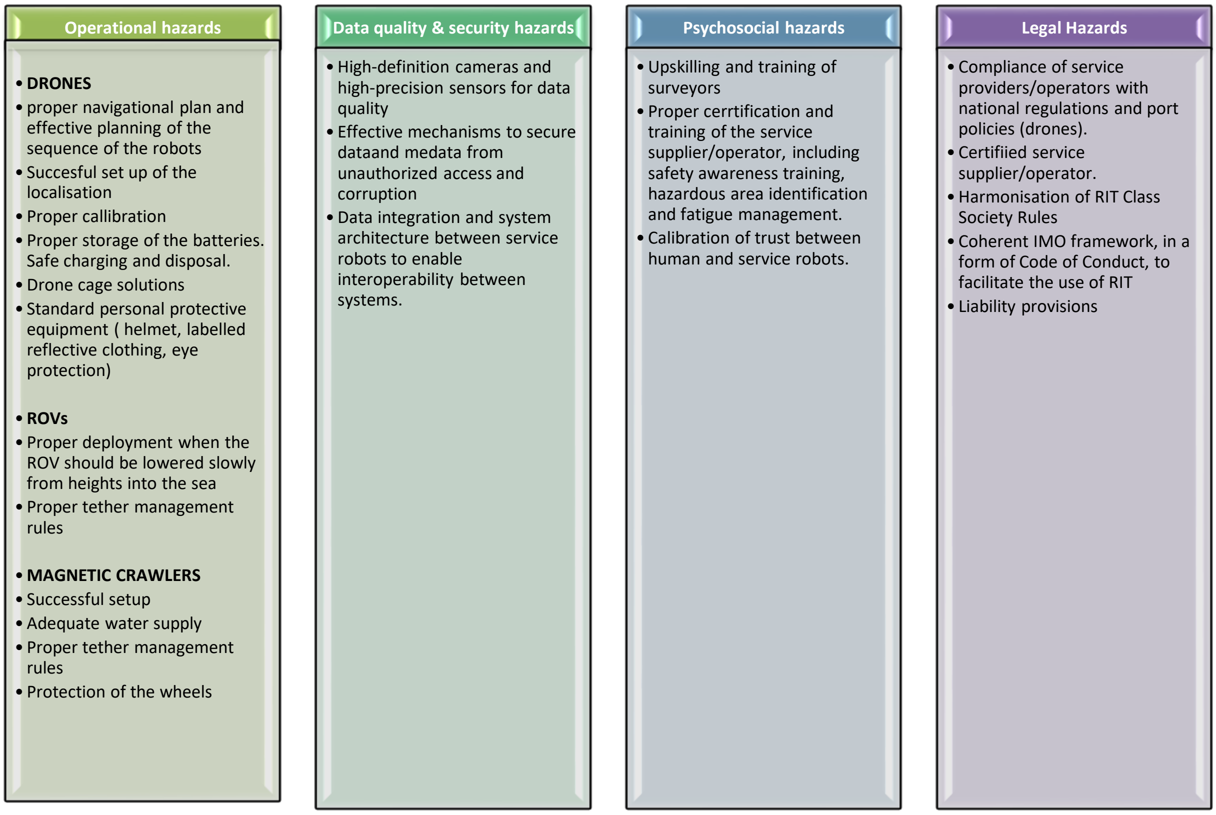
Source: Authors' original contribution

For identifying the hazards with BUGWRIGHT2 Remote Inspection Techniques, in-depth interviews with subject matter experts were conducted, including service suppliers, engineers, classification societies, psychology analysts as well as academic counterparts. Furthermore, participant observation at a Greek shipyard helped with the observation of technical tasks and activities initiated by service robots.

The findings draw reference to operational hazards, data governance, psychosocial and legal hazards. Recommendations for mitigating RIT hazards have been tabled considering the status quo, state-of-the-art, perceived drawback and strategic options. The proposed recommendations have the potential to bolster support in conceiving international harmonized rules (as requested by member States of the International Maritime Organization member states) that could, in turn, provide legal certainty as human-in-the-loop transitions to advanced autonomy.

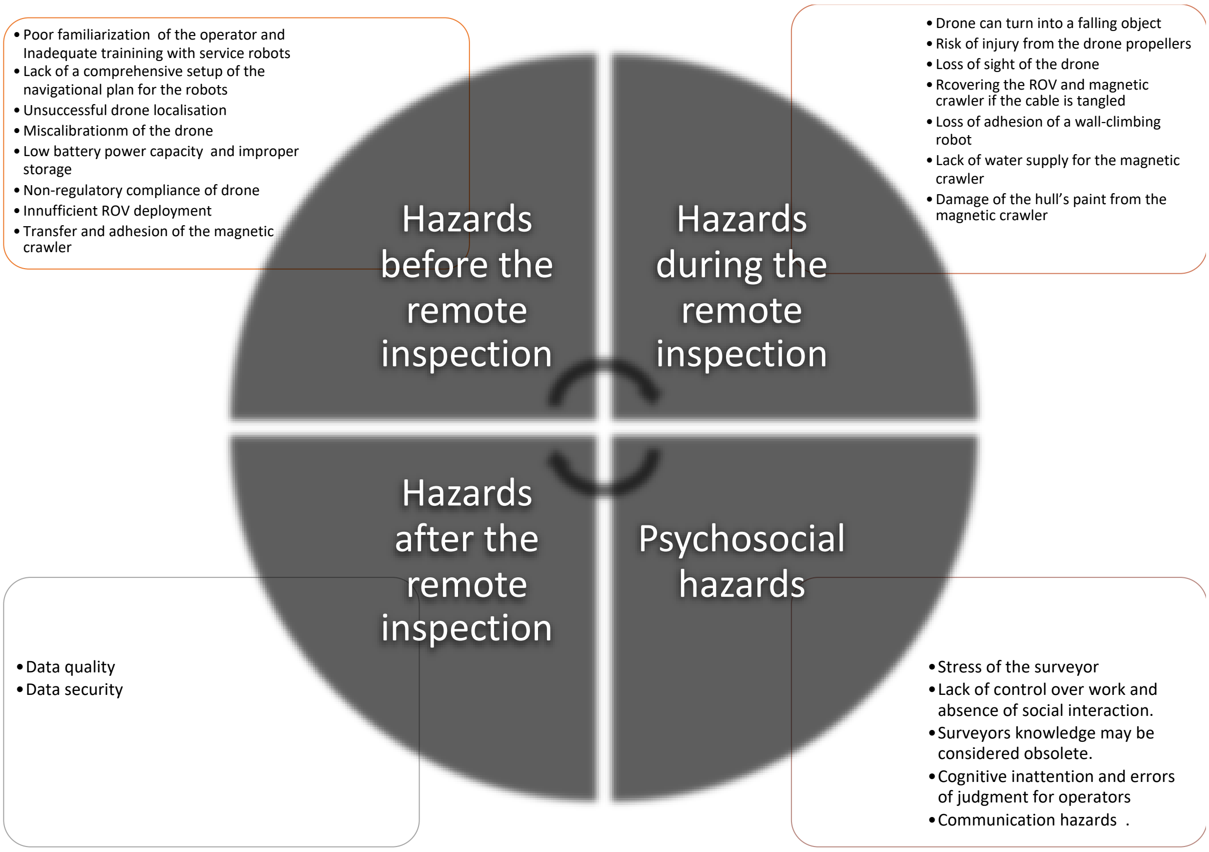
Hazards identified from the participant-observation method coupled with in-depth discussions before, during and after the ship inspection processes are synthesized and presented in Figure 12 and subsequently analyzed. Operational, data quality and security, psychosocial and legal hazards have been identified for drones, ROVs and magnetic crawlers. In addition, the relevant mitigation framework of the relevant hazards has been presented in Figure 13 and includes recommendations for addressing all the hazards before, during and after the inspection of the vessel process.

Figure 12: Mitigation framework of the main RIT hazards



Source: Authors' original contribution

Figure 13: Main Hazards during a Multi-robot Remote Inspection



Source: Authors' original contribution

3.2.1 Addressing the Hazards of Remote Inspection Techniques: A Safety-Net for Vessel Surveys

[N.B. This part of the report has been published in the Journal of Law, Innovation and Technology approved in December 2023. Some parts have been, modified and extended by authors, and subsequently edited by the Editor of the Journal as a part of the editorial process. Nevertheless, the final version stems from this original piece].

From autonomous automotive technologies to autonomous vessels - the scale of Robotic and Autonomous Systems (RAS)-influence in both land-based and maritime-based transportation is staggering. The genesis of RAS emerged after a cascade of Artificial Intelligence (AI) technological breakthroughs (Johansson, 2022). In retrospect, the velocity, breadth and depth, and systems' impact of what is in fact a fourth industrial revolution has led to a conflux of innovative advancements shaping the modern technological environment (Schwab, 2016). Commonly referred to as disruptive technology, remote inspection techniques (RIT), an offshoot of RAS, is best described as "… a means of survey that enables examination of any part of the structure without the need for direct physical access of the surveyor" (IACS UR Z1, 1997). But the absence of a human surveyor on-site does not preclude the need for oversight. This operational environment is known as the "supervised autonomy" paradigm.

Common types of industry deployed RIT include unmanned aerial vehicles (UAV) or drones, remotely operated vehicles (ROV), and climbers or magnetic crawlers. The above possess the ability to comprise a multi-robot survey team programmed to follow a pre-determined algorithmic pathway for visual and acoustic inspection of a vessel structure to detect corrosion patches, buckling, cracking and deteriorated coatings. Notably, maritime industry and applicable government and organizational regulators have started adapting to the use of RIT for ship-outer-hull inspection, tank inspection, thickness measurement and cleaning.

Central to this multi-robot environment is *intentionality*. In the maritime context, it is significant to point out that the underlying intention of contemporary innovations, such as bridging the gap between current and potential capacities of RAS-led vessel inspections, is among other things, a part of classification surveys, as well as statutory survey criteria. Satisfying the regulatory goals and objectives with minimum effort while maintaining the highest safety standards is a unique aspect of the modern maritime technological environment.

Mass exploitation of RIT in the maritime sector cannot be achieved unless associated hazards are adequately controlled and regulated. To address safety issues in a satisfactory yet comprehensive manner, the topic of RIT demands a broader understanding of associated hazards throughout the ship inspection process. Observably, to date, there is a lack of homogeneity in understanding what RIT safety truly entails. This bleak situation is heightened by the existing dearth in literature that carves out the much-needed systematic review of all potential hazards that could emanate from the deployment of RIT either independently or when combined with human-centric survey and inspection at different stages. Ergo, this study aims to contribute to the ongoing international dialogue and discussions that aim to facilitate harmonized guidance that promotes user-friendly and liability-free RIT.

To this end, this article rigorously extracts and critically evaluates potential hazards inherent in the application of RIT across the entire process, from initiation to completion. The authors, subsequent to a thorough examination of pertinent theoretical frameworks and a critical evaluation of qualitative interview data, present a strategic framework. This framework holds the potential to provide valuable guidance to stakeholders including policymakers in identifying and mitigating hazards throughout the remote ship inspection process, ultimately reinforcing a justified paradigm shift towards RIT adoption within a specific yet significant maritime domain. The main purpose of this article is to discern the essential elements that can collectively establish a "safety net" particularly in the absence of a unified legal framework. In pursuit of this objective, the concluding section delves into, yet another, exploratory research, building upon the foundational work laid out by Pastra et al. in their seminal 2022 study on the "trust ecosystem". This research then extends its focus to the domain of "liability" --- investigating the interrelationship between "trust-safety-liability". While contributing to the body of literature within the academic domain, this correlation represents a noteworthy aspect for consideration by policymakers and legislatures. The analyses could be instrumental in constructing arguments before courts adjudicating civil liability issues stemming from the utilization of RIT.

Authors stress that a comprehensive governance framework for the implementation of RIT calls attention to a broader perspective that ventures beyond the examination of prospective liability systems. It is imperative to situate inquiries concerning legal liability within the broader context of risks and hazards. In doing so, it not only facilitates a more comprehensive understanding of the intricate relationships between technological deployment and potential consequences, but it also permits a nuanced assessment of the intricacies involved in determining legal liability. Legal liability, more often than not, cannot be examined in isolation, as it intersects with a spectrum of risks and hazards. Understanding those interconnections is vital to developing informed legal frameworks and policies that effectively address and mitigate issues that could, in turn, stifle innovation.

Steady advancements and the introduction of innovative semi-autonomous systems have ameliorated the functioning of various industries. Admittedly, this includes the maritime sector where a surge in robotic-solution demands for survey, inspection and maintenance, especially during the COVID-19 pandemic, renders technology at the top of the pile (Rubagotti, 2022). These technologies offer substantial benefits when it comes to increasing operational safety, energy efficiency and reliability (Grasso, 2021; Poggi *et. al.,* 2022). In specific, adopting Robotics and Autonomous Systems (RAS) to carry out inspection and maintenance could lead to minimal downtime, cost efficiency, and enhancement of human safety through the minimization of danger in tasks conducted in confined spaces (Bolbot *et al*., 2022; Poggi *et. al.,* 2020). In addition, evidence-based research indicates that the employment of RIT could improve overall ship-safety since human errors account for between 60 and 90% of the total number of accidents at sea (de Vos *et al.,* 2021).

Despite the aforementioned benefits, the integration of RAS highlights conspicuous challenges on the margins of design and operation. In retrospect, a plethora of research projects have investigated human–robotic cooperation and the issues concerned with safety, performance and training (of collaborative robots) (Guiochet, 2017). "Robots have to be safe, but the question that prevails is '*how safe is enough safe*?", --- is an aspect that is well documented (Christensen *et al*., 2020). Following the ISO/IEC Guide (2014, 3.14), safety has been conceptualized as "… freedom from risk which is not tolerable". Within this context, the term "hazard" has been conceptualized as "the conditions with the potential to compromise safety" (Kristiansen, 2005), or a "potential source of harm" (ISO, 2014: 13482:). More precisely, in the case of human-robotic interaction, safety is defined as "ensuring that only mild contusions may occur in worst case scenarios" (Haddadin and Croft, 2016).

Indubitably, regulatory frameworks, tools and procedures are integral to RAS safety aspects whereby compliance and enforcement could mitigate risks that could otherwise impact stakeholders and the environment (Ghasri and Maghrebi, 2021). "Risk", in general terms, can be defined as the combination of the probability of occurrence of harm and the severity of that harm (ISO/IEC Guide 51, 2014:3.9). Conversely, risk is calculated for identifying hazards and indicates "the likelihood and consequences of a future hazard event in a given context" (Kristiansen, 2005). "Harm", in tandem, has been defined as the "injury or damage to the health of people, or damage to property or the environment" (ISO/IEC Guide 51,2014: 3.1). Taken together, the identification of hazards and determination of associated risks is the resultant of a risk management process (Christensen *et al*., 2020). In this process, it is crucial to consider "individual" and "societal" risk criteria to determine the safety and integrity requirements for the investigated system (Bolbot *et al.,* 2022). Relevantly, even though the hazards associated with RAS are well documented, in many cases the sources (of these hazards) are observed as being tied to the robotic platform, and not all hazards identified are common to all types of robots in relation to risk-level and potential-to-harm (Vasic, and Billard, 2013).

Scholarly literature details the greater ramifications of human-robotic interactions, safety perceptions, benchmarking and measurements and, most importantly, the impending challenges (Rubagotti *et al.,* 2022; Bicchi *et al.*, 2008; *Lasota et al*., 2017). A tacit agreement among authors is that robots' have both positive and negative impacts on people, thus necessitating the need for furthering thorough research in this field. In other words, research on RAS safety should transcend the confined limits of physical impact, such as collision risks, and be expanded to capture other types and forms of hazards.

The emergence of new generation RAS with increased autonomous capabilities (through machine learning) and their physical interaction with humans has introduced novel hazards (Jérémie Guiochet, 2017). One of these so-called "novel hazards" could occur during close-proximity and collaboration with the end-user resulting in "bad synchronization" and "communication mishap with robot interface" (Guiochet, 2017). Other forms of hazard include impacts from bugs in the software, technical glitches, latent damage and defects, and inadequate perception of the environment (Guiochet *et. al.*, 2017; Steinbauer, 2013: Tomatis *et al.*, 2003).

Cyber security, for example, is a timely topic that borders on security threats and vulnerabilities --- critical concerns that have garnered international attention more than the topic of physical injury from RAS (Christensen *et al*., 2020). Privacy and security hazards, in fact, exist due to their interconnectivity with multiple devices and cloud services (Martinetti *et. al.*, 2021). The increased functions of interconnected devices and systems could weaken those systems thereby increasing the risk of system failure or malicious attacks (Michels and Walden, 2018).

Mental-health is another issue that may stem from human-robotic interface (Bankins and Formosa, 2020; Martinetti *et al.,* 2021). The study of psychosocial influences in relation to RAS-safety has gained momentum quite recently. Studies stress that the looming effects of psychosocial influences include nervousness of the operator, stress and fear, to name a few (Chemweno *et al.,* 2020; Riley, 2015).

Finally, societal, and ethical issues, indeed, arise from the use of RAS. These include de-skilling, trust, security and deployment (Royakkers and van Est, 2015). A public concern remains that robots might replace humans in high or low-skilled jobs, and the introduction of robots in the workplace might lead to duplicative efforts, which could result in passive behaviour or even depression (Christensen *et al*., 2020; Martinetti, 2021). This has a tendency to encourage social pressure in the sense that employees might feel a sense of insecurity about their work-future owing to the fear of being replaced (Martinetti, 2021). Another issue that has been identified is the limited trust in the robots, which could lead to diametric challenges: acceptance and collaboration (Schaefer, 2016).

Despite the aforementioned, promulgated guidelines that promote safety do not often focus on psychological and or behavioral factors (Martinetti, 2021). In addition, the existing classical hazard analysis techniques are not well-suited to capture the complex interactions between humans and robots (Guiochet, 2016). It is posited that ethical hazards such as liability, dehumanization, and unemployment call for the conduct of an ethical risk assessment with a view to identifying and mitigating the ethical risks derived from human-robotic interactions (Winfield, 2019). It is evident that an exhaustive hazard analysis and risk assessment is needed to identify all the potential hazards associated with each type of service robot if the intention is to develop appropriate and adequate appropriate safeguards (Djuric, *et al.,* 2016). In a maritime context, RIT brings to the hazard-landscape a unique set of safety concerns; therefore, hazard recognition and mitigation is paramount to reduce workplace injuries, fatalities and social risks both projected and unforeseen.

Hazard-identification as the target objective, a qualitative approach was adopted to quantify expert opinion on human-robotic interaction/interface. Participant-observation was the principal research methodology that helped observe technical tasks and activities initiated and completed by the consortium members of the BUGWRIGHT2 project during a five-day integration week in November 2022 at the Perama Shipyard in Greece. The objective of the BUGWRIGHT2 integration week was to test drones, ROVs and magnetic crawlers in actual conditions at the pre-determined shipyard. The integration week presented itself with the opportunity to obtain first-hand data and information from service suppliers, engineers, classification society representative, psychology analysts as well as academic counterparts. Thirteen (13) in-depth semi-structured interviews with subject matter experts were conducted at the testing site in the course of pre-deployment, during-deployment and post-deployment phases of RIT testing.

Findings

Hazards identified from the participant-observation method coupled with in-depth discussions before, during and after the ship inspection processes are synthesized and subsequently analyzed in this section.

RIT Pre-survey Hazards

The main hazard that stems from the usage of Unmanned Aerial Vehicles (UAV) is related to the poor familiarization of the operator with the service robot. Inadequate training of inexperienced users operating complex systems could lead to "crash" or operational-failure due to human error. Prior to the conduct of survey, the operator/service supplier should be certified based on UAV/aviation national safety policy. The certificate is evidence that the required standards of training and knowledge for safe operation have been met. Relevantly, a service supplier with the capacity and knowledge, and one that ensures that the desired safety management system is in place, is of utmost importance. It is noted that classification societies, such as Registro Italiano Navale (RINA), Bureau Vertias (BV) and Lloyds Register (LR) certify external companies with qualified operators as "service providers" after they have successfully satisfied class criteria and tick-off items from respective prescribed verification-checklists.

Interview participants underscore that the lack of a comprehensive setup of UAV navigational plan for UAV, which covers all the necessary inspection areas, could lead to damage of the technology, ship structure or personnel injury. The pre-inspection planning stage between the operator and surveyor is critical. It is also noted that in the case of multi-robot visual and acoustic inspections, the sequence of the service robot should be incorporated into the navigational plan.

Calibration, another vital aspect, should be carried out by adjusting various sensors on board the platform (i.e., compass calibration, gimbal calibration, inertial measurement unit-IMU-calibration or vision sensor) to maximize the accuracy and reliability of the operation. Localization errors that originate from the relative geometry between transmitters and receivers should be alleviated by integrating approaches such as Global Positioning System (GPS) signals, UAV IMUs, Light Detection and Ranging (LIDAR), ultrasonic acoustic signals, 2D/3D cameras or laser range finders mounted onto the robot. Unsuccessful localization and miscalibration could lead to an unsafe and unstable drone flight pathway.

Improper storage of batteries during the transportation of the UAV could also lead to fire/explosion and injury to operator. In addition, battery power capacity should be adequate to cover all the necessary inspection areas.

UAV pose various hazards to people on the ground and other aviation crafts, creating great challenges for law enforcement agencies. Non-regulatory compliance of UAV with national authorizations and guidelines, taking into account UAV's weight, specifications and the type of operation, could be considered as another type of hazard. Within the port area, UAV operators should ideally obtain the approval of port authorities and comply with the port's policy for permission to fly UAV.

Compared to UAV, remotely operated vehicles (ROV) encompass fewer hazards, and require much less pre-inspection and associated preparation time. The main concern revolves around their deployment, i.e., they should be lowered slowly from heights into the sea. For magnetic crawlers, special attention is required on the potential physical damage to the person carrying the crawler, as well as the potential damage to the robot, due to its significant heavy weight. The operator should be vigilant during the adhesion of the welding robots, as damage to the finger is highly possible.

During the survey process, an UAV may become a potential risk known as "falling object" due to collision, battery failure, propeller failure or extreme weather conditions, causing severe damage to its equipment, on-site surveyors and the vessel itself. The risk of injury, especially from the UAV propellers that are attached to the motor, is high. During vessel dry dock of, everyone working in the near vicinity should be made aware that aware remote inspection using UAV is ongoing.

UAV loss-of-sight could also lead to damage and collision. Therefore, UAV Beyond Visual Line of Sight (BVLOS) operations should consider an advanced navigation system that enables them to make decisions, in line with airspace regulations, and automatically detect and avoid objects in their path. However, it should be noted that UAV utilized in a ship inspection process usually fly within Visual Line of Sight (VLOS) rules.

ROV, under the current strand-of-discussion, include minimal hazards during vessel survey and inspection. Operators encounter the challenge of recovering and steering the robot if the cable is tangled or if it gets fastened to any parts of the ship; therefore, due attention should be given to tether-management. Tethers could be tangled during autonomous operations leading to the stumbling of human operators.

Finally, in terms of magnetic crawlers, loss of adhesion of a wall-climbing robot could lead to damage to the robot and injury to the operator during the inspection of large ship structures. If the robot reaches an area with impedance to the magnets, or if the wire-torque is too heavy for the crawler, then there is a high probability of injury-risks. Magnetic crawlers are equipped with a tether that transports a tube to transfer water at the interface between the sensor and surface with an electrical water pump. Lack of water supply to ensure adequate surface contact between the piezoelectric transducer and the hull could also affect the survey. Moreover, the absence of magnetic wheel protection may damage the hull's paint used for anticorrosion and antifouling.

After completing a survey and inspection using RIT, the hazards that come into play include those that are tied to "data quality" and "data security". It is posited that data quality, including videos, images and light detection and range (LiDAR) data, should be precise for a complete AND HOLISTIC understanding of the condition of the inspected area. Besides, the interpretation of multi-echo data in noisy environments resulting from metal extractions can also affect the UAV sensor and the data analysis results.

Effective mechanisms should be in place to secure data from unauthorized access and corruption. In the case of UAV --- sonar and radars on board a vessel may interfere with the operation of the UAV, affecting the safety and security of sensitive data. Loss of data could also occur in tethered vehicles, such as ROV and magnetic crawlers, due to damage/loss of connection of the cable.

In the case of multi-robot inspection, there are serious concerns with regard to data integration. The complexity of multi-robot monitoring for operators and inconsistency of data observations from different types of robots pose challenges for the presentation of data in an optimized manner for human cognition. In the current stage, the absence of software and supportive technology that will enable the integration of ship inspection data raises challenges for effective data analysis. That being said, full-automation of these technologies is expected to address the data integration issues in the future.

Potential occupational hazards that affect the psychological well-being of operators and surveyors were highlighted by respondents, in tandem. Identified psychological hazards include nervousness and stress of the surveyor working closely with a robotic agent, lack of control, over estimation and absence of social interaction. Respondents, within this frame of reference, observe a form of diametric impact. The first of this impact concerns the on-board surveyor. A growing psychological tendency among surveyors is that robotic systems may eventually replace manual-driven operations leading to the deduction that a surveyors' knowledge gathered over the years may become "obsolete". The latter observation concerns the remote pilot. Cognitive inattention and prolonged duration of the remote survey, according to the respondents, may lead to errors of judgment and negative fallouts.

Essential point to note that several respondents highlighted that communication hazards between: a) human-human, b) human-robot and) robot-robot are critically evident. The level of communication and information exchange between humans will be reduced and "feeling of solitude" may surface. Indeed, communication between humans and robots requires the need for upgrading a set of additional and out-of-the-box skills. The more autonomous the work, the higher the need for integration and communication between the service robots. From this integration, various effects may appear, ranging from increased stress for the operator, weak social interaction for the surveyor and the fear of potential replacement in tasks jobs performed by humans regardless of how onerous, dull, dirty and dangerous it may be.

The dangers of poor trust calibration were also raised by the interviewees. In a human–robot context, trust influences an operator's intentions, enables the surveyor to understand the robot's capabilities, and paves the way for mass deployment of these technologies. Trust calibration is needed to boost the trustworthiness and reliability of remote inspection tools.

The overall findings confirmed that the RIT does concretely pave the way for safer inspections as they reduce the need for scaffolding and help surveyors reach dangerous and inaccessible areas. Notwithstanding, collateral issues, physical interaction, data management, social and legal hazards, *inter alia*, were unfolded by respondents in a non-linear order. In the absence of a common set of norms, this section seeks to proffer strategic recommendations based on:

- The three-part conceptual framework of "dynamic governance" comprised of actors, mechanisms and tools --- as propounded by authors Markell and Glicksman (Markell and Glicksman, 2016). Markedly, the three-part proposition by the authors is viewed as instrumental in enabling policymakers to "structure and administer" regulatory programs when faced with institutional change or "dynamic change", case-in-point, the integration of RIT (Markell and Glicksman, 2016);
- Three thematic strands of discussions for governance of emerging disruptive technologies: a) challenges of regulating emerging disruptive technologies; b) policy process and disruptive technologies; and c) regulatory responses to technological disruption (Taeihagh, Ramesh and Howlett, 2021); and
- Pathways (from *de lege leta* to *de lege ferenda*) indicated by respondents to the participation-observation.

Taking all of the above into account, this section amalgamates findings and formalizes the important elements for consideration under the following four specific headings: a) operational hazards in pre-survey and ongoing-survey phases, b) post-survey data quality & security hazards c) psychosocial hazards and d) legal hazards.

Patently. there are two types of main operational hazards before and during the ship inspection process: *hazards for technology* and *hazards for humans*. To address UAV-hazards, a navigational plan should be set up in a comprehensive manner to specify the inspection areas. In addition, the sequence of the robots should be specified and a chief inspection officer should be appointed for multi-robot surveys. The operation planning stage of the inspection is crucial whereby adjustment and coordination between the different operators (in case of multi-robot inspection) and between the “operator” and “surveyor” should be in order.

Special attention should be given to UAV-localization, which should ideally be accurate and reliable to ensure the safety of participants and the effectiveness of the survey. Localization can be achieved either through onboard sensors or with the help of a receiver that estimates its location based on a GPS or GPS-denied UAV technology. In the case of ROV, Underwater Positioning Systems (USBLs) can be utilized to detect the position of the ROV using acoustic positioning. Ultrasonic guided waves (UGWs) could provide accurate magnetic crawler localization and structural feature mapping by relying on acoustic reflections in combination with the other systems.

The regular calibration of UAV, based on the manufacturer’s instructions, is another measure of the effectiveness of the mission; thus, the operator needs to regularly and consistently re-calibrate the sensors of the UAV to ensure that it remains fit-for-service. Additionally, maintaining and storing batteries is integral to optimal UAV performance. Safe charging and safe disposal, therefore, are matters for consideration. It is important to stress that batteries must be stored at room temperature (for cooling purposes) and transported in specialized cases. UAV operators should carry extra battery packs during the inspection process so as to maintain continuous-flight momentum. At this point it should be noted that addressing the possible environmental hazards by energy consumption from the use of RIT could be mitigated by using renewable energy and zero-emission fuels; consequently, charging the batteries using renewable energy could lead to a zero-emission operation survey process.

In terms of explicit safety, UAV cage solutions could provide relief against physical injury and protect operators, surveyors and persons on land from physical injury from propellers and or the drone itself in case of a collision. Standard personnel protective equipment, such as helmets, labeled reflective clothing, and eye protection gears ought to be mandatory for survey participants.

For ROV, an issue noted earlier is the appropriate deployment of the ROV when it is lowered slowly into the waters. Although fully autonomous RIV may forgo tethers, however, until it reaches that stage, proper tether management for ROV and magnetic crawlers require the promulgation of niche organized rules so as to avoid dormant mishaps. Inadequate water supply should be ensured to enable the continuous operation of the magnetic crawler.

Data obtained from RIT includes information from close-up surveys and gauging. During an RIT-survey programme, visual data, such as still images, live-stream and recorded video, are collected to examine the vessel’s structural condition, ship’s holds and tanks to discover corrosion and measure thickness. Inaccurate data or incomplete information about the condition of the ship could have serious consequences for her safety and maintenance.

For post-survey processes, data quality and data security are the two main concerns underlined by the respondents. According to Khatri and Brown (2020), data quality refers to data’s capacity to accomplish their intended use through precision, timeliness, completeness, and credibility. High-definition cameras and high-precision sensors are essential to address data quality risks *(*Pastra *et. al, 2022*).

Apart from data quality, there are security risks also coined as hazards by respondents. According to the conclusions drawn by Johansson *et al.* (2021) data security and the effectiveness of data collection, data processing, and distribution of analysis-outputs need to be demonstrated if RAS platforms are to achieve the desired level of trust among the stakeholders of the business model. In this context, robust data encryption and access controls are crucial. Metadata should also be stored in an appropriate manner.

"Control of data" provision of the International Association of Classification Societies (IACS) as embedded in s. 5.2.6 of IACS UR Z17 highlights the responsibilities of service suppliers in relation to computer software's ability to acquire, record, report, store, measure and monitor data. While this does not conflict with laws on data protection, for example, the European Union's (EU) Regulation 2016/679 on the General Data Protection Regulation (GDRP), there is still the need to protect the data collected from a commercial asset (the vessel under inspection). According to s. 16.8 of IACS UR Z17, operational procedures for handling/operating equipment and guidelines on the collection, validation and storage of data rests with the service suppliers, which begs the questions of who should retain the copyright (ownership) of data gathered from RIT; what are the main characteristics of data quality, how should data be shared between the key stakeholders, what provisions on data control and security should be considered, what responsibilities do each party have to the other regarding data control and data security, what is the duration of preservation of data and image from close-up and in-water surveys, should there be any safeguard mechanisms for service providers against third-party liability? It is self-evident that a trustworthy process built on adequate data management and security is in need of implementation. Fortunately, answers to some of the questions posed above can be found in guidelines developed by individual IACS classification society members, which should suffice during the initial reign of supervised-autonomy.

Highlighting the precautionary principle, it is asserted that further research on engineering and system architecture is needed to integrate data and metadata reported from the UAV, ROV and magnetic crawlers if the ultimate intention is to achieve a holistic understanding of structural integrity and precise localization of defects (Chahine *et al.,* 2022).

Social and psychological hazards can adversely affect worker health and safety. Examples of these types of hazards include fatigue, stress, overload and absence of social interaction. To conditions must be met to encounter the social and psychological hazards: a) the training of the surveyor/operator; and b) the calibration of trust to the technology.

Training

In order to strategically tackle future impacts, the issue of multi-skilled professionals must be confronted. The education and responsibility of operators should be strengthened through mandatory training, registration of UAV operators and a quality-based certification process. Suppliers of RIT, should have mandatory training requirements for their personnel, including safety awareness training, hazardous area identification and fatigue management.

Upskilling surveyors is essential to expanding abilities and minimizing skill gaps. This can be achieved through continuous learning that entails the know-how of RIT operation as it moves forward in the autonomy-paradigm, capacity to analyze the findings from RIT and conceptualize 3D Models of the inspected area. The training schemes that will evolve over the years should be aligned to match the level of sophistication required to carry out services using individual RIT. Classification Societies have introduced 3D simulator training designed to train inspectors more effectively for raising safety levels.

In the not-so-distant future, it is projected that the operator could be replaced by the surveyor --- an aspect duly noted by the respondents. Here, the surveyor's experience, skill and training should not be underestimated since the surveyor's professional judgment should not deviate from existing physical survey procedures (Pastra *et al.,* 2022). Even if the world reaches a fully-autonomous phase free from the human-element, regardless, a human should still retain vigilance so as to be able to intercept, if needed, to verify safety of survey operations (Pastra *et al.,* 2022). It will still be important to uphold the relevant provision of IACS Recommendation 42: "… the results of the surveys by remote inspection techniques, when being used towards the crediting of surveys, are to be acceptable to the attending surveyor" (IACS Rec. 42, 2016).

Trust

In literature, trust has been perceived as a psychological state with foundation dependent upon reciprocity, cooperation, and mutual concern (Pastra et al., 2021; Pastra et al., 2022; Schabram et al., 2018). Rochel (2023) underlined that conception of trust in this digital era should be enriched by addressing the responsibility of developers, the power relations between users and developers of AI systems and the benefits associated with the use of AI systems.

Trust to artificial intelligence and digital technologies is a strategic priority for the European Member States as human workflows are increasingly intertwined with AI systems to support them. The European Commission (2019) makes it clear that trust is a prerequisite to ensure a human-centric approach to AI; thus, in this context, the trustworthiness of RIT should be ensured.

Pastra *et al.,* (2022) support that trust in RIT is a multi-dimensional concept that relates to a multifaceted interplay among specific work tasks, human dispositions, organizational and team settings, stakeholder needs and policies. The authors support that to move inside the "black box" of trustworthy RIT processes, the following elements should be considered:

a) technical robustness of the system without glitches or interruptions;

b) data quality and data security;

c) lawfulness of the system through the development of common standards;

d) skills and expertise of the surveyor; and

e) the lifecycle of the vessel.

The absence of a common framework for the use of RIT in the maritime sector creates a number of regulatory concerns. Those concerns and pathways forward have been addressed in the following sections.

Development of common safety standards

International Maritime Organization (IMO) and IACS, set the safety, environmental and security governance framework for shipping operations. IMO is the international governing body that sets a compliance and enforcement regulatory framework for the maritime sector. IACS, with its eleven member societies, is the technical standardization body that contributes to the IMO framework through technical support and compliance verification. Member societies have, over the last several years, identified the main risks identified with the different varieties of RIT. Examples of this approach can be found in the different sets of requirements developed by RINA, American Bureau of Shipping (ABS) and the China Classification Society (CCS). Guidance Notes developed by ABS include provisions on: explosion risks in hazardous areas, dropped object risks, collision risks (e.g., with other RIT), lost link risks (e.g., network compromise), other risks associated with high-risk working areas, and risks associated with parallel operations as well as emergency situations (ABS, 2022). The other set of unique RIT operational standards are found in the Guidelines for Use of Unmanned Aerial Vehicles developed by the CCS (2018) which include: safety, operation performance, enduring capacity, data transmission and communication, data storage (e.g., video and image resolution and video and photo formats), as well as requirements for airborne cameras. Guidance notes for the use of RIT can also be found in RINA's Rules for the Classification of Ships (2023), outlining the requirements for data storage, cyber security, data protection and internet connectivity.

Despite the provisions published by the respective classification societies, the international maritime RIT governance framework still remains fragmented as there are currently no agreed-upon standard procedures at the international level for statutory surveys (Pastra and Johansson, 2022; Pastra *et al.* 2023). Adopting a common methodological approach will also likely require developing operational common minimum requirements to harmonize categories of risk-assessments.

Given the urgent demand for guidance on remote surveys for the International Safety Management (ISM) Code audits and ISPS Code verifications, the Maritime Safety Committee, at its 104th session, considered developing guidance on assessments and applications of remote surveys. The term of "remote survey" has been conceptualized as the ''process of verifying that a ship and its equipment are in compliance with applicable statutory regulations or partially undertaken, without physical attendance on board the ship by a surveyor'' (IMO doc III 8/INF.19, 2022). Although that this term is distinct from that of RIT, the authors support that these guidelines could serve as the basis for the development of guidance for RIT-based surveys. Some of the main topics addressed in the draft guidance on remote statutory surveys (i.e., digital quality, qualification of the surveyor and the risk assessment framework carried out by the flag State) can be applicable to the RIT context.

Therefore, it is recommended that a new output on the "development of common safety standards for RIT'' be added to the work programme of the Sub-Committee on Implementation of IMO Instruments. Hence, overcoming regulatory challenges associated with RIT is considered by the authors as the first step in facilitating remote performance transition, not only during global emergencies such as COVID-19, but also when a normal steady state prevails.

Proof of Concept" via Regulatory Sandbox

Understandably, remote inspections conducted *off site* should be approved with the objective of achieving at least the equivalent results as *in situ* surveys, with "safety" being the primary consideration, especially during *force majeure*. Beforehand, adequate tests should be carried out through joint collaborative efforts in a controlled environment allowing for the strategic development of both methodologies for remote classification inspection operations (on the external and the internal areas of a vessel) as well as necessary rules and requirements. Survey respondents deemed this as an important step for determining "proof of concept" of the functionalities of remote RIT-surveys. Respondents also noted that flag states and classification societies could engage in extensive testing using the "regulatory sandbox" methodology to establish "proof of concept" for conducting RIT-surveys (with the possibility of a surveyor intervening as well as the possibility *without* a surveyor intervening) to ensure safer and even higher-quality evidence in the survey process offering optimum benefits to ship-owners and operators (Attrey et al, 2020). The authors propose that the survey findings could serve as the impetus to initiate an international scoping exercise.

Liability

A unified and well synchronized safety and liability approach can mitigate the hazards related to service robots (Alexandropolou *et al.,* 2021; Pastra *et al.*, 2023). Ultimately, RIT is an innovative and integrating such transformative product, such as service robots, into traditional human-driven tasks calls for a safety-net to guard against third-party liability. At present, IACS UR Z17 does not provide any caveats that prompt necessary pre-emptive steps from service providers, flag administrators or classification society members. The authors emphasize that quality assurance schemes for protection against liability are not generic either in scope or nature, and that the current legal regime only requires service suppliers ensure that these elements are in place. As previously discussed, *inspection and certification* fall under the conditional assessment program that is a requirement of charterers and cargo owners. Through such assessment programs ship-owners can demonstrate “operational reliability” to their clients.

New forms of RIT liability emanating from dropped object or collision risks, or even unseaworthiness of a vessel due to deterioration or corrosion from biofouling, may seem far-fetched since current routine options, such as reverting back to manual inspections and checks through periodical surveys remain readily available. Even so RIT does have the potential to create some new and unforeseen risks due to the introduction of multiple new actors during an RIT survey (Alexandroupoulou *et al.,* 2021). For example, input-material supplied by the asset owner to the service supplier prior to hull inspection (i.e., images, drawings and designs) could infringe on the copyright or other rights belonging to a third party. Hull survey data could be used for marketing by the service supplier without the prior approval of the asset owner. Therefore, the path forward should connect the RIT-survey regime to the liability laws of the flag state, referred to as a “liability clause” in the texts of classification society member state requirements. An alternative is to follow the example set by Lloyd’s Register (2022) by including a provision that requires end-users to maintain third-party liability insurance in case of accidents or incidents.

In any event, these new risks go beyond and dissociate from the three-pronged concept of the vessel’s seaworthiness, whose main aspect, in its narrow sense, refers to the physical stature of the vessel, being fit enough to perform the voyage safely. In this regard, “unseaworthiness” signifies an attribute of the vessel which threatens the safety of the vessel or her cargo (*Meredith Jones & Co Ltd Vangemar Shipping Co Ltd* (*The Apostolis*) [1997] 2 Lloyd’s Rep.241, Actis Co Ltd v Sanko Steamship Co Ltd (The Aquacharm) [1982] 1 WLR119).

Traditionally, under England and Wales case law, classification societies have been discharged of liability whether in contract or under the tort law of negligence “the purpose of the classification certificate is not to guarantee safety” Sundance Cruises v. American Bureau of Shipping, 7 F.3d 1077, 1084 (2d Cir. 1993), but merely the vessel’s compliance with the standards and rules set by the society and, policy issues oppose the imposition of liability on classification societies, (Marc Rich & Co. A.G. v Bishop Rock Marine Co Ltd Citation1995) whereas it is the ship-owners absolute obligation, at common law, to provide a seaworthy vessel (Steel v State Line Steamship Co; (Baatz, 2014, p.125; Baughen, 2018, p.84), under the Hague-Visby Rules the carrier/ship-owners obligation to exercise due diligence to make the ship seaworthy vessel before and at the beginning of the voyage (Hague-Visby Rules 1968, Art III rule 8), the latter being a non-delegable duty (Riverstone Meat Co Pty Ltd v Lancashire Shipping Co Ltd 1961).

However, this is not always the case in other jurisdictions. A classification society might be held liable where a marine casualty -resulting in damage or loss to property, personal injury or death is attributed to a willful act or omission or gross negligence of its bodies, employees, agents or others who act on behalf of the classification society. In particular, where the classification society (RO) performs statutory surveys and issues certificates of compliance to the respective IMO Conventions, it acts as agent and on behalf of the administration, having been entrusted and delegated to exercise the said powers by the flag state in fulfillment of the latter's duties under Art.94, 217 UNCLOS (Appendix II of IMO Resolution A.739(18); IMO Instrument Implementation Code [III Code] (IMO, 2013a); Resolution MSC.349(92) (2013) Code for Recognized Organizations (RO Code)) acting on behalf of the administration in the event of a marine casualty causing loss, damage to property, injury or death where it is proven by a court of law to have been attributed to a willful act or omission or gross negligence of the recognized organization -its bodies, employees, agents or others who act on behalf of it-, liability with a requirement to compensate will be imposed on the administration which is entitled to claim compensation from the classification society (Article 5 Directive 2009/15/EC). While performing non-statutory surveys the classification society will be liable in contract and in tort as applicable to the relevant claim.

RIT surveys fall within the remit of semi- autonomous processes, still maintaining the human actor in the loop in combination with remote operated vehicles, complex digital technologies, dependent on data and interconnectivity, comprising semi- or autonomous systems with features specific to artificial intelligence (AI).

Under 5.2.3. Z17 IACS Req. 1997/Rev.172022 the service supplier of RIT surveys is defined as an independent contractor that undertakes to provide supervision for all services provided; so, it seems that liability rests with the service supplier in case of accident or incidents i.e., third party liability. Nevertheless, it could be argued that a classification society could be held liable under the extended theory of vicarious liability embraced by the case law, stepping out the established employer-employee relationship and encompassing such relationships not considered within the ambit of employment but akin to the latter.

The result of the above approach is that a relationship other than one of employment is, in principle, capable of giving rise to vicarious liability where harm is wrongfully done by an individual that conducts activities as an integral part of the business process carried out by a defendant and for its benefit (rather than his activities being entirely attributable to the conduct of a recognisably independent business of his own or of a third party), and where the commission of the wrongful act is a risk created by the defendant by assigning those activities to the individual in question. (as per Lord Phillips in Christian Brothers; as per Lord Reed in Cox,24). Although vicarious liability is not meant to apply to independent contractors per se, the nomenclature is not significant for the designation of relationship, as it is judged on the facts of each case, it could be argued based on the above that a classification society could be held vicariously liable if the service provider acting on the instructions of the class surveyor and in particular, in terms of the method of performing the services and due to the fault of the former there is data disclosure, IP leakage etc. Under Z17, 16.10 Verification – The supplier must have the surveyor's verification of each separate job, documented in the report by the attending Surveyor(s) signature. In any case, the suppliers' private contracts should be reviewed concerning the roles and responsibilities in respect of the data quality, storage, security, and sharing of information (Johannsson *et al.,* 2021). The accountability, thus liability of the actors participating in the RIT survey in terms of data flow, data storage and data processing, -apart from the personal data being subject to EU general data protection regulation, Regulation (EU) 2016/679 (GDPR), should be clearly defined.

However, the features of digital technologies, primarily their complexity, their dependence on data and their interconnectivity and in particular AI systems performing continuous adaptation through machine learning, entail opacity and limited predictability in their operation, rendering it difficult to trace the fault and identify the liable person. Thus, AI systems pose new risks and also challenges to the traditional regulatory liability regimes, which currently are under reform in most states for purposes of adapting to the requirements of emerging digital technologies, in particular AI. Henceforth, it is worth considering the liability regime introduced by the Commission's proposals for two complementary Directives to address liability arising out of damage caused by the digital technologies, including AI, potentially applicable to liability arising out of RIT surveys.

The EU Commission in its Report on the safety and liability implications of IoT, AI and robotics (2020), accompanying the White Paper (2020) on AI, identified new challenges and risks associated it with the uptake of AI and its uses in terms of product safety and liability, like connectivity, autonomy, data dependency, opacity, complexity of products and systems, software updates and more complex safety management and value chains. (European Commission,2020). In this regard, the Commission developed a coordinated horizontal, risk-based approach on AI systems - AI products or AI enabled services - in order to both promote the roll out and uptake of AI systems and address its risks in its'Proposal for a Regulation laying down harmonised rules on artificial intelligence' (Artificial Intelligence Act) (COM(2021 206 final), therein presenting a regulatory framework for operators that design, develop or use AI systems which aims at safety and prevention of harm caused by AI systems and the protection of fundamental rights, indicating prohibited AI uses and establishing an hierarchy of AI comprising 'high risk' AI systems to the health and safety or fundamental rights of natural persons, up to 'non risk' AI systems. The proposal contains specific rules applicable to the design and development, in particular, of the 'high risk' AI systems before they are placed on the market, thereby being subject to compliance with certain mandatory requirements and an ex-ante conformity assessment.

Considering that a safety-centric regulatory framework is effectively reinforced through the establishment of an efficient redress mechanism in case of the former's violation, safety and liability are essentially the two sides of the same coin. At the EU level, member states' non-harmonized fault-based, non-contractual/ tort liability rules, are not suited to handling liability claims for damage caused by AI-enabled products and services since the claimant is required to prove a negligent or intentionally damaging act or omission ('fault') by the person potentially liable/ wrongdoer, as well as a causal link between that fault and the respective damage.

Where AI is interposed between the act or omission of a person and the damage, the specific characteristics of certain AI systems, such as complexity, autonomous behavior and opacity (the so-called "black box" effect), may render it excessively difficult, if not impossible or prohibitively expensive for the victim to meet this burden of proof, identify the liable person and prove the facts for a plausible liability claim, in particular that a specific input by the potentially liable person caused a specific AI system output that led to the respective damage. To this effect, a harmonized liability/redress regulatory system is currently underway in the EU to counterbalance harm caused by AI. In line with the above, the Commission takes a holistic approach in its AI policy to liability by proposing adaptations to the producer's liability for defective products under the Product Liability Directive as well as the targeted harmonization under the AI Liability Directive. These two policy initiatives are closely linked and form a package, as claims falling within their scope deal with different types of liability.

The Product Liability Directive covers producer's no-fault liability for defective products, leading to compensation for certain types of damages, mainly suffered by individuals whereas the AI Liability Directive covers national liability claims mainly based on the fault of any person with a view of compensating any type of damage and any type of victim, legal entities included. They complement one another to form an overall effective civil liability system, based on, in certain circumstances, on the presumption of causality or defectiveness.

Hence, the Commission's proposals focus on the following elements:

The *Directive on Liability for Defective Products* which revises the existing EU harmonised regime on the no fault-based -liability of the manufacturer/producer/designer/developer of defective products and possibly the further economic operators related to them (importer and the distributor), providing for the right to compensation of natural persons for the damage suffered by defective products (physical injury/ death, psychological damage, property damage or data loss not used exclusively for professional purposes. The definition of 'product' is expanded to include software, digital manufacturing files and AI enabled products while a product shall be considered defective if it does not provide the safety the public at large is entitled to expect, in particular where the product safety requirements and regulations whether national or EU are not complied with, taking into account all the circumstances, amongst others, the effect on the product the ability to continue to learn after deployment. A claimant with a plausible claim can seek an order for a defendant to disclose relevant evidence whereas failure to comply results in a presumption of the defect. However, if a claimant faces excessive difficulties in proving the defect and/or causation due to technical or scientific complexity, then the defect / causation can be presumed on the basis of sufficiently relevant evidence (Art.8, 9).

The *Directive on Adapting Non-Contractual Civil Liability Rules to Artificial Intelligence* (AI Liability Directive) aims to lay down common rules towards alleviating the burden of proof of the claimant (natural person or legal entity) in non-contractual/tort fault-based civil law claims for damages pursued under the national fault-based liability regimes for any harm caused by AI systems, in particular by an output of an AI system or the failure of such a system to produce an output where such an output should have been produced (Art.2). In consistency with the AI Act, the AI Liability Directive maintains the same definitions as the AI Act, the distinction between high-risk/non-high-risk AI, the documentation and transparency requirements of the AI Act (Art.4 (2)) through the right to disclosure of information, and incentivises providers/users of AI-systems to comply with their obligations under the AI Act. Nonetheless, the Directive is meant to be the least possible interventionist; it does not affect national rules determining which party has the burden of proof, which degree of certainty is required as regards the standard of proof, or how fault is defined (Art.1), other than the introduction of rebuttable presumptions provided for in Articles 3 and 4.

The *AI Liability Directive* alleviates the victim's/ claimant's burden of proof by introducing the rebuttable 'presumption of causality' (Art.4) **-**where the claimant has demonstrated or the court has presumed the fault of the defendant- or of a person for whose behavior the defendant is responsible- consisting in the non-compliance with a relevant duty of care laid down in EU or national law directly intended to protect against the damage that occurred due to the defendant having failed to comply with a national court's order to disclose or to preserve evidence pursuant to Article 3(5), and it can be considered reasonably likely, based on the circumstances of the case, that the fault has influenced the output produced by the AI system or the failure of the AI system to produce an output gave rise to the damage. If a claimant presents facts and sufficient evidence to support the plausibility of a claim in damages suspected to have been caused by a 'high risk' AI system, Article 3 of the *AI Liability Directive* grants to the claimant the right to request disclosure of evidence at the provider's or user's disposal about the high risk AI system (subject to the principle of proportionality taking into account confidential information, like trade secrets) in order to assist a claimant identify potentially liable defendants. If the defendant fails to comply with a court order to disclose or preserve evidence in a claim for damages, there is a rebuttable presumption that the defendant breached the relevant duty of care (Art.3 (5)).

By contrast, the rebuttable presumption does not apply to 'high risk' AI systems where sufficient evidence and expertise is reasonably accessible (Recitals p.28, through technical documentation and logging requirements pursuant to the AI Act) for the claimant to prove a causal link (Art.4 (4)) whereas with regard to non-high risk AI systems it only applies where it is excessively difficult for the claimant to prove the causal link (Art.4 (5)). Where it concerns a damages claim against a 'high risk' AI system provider, a breach of duty is only established if considering the 'high risk' management AI system's results, the provider breached their obligations according to the AIA, in particular the AI system was not designed and developed in a way that allows for an effective human oversight, or to meet transparency requirements or to achieve an appropriate level of, accuracy, robustness and cybersecurity, or the provider failed to take corrective actions to remedy another breach or withdraw / recall a 'high risk' AI system. Similarly, a breach of duty of care is established in damages claim against a 'high risk' AI system user if the latter breached its obligation to use / monitor the AI system in accordance with accompanying instructions of use or, where appropriate, suspend or interrupt its use or exposed the AI system to input data under its control to data not relevant in view of the system's intended purpose (Art. 3).

The abovementioned approach does not ensue a reversal of the burden of proof, whereby the claimant no longer bears the burden of proof requiring from the defendant to prove that the conditions of liability are not fulfilled. The Commission discards such a reversal of the burden of proof to avoid exposing providers, operators and users of AI systems to higher liability risks, which could hamper innovation in AI-enabled products and services.

Nevertheless, it is noteworthy to mention that the easing of the burden of proof based on the presumptions is not readily acceptable by the EUCJ. The Court in its judgement of 21 June 2017 on the preliminary ruling concerning the interpretation of Article 4 of Council Directive 85/374/EEC rejected the establishment of a presumption of causality between damage and defect or defectiveness of the product. The Court ruled that Article 4 of Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the member states concerning liability for defective products must be interpreted as not precluding national evidentiary rules such as those at issue in the main proceedings. National courts must, however, ensure that their specific application of those evidentiary rules does not result in the burden of proof introduced by Article 4 being disregarded or the effectiveness of the system of liability introduced by that directive being undermined. Article 4 of Directive 85/374 must be interpreted as precluding evidentiary rules based on presumptions according to which, where research neither establishes nor rules out the existence of a link, the existence of a causal link between the defect and the damage suffered by the victim will always be considered to be established when certain predetermined causation-related factual evidence is presented.

In particular, *national courts must, however, ensure that their specific application of those evidentiary rules does not result in the burden of proof introduced by Article 4 being disregarded or the effectiveness of the system of liability introduced by that directive being undermined* (para 43*). A presumption could undermine* *the burden of proof set out under Art. 4* (in the revised Directive Art.9) whereby the injured person is required to prove the damage, the defect and the causal relationship between defect and damage. *However, in laying down rules of and evidence applying to cases within this Directive, the procedural autonomy of Member States is not unlimited. The combined effect of national rules of proof and evidence must respect the principles of equivalence and effectiveness* (para 24) […] *In particular, national rules of proof and evidence that unduly hamper the national court's ability to assess 'sufficiently relevant evidence' (para 14) or that are not sufficiently rigorous so that they in practice result in a reversal of the burden of proof, would not be consistent with the principle of effectiveness (para 25).*

It will be interesting to follow the development of EUCJ jurisprudence in the context of the new liability mechanism introduced by the abovementioned Directives and whether it will have an impact on liability in the context of RIT surveys.

An evaluation and targeted review of the AI Liability Directive's application shall take place five years after the end of the transposition period through a monitoring program established by the Commission which will present a report to the European Parliament, to the Council and to the European Economic and Social Committee, examining the effects of Articles 3 and 4 on achieving the objectives pursued and evaluate the appropriateness of strict no-fault liability rules for claims against the operators of certain AI systems, as long as not already covered by other Union liability rules, and the need for insurance coverage, while taking into account the effect and impact on the roll-out and uptake of AI systems.

Correlation between trust-safety-liability

An effective safety culture develops from the systematic monitoring of safety and by updating the system in accordance with the experiences of both the operator and the industry. However, this updating process is dependent on the open reporting of safety incidents, which is facilitated by trust (Conchie et al, 2006). Trust in organizations has been studied in different ways to address positive outcomes on organizational phenomena, such as positive impact on safety culture and safety performance (Burns et al., 2006; Conchie et al., 2006; Reason, 1997). Therefore, the key aspect of building safety culture is the level of openness and trust and access to information that may indicate compromising of safety. Reason (1997) argues that the safety culture is based on an underlying element of trust through the development of three subcomponents: a reporting culture, a just culture, and a learning culture that interact to create a safety culture. Research shows that high levels of trust in relationships contributes to high levels of safety in high-risk enterprises (Conchie et al., 2006); the shipping industry is considered a high-risk industry.

Similarly, trust acts as the central mechanism through which other drivers impact AI acceptance. It is important, therefore, to understand what influences trust in AI systems. A global study in 2023 examines four distinct 'pathways to trust' their comparative importance in predicting trust – the institutional drivers: the belief that current laws, rules and governance are sufficient to ensure AI use is safe and confidence in government and technology/commercial organizations to develop, use and govern AI, motivational drivers concerning the perceived benefits of AI, uncertainty reduction drivers regarding the perceived risks of AI, and subjective knowledge: the extent to which people feel they understand AI, and tech efficacy (Gillespie,2023).

Transparency in respect of AI systems' use and the way AI systems operate is important for AI to become commonly accepted. Furthermore, the use of risk management in the AI systems' lifecycle as well as the documentation can improve the AI systems' transparency ensuing an organization's accountability and consequently liability. (OECD, 2019)

Transparency and traceability as well as accountability are fundamental factors in building trust in AI. Mechanisms should be put in place to ensure responsibility and accountability for AI systems and their outcomes, both before and after their implementation. Auditability of AI systems is key in this regard, as the assessment of AI systems by internal and external auditors, and the availability of such evaluation reports, strongly contributes to the trustworthiness of the technology (Commission, 'Building Trust in Human-Centric Artificial Intelligence' (Communication) COM (2019) 168 final).

In its White Paper 'On Artificial Intelligence - A European approach to excellence and trust' COM (2020) 65 final, the Commission stressed that AI systems – and certainly high-risk AI applications – must be technically robust and accurate in order to be trustworthy. That means that such systems need to be developed in a responsible manner and with an ex-ante due and proper consideration of the risks that they may generate. Their development and functioning must be such to ensure that AI systems behave reliably as intended. All reasonable measures should be taken to minimize the risk of harm being caused.

RIT or ICT-fused inspections and surveys are not an aberration but an amelioration towards a likely safer future of fully autonomous RAS. RIT can provide better and perhaps safer modes of conducting surveys and inspections. For example, after being integrated, RIT can provide relief from tasks that are otherwise time-consuming, strenuous and in some instances, fatal due to lack of oxygen or polluted vapors in confined spaces of tanks and holds (Poggi *et al.*, 2020).

Despite the many benefits of remote inspection technologies, some hazards are still evident. Hazard recognition of robotics in the workplace is a prerequisite for their massive exploitation and use if they are to make an impact in reducing the number of injuries and fatalities. The hazards identified in our study include a) operational hazards that emerge during the physical interaction with the service robots b) data quality and security hazards c) social hazards and d) legal hazards.

International regulations for RIT, or top-down rules and requirements, if developed the right way, could help provide guidance and avoid a plethora of hazards for a system marked by multiple echelons and diverse stakeholders. The law is part of a general normative framework, which substantially affects the type of technology being developed and brought to society, securing the trustworthiness of an AI system (Rochel, 2023). Common procedural rules covering data management, liability, and operational standards, will all have a crucial bearing on the types of technology that will emerge in the not-so-distant-future. Transition from UAVs to hybrid Unmanned Aerial Underwater Vehicles (UAUV) capable of navigating and operating in both air and underwater water environments is in the making, and will soon be deployed in the offshore industry (Chu *et al.,* 2023; Kartsimadakis, 2023; Knukkel, 2023). This will further raise RAS-governance questions as both aviation and admiralty stakeholders will need to unravel complex layers to set new industry-based standards.

Moving to the niche liability domain, it is anticipated that the proposed liability framework shall engender confidence in AI technologies and facilitate access to a proficient judicial apparatus by ensuring accountability/culpability and adequate reparation for individuals (natural or legal) and entities adversely impacted by AI systems. This framework delineates a foundational level of protection for victims, aiming to both redress harm and incentivize proactive measures to avert such harm. The envisaged reforms, seeking convergence in fault-based, non-contractual liability regulations among member states, are poised to dissipate legal ambiguities surrounding the elucidation and application of extant national liability statutes in cases involving AI, thereby striving for equitable outcomes for the affected parties through consistent legal interpretation. Enhanced societal trust is a corollary of these reforms, yielding benefits for all stakeholders within the AI-value chain, affording them the ability to evaluate and mitigate their liability exposure, notably those engaged in cross-jurisdictional trade within the EU, thereby forestalling distortions of competition within the internal market. Thus, the harmonization of the AI Liability framework emerges as a stabilizing force and a prerequisite for the widespread adoption of AI technologies.

A governance structure in the form of a framework for cooperation of national competent authorities, classification societies and relevant stakeholders is imperative. This structure is indispensable for averting the disintegration of responsibilities, amplifying testing and certification capabilities for AI-infused products and services, and maintaining coherence within the industry. Control in the assignment of such authority is needed in order to promote uniformity of inspections and surveys and maintain established standards.

In light of the liability package proposed in this article, a fault-based liability paradigm emerges as fitting, wherein AI interposes between an individual’s act or omission and resultant damage. Conversely, a strict, non-fault liability model, reminiscent of liability regimes applicable to defective products, is recommended, further fortified by mandatory insurance coverage. This augmentation aligns with the evolving nature of RIT survey processes, transitioning from human intervention to autonomous and automated modalities. In order to avoid further regulatory fragmentation uniform industry standards as to RIT surveys must be elaborated and established through review processes, relying both on transparent procedural and qualitative criteria while being able to adapt to the AI systems’ development. A governance structure should serve as a forum for a regular exchange of updated information and best practices, identifying emerging trends, advising on standardization and on certification, thus facilitating the implementation of the legal framework. To that effect, it should rely on a network of national authorities, as well as sectorial networks and regulatory authorities, at national, EU and international level.

The writers further contend that the maritime industry and applicable government and organizational regulators will need to adapt to technological transformation. For that transformation to be triumphant --- consensus-based methodologically-sound all-embracing guidelines mitigating much-needed liability concerns are indispensable (Kartsimadakis, 2023). Hazard and liability aspects will need to be appraised with due diligence at any given stages of development of international guidance on the topic. If carefully structured, the international guidance will enable the maritime industry to unleash the full potentials of RAS in the face of current and future global emergencies.

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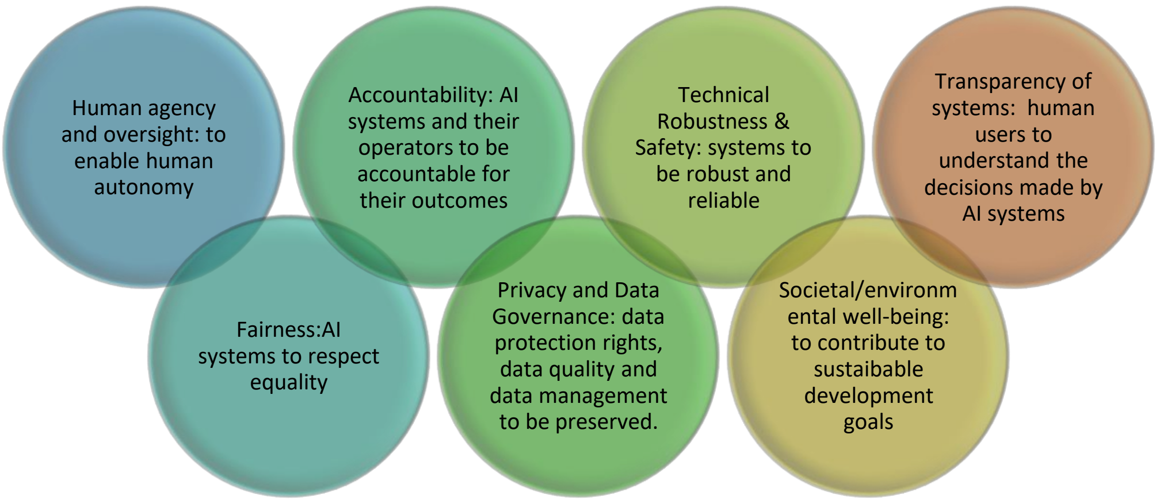
3.3 Establishment of Ethical and Human-centric Principles

Once a clear understanding of the landscape is established and the risks are identified and mitigated, the next step is to develop the principles that will guide regulation. Technology developers and manufacturers before creating and launching a new product, should take into consideration the wider ethical and legal concerns—including, for instance, privacy and data protection- so as to ensure that the human–robot interaction is safe, secure and trustful, (Fosch-Villaronga and Drukarch, 2020; Drukarch et al., 2023).

The principles should provide a comprehensive framework for developing and implementing AI technologies that are trustworthy, ethical, and human-centric. The principles should be relevant to the *Communication on Building Trust in Human-Centric Artificial Intelligence* (European Commission, 2019) which sets seven key requirements for trustworthy AI: Human agency and oversight, Technical Robustness & Safety, Privacy and Data Governance, Transparency of AI systems, Fairness, Societal/environmental well-being and Accountability (Figure 14). These principles provide a pioneering roadmap for the ethical regulation of AI within the EU. It is critical for all the stakeholders to engage actively with this framework in order to ensure that AI's transformative potential is harnessed responsibly and ethically, fostering societal trust and well-being. A strong need exists for engagement between the manufacturers of service robots with end users in order to identify unregulated and underestimated challenges (e.g., psychological harm) that the regulatory frameworks and principles should cover (Fosch-Villaronga and Drukarch 2020; Drukarch et al., 2023).

Figure 14: Key Requirements for Trustworthy AI



Source: Adapted from European Commission, 2019

3.4 Regulatory Sandboxes and Living Labs Contributing to Norms and Standards

In the ever-evolving landscape of technology and artificial intelligence, two methodologies have emerged as key mechanisms to foster and regulate new technologies: regulatory sandboxes and living labs. Both these approaches provide a space for experimental and real-world testing of innovative solutions, but they differ in terms of purpose, structure, and the nature of engagement with the stakeholders.

Regulatory sandboxes represent controlled environments within which innovative solutions can be tested under a relaxed regulatory regime, thereby addressing the challenges of governing rapidly advancing technologies (Zetzsche et al., 2018). Regulatory sandboxes could be effectively used in the field of robotic technologies to test various applications, such as autonomous vehicles, drones and AI-enabled service robots. These controlled and safe 'experimental spaces' that are monitored by a flexible regulatory oversight allow for real-world testing and observation, while managing potential risks and informing future regulation. Manufacturers, along with service providers, policymakers and academia could engage in extensive testing using the “regulatory sandbox” methodology to establish “proof of concept” and contribute to the development of robust, adaptive, and effective standards that foster the responsible development and deployment of autonomous systems. However, implementing regulatory sandboxes involves challenges, including ensuring equal access to the sandbox, managing potential risks during testing, and scaling successful innovations to full market operation (Zetzsche et al., 2018). Despite potential challenges, the strategic use of regulatory sandboxes will likely be instrumental in navigating the future of autonomous technology regulation. The overall goal of regulatory sandboxes is primarily to understand the implications of new technologies, adapt regulatory frameworks accordingly, and manage risks (Yeung, 2019).

On the other hand, Living Labs provide an innovative avenue for real-world, user-centered evaluation of autonomous systems, significantly contributing to the evolution of norms, standards, and regulations. Living labs are conceptualised as "user-centered, open-innovation ecosystems" that facilitate a collaborative process where users and producers co-create innovation and enhance the technology's relevance and acceptance (Bergvall-Kåreborn and Ståhlbröst, 2009). These environments foster a co-creative approach with all the relevant stakeholders throughout the entire process of innovation, and their key characteristics include contextuality, openness and user engagement (Nyström, et al., 2014). While Living Labs provide some opportunities to test regulations, their primary goal is to foster user-centered innovation and accelerate technology uptake (Schuurman et al, 2012).

Within the context of robot regulation, it is noticeable that a common platform for channeling the interaction between public policymakers, standard organizations, robot manufacturers, and consumers is currently lacking (Fosch Villaronga and Drukarch, 2021; Drukarch et al. 2023). Living Labs can address this gap and create the opportunity for an ecosystem approach that encompasses all the relevant stakeholders.

While regulatory sandboxes and living labs have different focal points – regulatory understanding versus user-centric innovation – they share a common ground in enabling real-world experimentation of new technologies. A potential convergence of these two approaches could lead to 'Regulatory Living Labs', a hybrid model that blends the regulatory focus of sandboxes with the user-centric, open-innovation approach of Living Labs.

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4. Analysis of Strand 3: Advance Understanding Whether New Regulatory Approaches or Self-Regulation is Best for the Future Development of Robot-Technologies for Automatic Robotic Guidance and Inspection Systems

Acronyms

AI	Artificial Intelligence
ABS	American Bureau of Shipping
AI	Artificial Intelligence
CCS	China Classification Society
DoD	US Department of Defense
DNV	Det Norske Veritas
EU	European Union
ESP	Enhanced Survey Programme
HSSC	the Harmonized System of Survey and Certification
IACS	International Association of Classification Societies
ICAO	International Civil Aviation Organization
ICS	International Chamber of Shipping
IMO	International Maritime Organization
IoT	Internet of Things
NGO	Non-Governmental Organization
PSC	Port State Control
RAS	Robotic and Autonomous Systems
RIT	Remote Inspection Techniques
ROV	Remotely Operated Vehicle
SOLAS	International Convention for Safety of Life at Sea (SOLAS
UAV	Unmanned Aerial Vehicle
UNCLOS	United Nations Convention on the Law of the Seas

4.1 Umbrella Regulation v. Self-regulation for Robotics

From Artificial Intelligence (AI) and the Internet of Things (IoT) to blockchain and quantum computing, such new technologies have the power to enable devices to learn from past decisions and improve their decision-making capabilities. Given their transformative potential, regulating their development and use is imperative. Governments and stakeholders are engaged in deliberations on how best to regulate emerging technologies to address the uncertainties pertaining their long-term consequences as well as to specify the role of national governments along with the level of cross-border policy harmonization (McManus & Eijmberts, 2017).

The Industry 4.0 digital revolution has introduced 'smart' and autonomous shipping, paving the way for maritime changes to ship design, operations, manning and logistics. The seamless integration of robotic and autonomous systems (RAS) into maritime operations has the potential to relieve the human element from tasks that are dull, dirty and onerous. Markedly, multi-Aerial vehicles, remotely operated vehicles and magnetic crawlers, and the likes, commonly known as remote inspection techniques (RIT), are designed to conduct close-up surveys, maintenance and thickness measurements of vessels. Manufacturers, service providers and a number of classification societies acting on behalf of flag States assert that RIT will inevitably replace the current inspection manual-driven rudimentary system. Bottlenecks need to dissipate; regulatory barriers need to come down.

Striking the right balance between regulating emerging technologies and promoting innovation remains challenging, given that too much regulation can stifle innovation while too little regulation can lead to collateral consequences. Policymakers encounter a trade-off between reducing possible Type 1 and Type 2 errors – overregulating benign technologies or under-regulating novel technologies that pose regulatory challenges (Miller et al. 2011; Waring et al. 2020). Type 1 error of overregulation aims to safeguard society before all the adverse effects of technological deployment are apparent, whereas type 2 error protects the economic interests of the innovators yet running the risk of causing social damage (Taeihagh et al. 2021). Policy design in various industries takes place in an environment of great uncertainty as technologies are still evolving with unclear trajectories (Walker et al., 2013; Taeihagh et al., 2021). Addressing the challenges of disruptive technologies requires thoroughly examining the alternatives between an umbrella framework, self-regulation or regulatory mixes that exist as sectoral "regimes".

Umbrella regulation provides a comprehensive and consistent framework for all stakeholders, including industry, government, and civil society, to operate within. This framework is a command-and-control form of regulation administered and enforced by the state. On the other hand, self-regulation is designed by industry associations to address concerns and issues within a particular sector. Self-regulation addresses issues not covered by public regulation and exists when the industry/business community sets its own standards of behavior (Hemphill 1992; Wotruba 1997). Self-regulation is usually developed under a leading industry organization that sets the minimum safety and quality standards along with Codes of Conduct. Although this form allows for flexibility and lower costs, there are cases where this practice has been perceived as a strategy to give the government an excuse for not ''doing its job" (Braithwaite 1993: 91). Other criticisms mention that self-regulation cannot be a very successful "stand-alone" mechanism of social control since it lacks credibility, rigorous standards and sanctions' (Gunningham and Rees, 1997; Webb & Morrison 1996).

This suggests a synthesis of public and private regulation and the need to identify ways for a harmonious combination of the state's role and the industry's regulatory strategies (Gunningham and Rees, 1997). This fit is evident in mixed systems that combine government and self-regulation into a form of ''co-regulation'' (Gupta and Lad 1983). This leads us to the concept of "multi-level governance" which involves the complex interactions that take place among national governments and non-state actors involved in policymaking at local, national, and supranational levels (McManus and Eijmbertsm 2017:275). The maritime sector is the best example of the practice of multi-level governance from the international to the national, via IMO, down to regional and industry levels. The maritime governance framework for RIT is analyzed in the next section.

4.1.1 The role of UNCLOS as an Umbrella Convention

The United Nations Convention on the Law of the Seas, commonly referred to as "the Constitution for the Ocean, provides a comprehensive regime of rules governing all uses of the oceans and their resources. Article 94, PART VII, specifies that every Flag State shall take such measures for ships flying its flag to ensure safety at sea with regard to the construction, equipment and seaworthiness of ships. Flag States should conduct services on vessel structures in support of good operation and performance. The integration of RIT falls into the survey and maintenance requirements of UNCLOS. Notwithstanding the absence of a point of reference that determines the legal status of professional service robots, compliance with UNCLOS's "safety at sea" provisions will still remain applicable (Johansson, 2022).

Article 194 of Part XII deals with protection and preservation of the marine environment and states that measures should be taken to prevent pollution of the marine environment by vessels, ensuring the safety of operations at sea, and regulating the design, construction, equipment, operation and manning of vessels and devices operating in the marine environment (UNCLOS, Part XII, Article 194). Flag States are required to demonstrate environmental stewardship and undertake all the essential measures, individually or jointly to prevent pollution of the marine environment and the intentional or accidental introduction of alien species, denoting an important connection to remote inspection techniques. According to Article 196, States shall take all the essential measures to prevent pollution of the marine environment resulting from the use of technologies or the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment (UNCLOS, Part XII, Article 196.1).

Part XIII of the Convention is devoted to "marine scientific research" activities. A clear definition of the term marine scientific research has not been provided in the Convention, despite the long-standing discussions that have taken place all these years. Nonetheless, the equipment used in vessel inspection and maintenance falls within the ambit of marine scientific research as long as the vessel to be inspected and cleaned remains berthed, anchored or dry-docked within internal waters of a flag state (Johansson, 2022).

The importance of cooperation is underlined in the Convention. For example, Article 266 makes provisions for the development and transfer of marine science and technology, and Article 268 requires from states to promote the development of appropriate marine technology and international cooperation.

Although negotiated as a universal "package deal," the Convention was always intended to be capable of further evolution to accommodate the tremendous technological innovations (Boyle, 2005; Petrig, 2020; Woker et al., 2020; Redgwell, 2014). The General Accepted International Rules and Standards (GAIRS) established in UNCLOS comprise a valuable legal mechanism that endorses the standards developed by the "competent international organization" (IMO). In that vein, GAIRS regulates consistency with International Maritime Organization (IMO) promulgated instruments and elucidates a broad scope for accommodating IMO Recognized Organizations (RO) and their rules and requirements. GAIRS is the optimal pathway for a flexible adaptation of UNCLOS over time.

Overall, as UNCLOS is impossible to regulate every legal issue sufficiently, most of its provisions relating to shipping, navigation and the protection of the marine environment follow the "rule of reference" approach, which is the technique that incorporates existing rules and standards contained in external instruments (Nguyen, 2021). UNCLOS should not be renegotiated on account of autonomous maritime vehicles, cybersecurity, digitalization and RIT; instead, it should receive a functional interpretation in the construction and application of its provisions in line with the goal-based standards approach (Ntovas, 2021).

4.1.2 The role of IMO as an Intergovernmental Organization

IMO, a UN specialized agency and a standard-setting organization conscientiously operates within the UNCLOS framework in the development of regulations. The organization's function reflects the diverging interests of its 175 member states and 3 associate members. Article 1 of the IMO Convention specifies the mandate of IMO, which among other entails:

> To provide machinery for cooperation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting international shipping engaged in international trade; to encourage and facilitate the general adoption of the highest practicable standards in matters of maritime safety, efficiency of navigation and prevention and control of marine pollution from ships; and to deal with administrative and legal matters and effective implementation of IMO's instruments with a view to their universal and uniform application (IMO, Article 1, paragraph 1)

Flag States enforce the standards set in international maritime conventions through incorporation into national legislation, implementation and monitoring. IMO instruments don't apply to vessels operating solely within internal waters, as their framework remains subject to national law, unless State parties elect to apply these conventions to their vessels (Balkin, 2018). It should also be underlined that the rule of reference to the IMO does not guarantee that all the regulations established by the IMO would automatically become binding on UNCLOS States parties (Nguyen, 2021). In the absence of an established set of criteria for "generally accepted rules and standards", IMO Conventions (e.g., MARPOL or SOLAS) that have been adopted through state practice and ratified by the majority of world tonnage fall under the premise of 'generally accepted' (Nguyen, 2021).

Umbrella regulation is an indispensable element of IMO's work as it enables the organization to develop an integrated regulatory framework for safety and environmental protection. IMO has developed more than 50 Conventions under three main pillars: maritime safety, prevention of marine pollution and liability; thus; designing a uniform maritime law framework for international shipping engaged in international trade (IMO, 2023).

The international maritime governance regime is supplemented by a series of 'soft law' instruments, including resolutions, guidelines and Codes of Conduct. Since the nineties, the proliferation of various sectoral "soft law" instruments and, in particular, self-regulation and framework legislation (co-regulation), involve the key stakeholders in the legislative process in a way that is binding in order to achieve technical standardization, professional rules and social dialogue (European Economic and Social Committee, 2021). All the soft instruments in the maritime sector can transcend the limitations other sectors encounter since IMO is the body that ensures their implementation is followed up, updated and verified. IMO guidelines cannot be perceived as substitutes for regulation by the public authorities. Therefore, IMO constitutes a form of co-regulation approach where, in cooperation with national authorities, standardization bodies and industry safeguard harmonization in maritime safety, security, environmental protection and the human element, while delegating the corresponding technical specifications to the standardization bodies such as

IACS. Yet, it should be noted that amidst policy harmonization at the IMO level we notice variations in domestic policymaking approaches and institutional structures.

4.1.3 The role of IACS as a Standard-Setting Organization

Within the maritime policy context, classification societies play an indispensable role in the regulation and safety of the maritime sector. There are approximately 50 classification societies around the world, with 11 of the largest ones having grouped within the International Association of Classification Societies (IACS). The role of classification societies is well noted in international law and especially in the International Convention for Safety of Life at Sea (SOLAS) and in the 1988 Protocol to the International Convention on Load Lines. The scope of a classification society is not only linked to the classification and certification of ships but also to the assistance to the maritime industry and regulatory bodies based on the accumulation of maritime knowledge and technology (IACS document). The standards of classification societies for the construction and survey of vessels comply with the international IMO instruments relating to personal safety and marine environmental protection.

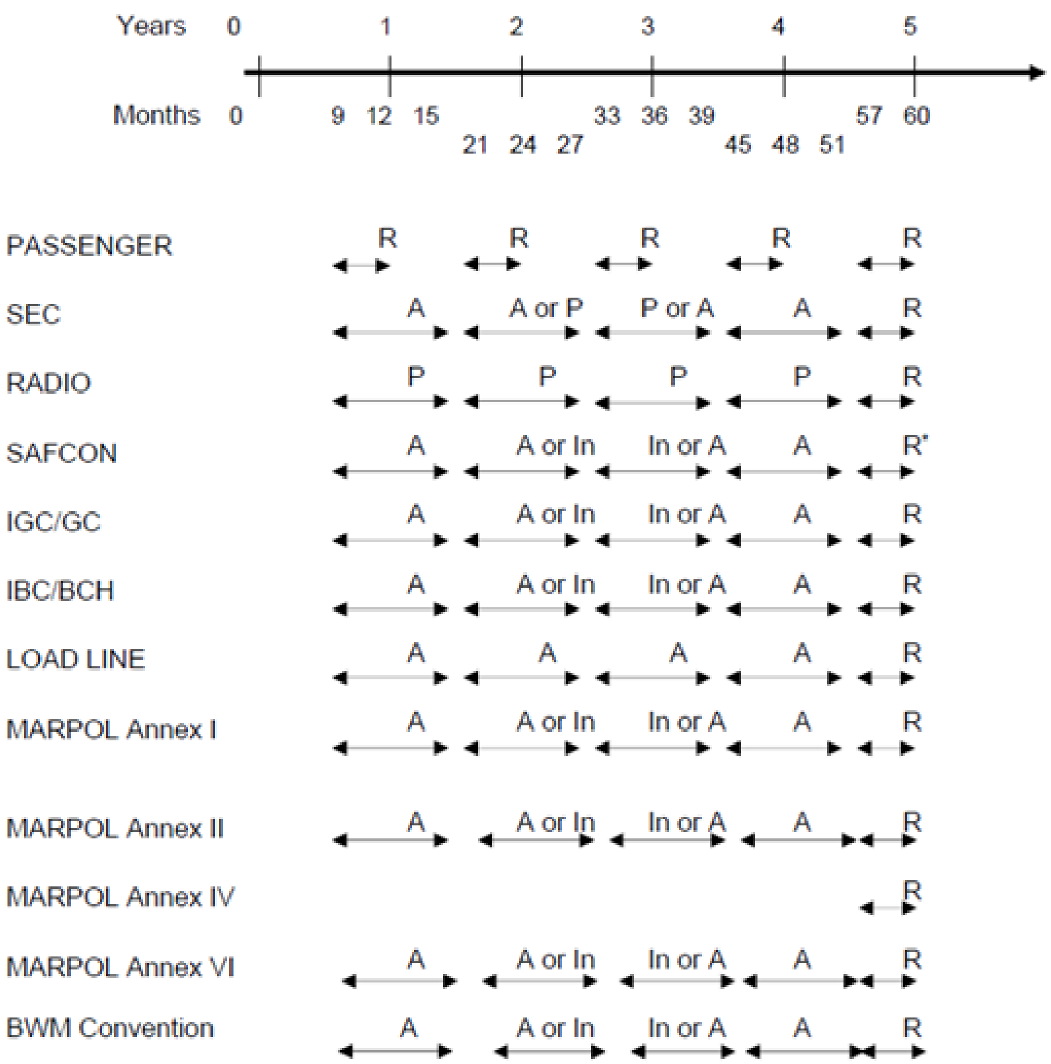
Besides, class societies can act as ''Recognised Organizations'' of Flag States which entrust statutory surveys and inspections of ships entitled to fly their flag, thus centralizing this way the majority of statutory inspections for IMO flag states. The contribution of the classification societies in Port State Control (PSC) regime is also crucial as the flag of registry and classification society are important target factors of inspection by PSC authorities (Cariou and Wolff, 2011; Fulconis and Lissillour, 2021). In parallel, ship owners and operator depend on classification companies for their knowledge of maritime safety.

Classification societies have a unique capacity to master the official framework and institutional vocabulary, which in turn enables them to strengthen their dominance in the shipping market and encourage cooperative behaviors based on relationships of interorganizational interdependence (Fulconis and Lissillour, 2021). The interrelation between the IMO and IACS is tight, as IMO can put pressure on classification societies, particularly after maritime disasters and accidents, to develop technical standards (Fulconis and Lissillour, 2021). IMO, in cooperation with IACS has adopted a harmonized approach to simplify the survey and certification process by introducing the Harmonized System of Survey and Certification (HSSC). HSSC addresses survey procedural matters that have resulted in duplication of efforts by the industry. The Survey Guidelines (2021) under the HSSS consider all the certificates that have to be renewed based on the following instruments:

- SOLAS 1974 as modified by its 1988 protocol;
- LLC 1966 as modified by its 1988 protocol;
- MARPOL 1973 and 1978 as amended by 1990 resolution (MARPOL 73/78/90);
- IBC Code;
- IGC Code; and
- BCH Code

Under the HSSC, the types of statutory surveys in the above international Conventions have been harmonized. Statutory surveys lead to the issuance of a statutory certificate and can be distinguished from class surveys that lead to the endorsement of a class certification. The types of ship surveys found in the IMO Resolution 1156(32) are: an initial survey before a ship is put into service, a periodical survey, a renewal survey, an intermediate survey, an annual survey, an inspection of the outside of the ship's bottom and an additional survey (Figure 15).

Figure 15: Survey Guidelines Under the Harmonized System of Survey and Certification



Source: IMO (Resolution A. 1156(32)

Considering the standard rules related to hull cleaning, inspection and maintenance for Bulk Carriers, the following IACS Unified Requirements (UR) have been developed:

- IACS UR Z3: Periodical Survey of the Outside of the Ship's Bottom and Related Items;
- IACS UR Z7: Hull Classification Surveys;
- IACS UR Z10.2: Hull Surveys of Bulk Carriers; and
- IACS UR Z17: Procedural Requirements for Service Suppliers

To ensure that all classification societies have uniform guidance on the concept of remote surveys, IACS developed the UR Z29 titled "Remote Classification Surveys" which conceptualizes remote survey as a "process of verifying that a ship and its equipment are in compliance with the rules of the Class where the verification is undertaken, or partially undertaken, without attendance on board by a surveyor'' (IACS UR Z29, 2022). A "remote survey" denotes the survey conducted via the use of ICT, such as email and zoom, without the requirement of the surveyor's physical presence. In the process, a remote survey should provide the same level of assurance as a survey with the physical attendance of a surveyor. IACS UR Z29 could set the foundation for the analogous suitable procedures and instructions for RIT under the purview of its regulations.

Classification societies (ABS, Bureau Veritas, CCS, DNV,) have produced various guidance notes for the use of RIT. Despite the various guidelines, there are currently no standardized procedures agreed upon at an international level for the execution of class and/or statutory surveys by remote means; thus, the international maritime RIT governance framework is fragmented and impedes the integration of RIT at the regional and national levels (Johansson et al. 2022).

4.1.4 Non-Governmental Bodies as Consultative Entities

Other industry bodies that play a significant role in forming maritime policy include the International Chamber of Shipping (ICS) and BIMCO. ICS is an international organization, with IMO consultative status, representing ship-owners with the various intergovernmental bodies that regulate shipping. It has underlined the need for the development of a global regulatory framework and, through a series of publications, complements the international maritime regulation, promotes best practices and supports the development of a common framework to regulate autonomous ships globally.

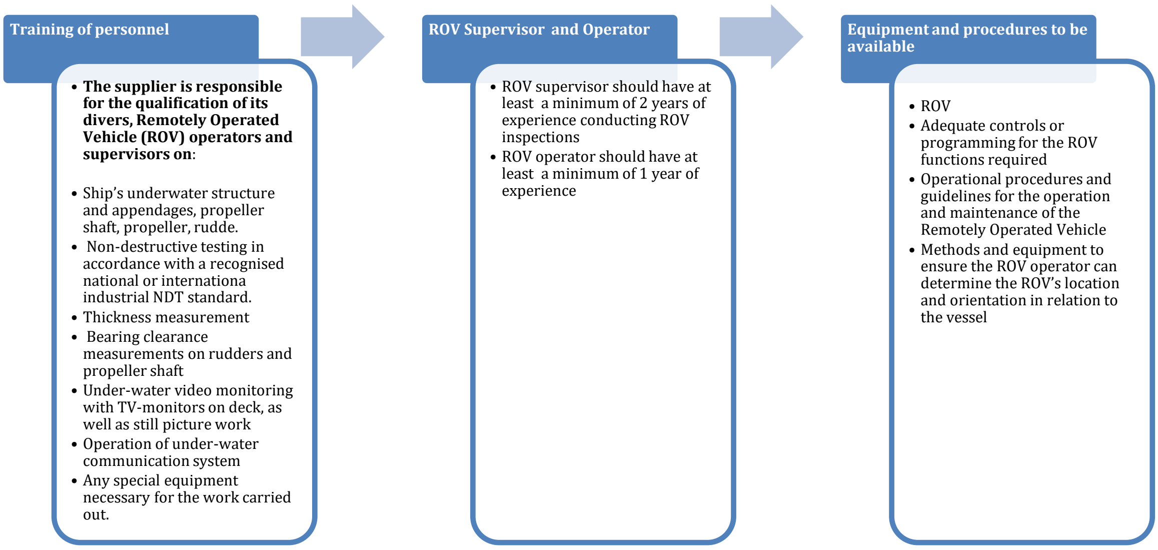
BIMCO is another industry body providing expert knowledge, with its company members covering 60% of the global fleet. The aim of BIMCO is to contribute to the regulatory framework through transparent standards and harmonization. For example, after the COVID-19 pandemic, BIMCO produced a regulatory analysis concerning COVID-19 effects on statutory ship certificates, surveys, inspections and audits. BIMCO supports the development of a uniform framework for remote surveys as the subsequent lack of understanding by the parties involved- including surveyors, ship-owners and shipboard crew- may cause a negative impact on the quality of ship inspections. A full list of non-Governmental international Organizations which have been granted consultative status with IMO are presented in Annex 1.

4.1.5 Operational Level Actors

At the operational level, manufacturers/software developers, service providers, asset owners and insurance companies, are directly or indirectly involved in the application of the policies implemented at the governance level (Johansson et al. 2021, Pastra and Johansson 2022). Service suppliers provide services, such as measurements, close-up inspections, and maintenance of safety systems and equipment. Their services will be utilized by surveyors in making decisions affecting statutory certification. The minimum requirements for the approval and certification of service suppliers is specified in IACS Unified Requirements Z17. According to the Unified Requirements, each society is responsible for verifying that the supplier's service operation system fulfils the criteria based on predetermined standards. The personnel should be qualified and trained based on recognized national, international and industry standards. Figure 16 includes the minimum requirements of the suppliers carrying out an in-water survey on ships by ROV. The requirements are based on training, experience, equipment and procedural provisions specified in the IACS UZ17 Section 3.

Manufacturers should design and produce their products based on industry standards, regulators and industry organizations such as the International Civil Aviation Organization (ICAO) and the European Union. Design specifications, production standards and rigorous quality control shall safeguard the safety of consumers. Manufacturers shall also ensure that appropriate instruction manuals are available to the suppliers along with proper training of the supplier's technicians.

Figure 16: Minimum Requirements for Firms Carrying Out an In-water urvey by ROV



Source: IACS, UR Z17, 2023

Ship-owners are the end users of these technologies who may request from service suppliers, in consultation with the class, to provide RIT services for measurements, tests or maintenance of safety systems and equipment. The use of the RITs should be incorporated into the Survey Planning Document prepared by the owner to support the survey pre-planning requirements.

Regarding the insurance companies, they could play an important role in mapping and understanding risks associated with RIT and allocating liability for the damage between and among the designers, manufacturers, software developers, service suppliers, class societies and owners. Currently, manufacturers are liable for damages caused by defective RIT based on the context of Directive 85/374/EEC. Nonetheless, the need for the development of RIT Code of Conduct is vital in order to ensure a harmonized liability management system that is precautionary in essence (Alexandropoulou et al, 2022). Albeit how provisions on liability take shape in the long run, service suppliers should secure third-party, public liability insurance for third-party property damage or injury whilst using RIT (Pastra et al. 2023).

4.1.6 Synopsis of the Maritime Governance Actors

Overall, based on the elements mentioned above, Figure 17 demonstrates the ecosystem of actors for mass deployment of RIT. This ecosystem includes IMO, IACS, NGOs, service suppliers, ship-owners/operators, manufacturers/software developers and insurance companies.

Figure 17: Ecosystem of Actors and Tools for Mass Deployment of RIT

Source: Authors' original contribution

All the actors should cooperate on the following elements identified by Johansson et al. (2022) and Pastra et al. (2023) and presented in Figure 18:

1. Review of the existing instruments to incorporate RIT in SOLAS and Enhanced Survey Programme (ESP);

2. The development of unified definitions for each and every type of techniques that maneuver in different environments. The definitions include: Unmanned Aerial Vehicle (UAVs), Remotely Operated Underwater Vehicle (ROV), Robotic Crawler, validation, verification, Remote Inspection Techniques, close-up survey;

3. The distinction between the different levels of degree of autonomy for these technologies: a) RIT-survey conducted in the presence of the attending surveyor, b) inspection with the possible intervention of the surveyor, c) survey without attending surveyor and d) artificial intelligence-based machine learning operating system;

4. The development of a data governance framework to establish provisions and processes for data ownership, quality, liability, sharing and security;

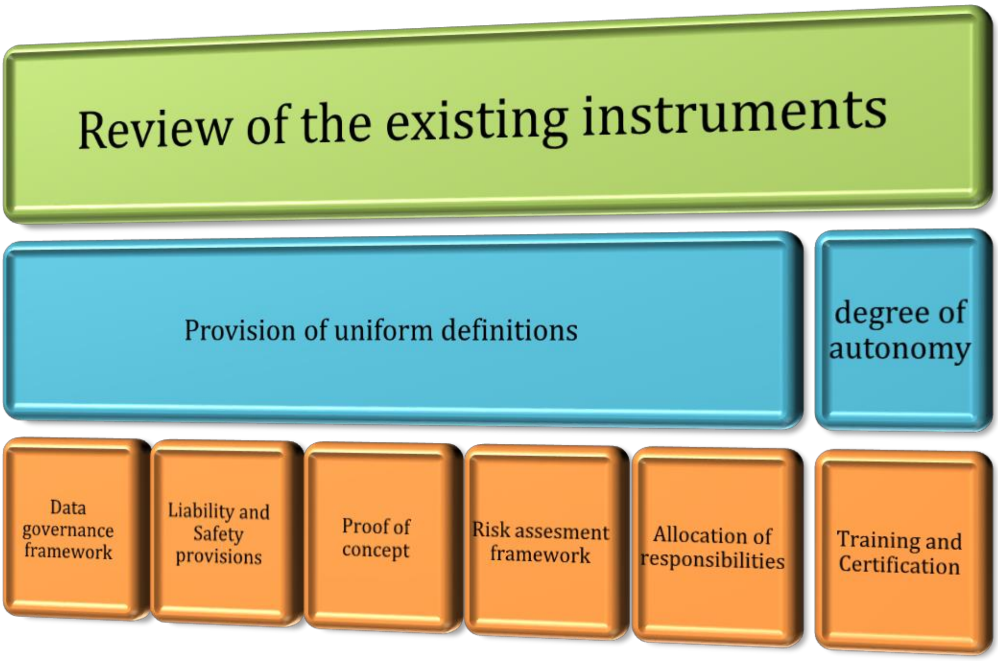
5. Review of the existing liability framework to ensure the safety of end-users;

6. Live experiments in a controlled environment to confirm the "proof of concept" of functionalities of remote surveys;

7. A strategic risk assessment process to confirm the eligibility of each remote survey; and

8. Allocation of responsibilities of each party (ship-owner, class society, surveyor, operator) during the different stages of the remote inspection process (planning, operation, reporting) (Johansson et al. (2022) and Pastra et al. (2023).

Figure 18: Main Elements for a Harmonized Framework for RIT



Source: Johansson et al. (2022) and Pastra et al. (2023)

4.2 Synopsis from the Maritime Governance Framework and its Application to RIT

From the aforementioned, we deduce that the international maritime framework is anchored in two interdependent bodies consisting of an umbrella framework (UNCLOS) and a regulatory regime which consists almost exclusively of instruments adopted by the IMO (Mukherjee and Bal, 2011; Johansson 2022) This framework is complemented and supported by an array of relevant instruments and measures at the regional and local levels. For RITs UNCLOS serves as the legal framework imposing obligations that are general in scope, but providing at the same time the basis for flag state obligations. IMO should set the international rules and standards for all the states involved which will reach the status of being "generally accepted" and ensure the relevance of UNCLOS in the face of new technological developments. Despite the centuries old intensive rivalry among maritime nations, governments have realized that global ocean governance can be regulated effectively only through cooperation at an international level (Balkin, 2018). Consequently, uniform global standards are needed to reduce sub-standard shipping and 'flag-shopping', that is, the practice of changing the place of registration of a vessel in order to avoid the application of IMO regulations (Balkin 2018).

The success of the maritime regime of self-regulation and co-regulation is linked to its compliance with a robust framework of international treaties and legislation. Multi-level governance in the sector focuses on the multifaceted interactions that take place among governments and non-state actors involved in policymaking at local, national, and supranational levels (McManus and Eijmberts, 2017: 275). The dynamic multi-level governance of the shipping sector is based on a post national network configuration with nodes that serve as momentum for organizing discourse dialogue, and cooperation (Klinke, 2016). Through this type of governance, peoples across various maritime nations and civil society actors cooperate horizontally to navigate the transformation in addressing environmental, safety and technological maritime issues. Dynamic multi-level regulatory governance requires attention to three key interrelated elements in order to address policy challenges and implement regulatory programs in a dynamic context:

1. The actors, those who should be involved in program implementation;
2. The legal mechanisms available to promote transformational change in regulatory design; and
3. The tools available to all the stakeholders that will advance desired results (e.g., monitoring regimes) (Markell and Glicksman, 2016).

The way that actors, tools and mechanisms should interact are evident in the Figure 3 above. Therefore, for RIT we don't need a new legislative framework; instead, we should update the existing umbrella framework provided by IMO, in line with UNCLOS provisions and in consultation with industry bodies such as IACS. Overall, in the RIT context, multi-level governance is essential in as much as combining the elements of umbrella regulation and self-regulation within a system that operates at multiple levels of authority beyond the traditional state-centric model.

4.3 The Way Forward for a Regulatory Process for Robot Governance in Other Sectors

For the deployment of robotic technologies and inspection systems in other sectors, the best solution is based on a governance framework similar to the maritime sector. The framework should provide a cross-border, flexible and adaptive approach to regulation that paves the way for international coordination and involvement of multiple stakeholders. This approach should consider the unique challenges and opportunities posed by each technology and sector and encompass a collaborative effort between the industry, government, and civil society. Within this context, the techno-regulatory instruments should be updated at regular intervals and communication channels should be formed with industry and/or public oversight groups, with a view to sharing best practices (Pastra et al., 2022).

Modern societies are having to cope with profound technological transformations and national authorities and mechanisms alone do not have the capacity to achieve eligible political outcomes that can guide and structure transformations (Klinke, 2016). Therefore, dynamic multi-level governance that goes beyond nationalism may be the solution to the policy problems. Effective self-regulatory mechanisms that can quickly respond to changing technologies and consumer needs for transparency are more crucial than ever. Well-designed and enforced self-regulatory codes of practice complementing a sensible legislative framework can deliver better and faster results than drafting new legislation. The industry should deliver and strengthen its self-regulatory frameworks to ensure transparency, accountability and value for consumers.

An important element for meeting the “AI challenge’’ is to consider the degree of autonomy of these robots and the extent to which they can perform tasks with full or semi-full autonomy. The framework for machines that are capable of decision-making and execution of tasks should be different from the one governing those machines which that entail human control, engagement and intervention. The distinction between the terms of autonomous and automated systems should be precisely made when designing policy strategies as they differ in the level of learning, adaptation to the environment and decision making. Automated systems are designed to perform repeated tasks efficiently, whereas autonomous systems evolve continuously and adapt to the new environmental conditions.

The operationalization of the level of human control remains crucial in this context. Two formulations of the notion of human control presented by Firlej and Taeihagh (2021) based on the Directive of US Department of Defense (DoD) in the policy on Autonomous Weapons (Directive 3000.09; DoD 2012):

- Direct Control: Human control as a “finger on the button,” which means that: “The system is designed to complete engagements in a timeframe consistent with commander and operator intentions and, if unable to do so, to terminate engagements or seek additional human operator input before continuing the engagement.” (DoD 1.a (2));
- Indirect control: Human control-by-design implies that “the system design incorporates the necessary capabilities to allow commanders and operators to exercise appropriate levels of human judgment in the use of force.” (DoD (n 9) 4.a.)

Therefore, direct control includes two categories: i) the human-in-the-loop control which is about the continuous human physical control over the system and ii) human-on-the-loop control which is characterized by the ability of a human to intervene in emergency cases (Firlej and Taeihagh, 2021). The two subcategories of indirect control or control-by-design include iii) systems that allow human operators to exercise appropriate levels of human judgment when using the system and iv) systems that are fully autonomous and their use is dependent on ethical guidelines. For the indirect control types, trust should be cultivated through rigorous hardware and software system developmental training, legal review and technical evaluation processes (Firlej and Taeihagh, 2021). The typology of the different control levels is presented in Table 19.

Figure 19: Typology of human control over Automated Systems

	Type of control	Operational Role	Intervention role	Key requirements
DIRECT HUMAN CONTROL Human control as "Finger on the Button"	Human in the loop (needs human command)	Human	Human	• the active presence of a qualified human operator, • system's responsiveness to complete tasks in a timeframe consistent with operator intentions
	Human on the loop (in case something goes wrong)	System	Human	• the presence of a human operator; • a manual override feature that allows an operator to assume control of the system at any time • operator's relevant credentials
	Remote control	System/ Human	Human	• Requirement to link systems with a qualified human operator; • two-way communication links; • monitoring information
INDIRECT HUMAN CONTROL Human control by design	Design control as default	System	System or human	• Software verification and validation (V&V) and tactics, techniques, and procedures (TTPs) are being established. • compliance with relevant laws • malfunction notification technology; • wireless communications and system location technology; • data-recording system; • operator's relevant credential
	Control by "ethical code"	System	System	• Same requirements as per design control as default; • additional requirement in the form of ethical guidelines for IT developers

Source: Firlej and Taeihagh (2021)

Besides, in developed AI generated robots, the protection of personal data should be safeguarded. The European General Data Protection Regulation should be updated as it includes outdated terminology about autonomy and artificial intelligence AI (van Genderen, 2018).

Multi-level and smart regulation should take the form of regulatory sandboxes that aim to provide a space for responsible AI-related innovation in which regulatory decisions are not treated as 'final events' (Fenwick et. al, 2018). Openness in the law-making process should provide for a de-regulated space which will enable the testing of innovative products/services for a specific timeframe. The process should overcome regulatory barriers and include subject matter experts' opinions and measures to ensure the safety of the public. The data that will be gained from this process can be utilized as input for the forthcoming legislation.

Another crucial element to be considered when regulating robots and artificial intelligence in robotized societies is the examination of a certain legal personhood of robots. This framework will incorporate provisions about civil liability and even criminal liability leading to the recognition of certain rights and obligations under the law. This framework will entail ethical values and fundamental rights to give a certain legal status to robots (van Genderen, 2018).

Disruptive technologies also impact the existing safety and liability framework, so traditional instruments may be insufficient in giving rise to legal liability for damage caused by a robot. The law-making process for AI and innovation should consider the current legal framework on safety and liability to ensure that it is still fit to protect users. Product safety legislations in the EU have suffered from fragmentation and incoherence as it is difficult to legislate consumer goods and services with this unprecedented pace of sectoral changes and technological progress (Ruohonen, 2022). The existing "Union product safety legislation or framework includes:

- Regulation (EC) No 765/2008 on the requirements for accreditation relating to the marketing of products;
- Decision No 768/2008/EC — a common framework for the marketing of products in the EU;
- Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment;
- Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery which aims at the free market circulation on machinery and the protection of users;
- Consumer Safety Network as established in Directive 2001/95/EC on general product safety (GPSD);
- Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for effective products.

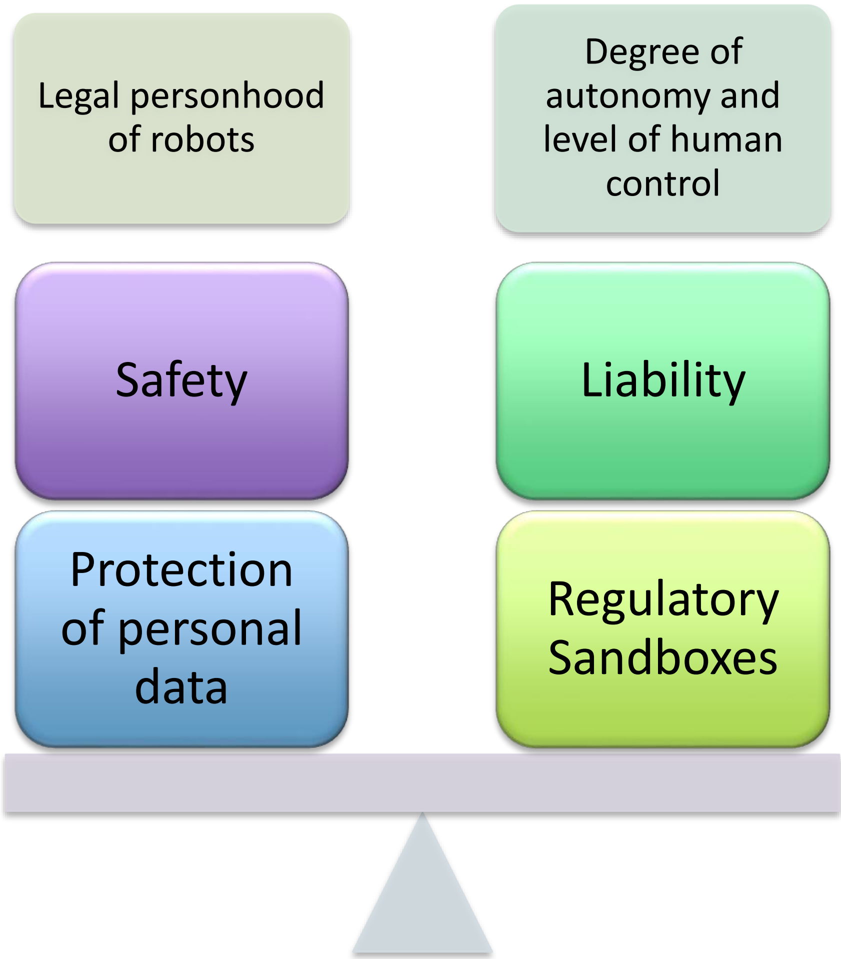
The Report on the safety and liability implications of Artificial Intelligence, the Internet of Things and robotics of the European Commission (2020) presented the gaps in the current product safety and liability legislation and the steps that have to be considered for the update of the existing technology-neutral framework. The new framework should include explicit provisions for a) human oversight throughout the lifecycle of the AI products b) producers of AI humanoid robots c) cooperation between the economic operators in the supply chain d) manufacturers/software developers and e) compensation for damage caused by products that are defective due to software (Figure 20).

Figure 20: Provisions to be included in the revision of safety and liability framework

Source: European Parliament (2020)

Overall, all the elements that ought to be considered for the development of a regulatory blueprint for robots include the legal personhood of robots, degree of autonomy, safety & liability, protection of personal data and regulatory sandboxes (Figure 21).

Figure 21: Main Elements for the Development of a Regulatory Blueprint for Robots



Source: Authors' original contribution

4.4 Applying BUGWRIGHT2 Model in Aquaculture

[*N.B.* Subject to minor modifications, the content contained in this section has been published in the form of an article in The Journal of Ocean Technology, Vol. 18, No. 2, 2023]

Historically, 'fishery' and associated activities are moored to the notion of 'food security'. Evidently, continuing in this anthropocenic epoch, fishery remains an acknowledged source of nutrition and is supporting the livelihood of more than three billion people globally. The estimates provided by the United Nations Food and Agriculture Organization (FAO) adds credence to the above claim. Numbers crunched by FAO researchers note that fisheries and aquaculture production have already reached a record-peak of 214 million tonnes in the year 2020 with a total of 20.2 kilogram per capita designated for human consumption. Unfortunately, fishery resources are plummeting. Recognizing the invaluable potentials of aquaculture to the staggeringly increasing population of the world, invested efforts seek to achieve sustainability in the fisheries domain.

At the outset, we note that 'innovation' and 'sustainable fisheries' are conjoined concepts. A cascade of technological breakthroughs under the auspices of the fourth industrial revolution (also termed as Industry 4.0) has catalyzed a paradigm shift in maritime and ocean *modus operandi*. Innovation bolsters support in sustainable movements and approaches --- a concept that applies to natural resources.

Labeled as robotics and autonomous systems (RAS), a conflux of disruptive technologies, such as micro aerial vehicles, crawlers and remotely operated vehicles (ROVs), has added meaning to the abstract concept of sustainability. Central in this innovation-led environment is the intention to sustain the ability of the human element. In other words, integrating RAS and machine learning systems helps complete monitoring and inspection tasks that are otherwise dull, risky, and at times strenuous in nature.

Observably, a plethora of challenges are associated with manual inspection, especially when it comes to underwater monitoring that entails inspecting water salinity, temperature, and/or 'potential of hydrogen' (pH)-level, as well as oversight in feeding and breeding tasks. Moreover, real time observation is required to contain corollary effects from untreated effluent discharges with heavy organic load, and fish farming infrastructure development. Patently, qualitative assessments indicate that net/fish cages are prone to biofouling and other sources of stress caused by waterbody movements that could potentially lead to net/fish cage deformation. These are instances where RAS-integration could act as an improved and perhaps safer method of completing the necessary monitoring and inspection tasks. The industry, as it appears, is slowly turning to service suppliers that are unleashing intervention tools replacing divers with the simultaneous objective of saving time and money, and mitigating environmental concerns.

It is correct to assume that the world of technology is standard-reliant. The technology-industry, similar to its counterparts, is assessed based on performance built on safety and risk management systems, *inter alia*. Today, safety and management systems are being integrated into standards. Systems and standards are collectively intertwined into a horizontal topic that necessitates the interaction between public and non-public norms [9]. Private and industry-developed standards, as well as corresponding norms and guidelines serve as external sources of the wider regulatory regime. Adherence and compliance are critical to the economic value of those industries, while safeguarding 'public' interests. The latter is deemed as one of the principal mandates of governmental bodies that encourage regulators to orchestrate the use of industrial standards. This is done with a view to striking a balance between "hard" and "soft" elements embedded in the subject-specific regulatory regime. Taking advantage of industry-based standards can help national regulators maintain a robust regulatory regime, and navigate in a complex landscape shared with other stakeholders to keep pace in a changing technological environment.

Markedly, there is no international regulatory guidance that underscores the dos from the don'ts with reference to aquaculture-related underwater inspection and monitoring tasks. Notably, the 2018 FAO publication titled *Guidance on Spatial Technologies for Disaster Risk Management in Aquaculture* only proffers insights into opportunities from spatial technologies including remote sensing, geographical information system, and information and communication technologies while highlighting the need for policy support. Inspection and monitoring technologies remain outside the scope of the 2018 publication.

Deficits are conspicuous when deploying remote inspection techniques. Other than issues emanating from latent defects --- usage of emerging technologies or technologies with emerging applications may sporadically give rise to collateral problems that require more than just rebooting the system to eradicate technical errors. In fact, here, one is faced with challenges for reconciling the tensions between "human" and "robots" simply because the techno-regulatory landscape is not fully autonomous despite "autonomy" being a term that is in common parlance. We notice a system that is marked by "human-in-the-loop" or "human-on-the-loop".

In the context of human-robot interaction, BUGWRIGHT2: Autonomous Robotic Inspection and Maintenance on Ship Hulls and Storage Tanks (funded by the European Union's Horizon 2020 research and innovation program under grant agreement No. 871260) is a project that deals with remote technologies applied in vessel hull inspection and maintenance that are statutory and classification in scope. Notably, project BUGWRIGHT2 has proceeded with the objective to bridge the gaps between current and desired potentials of selected remote technologies that are also deployed in aquaculture inspection and monitoring.

Three years into the project's life-cycle, academic partner World Maritime University has produced a state-of-the-art regulatory blueprint comprised of several strands-of-influence. Founded on state-of-the-art qualitative analysis and thirty-three interviews with organization representatives from the United States, Canada, China, Singapore, Netherlands and Norway --- the final outcome could serve as a tangible reference once dialogue and discussions commence at the International Maritime Organization (IMO)-level pursuant to previous requests tabled by member states (MS) for amendments to the Harmonized System of Survey and Certification and to the Revised Guidelines on the implementation of selected IMO instruments.

It is important to note that, BUGWRIGHT2 regulatory blueprint mirrors the need for "harmonization" of international rules and requirements that come into play taking into account the 1982 United Nations Convention on the Law of the Sea's rule-of-reference through which MS could implement generally accepted international rules and standards (GAIRS). Cutting a long way short, "harmonization" requires the existence of several parallel stand-alone rules and requirements developed by individual international organizations. Unfortunately, the aquaculture domain, apparently, lacks common minimum standards developed by a specific mandated organization unlike the vessel survey and inspection regime where classification societies are seen as playing a proactive role. A brief overview of standards developed by the International Organization for Standardization (ISO), it appears that ISO/TC 34, ISO/TC 94 and ISO/TC 207 do not necessarily provide insights into procedures for technology integration.

What are the noteworthy takeaways from BUGWRIGHT2 that could be applied to aquaculture-technology? The starting point could be that the existing vacuum of procedural requirements should be viewed with a positive outlook since stakeholders have the opportunity to reap the benefits of lessons learned from trial and errors from other sectors; move forward in unison from the get-go which would inevitably preclude the need for complex bureaucratic harmonization process (due to efforts being duplicated) in the long run; and establish a top-down platform comprised of organizations/actors that could collectively reform/amend standards at any given stages. Opportunities are many. That being said, top-down efforts need to concentrate on determining the breadth and scope of specific provisions that could altogether serve as the main frame of reference.

When dissecting two primary regulatory standards, case-in-point the 1996 *Guidelines for Use of Remote Inspection Techniques for Surveys* and Unified Requirement Z17 titled *Procedural Requirements for Service Suppliers*, developed by the International Association of Classification Societies, we note elements for a common-minimum-standard-blueprint. The above documents prescribe: the types of permissible technologies and areas of application (under the heading titled *general*); specific conditions for technology deployment (under the heading titled *condition*); procedures concerning niche applications (under the heading titled *procedures*); and procedures related to the work of the human element/service suppliers and the service firm that is approved by the main company (under the heading titled *procedural requirements for service suppliers*).

Subsequently, we turn to the BUGWRIGHT2 strands-of-influence to take stock of the dispensable elements that require consideration for transition from manual to technology-based solutions --- that would ameliorate and expedite technology-integration into aquaculture inspection and monitoring activities. Axiomatically, the first of these strands call for research into cost-benefit assessments to observe whether the advantages of technology deployment outweigh the disadvantages, taking into account, e.g., duration of inspection, costs of deploying technology and operational downtime. Such assessment could help companies determine the economic-feasibility of turning to *remote inspection techniques*, and rationalized through evidence-based research.

The second strand considers the need for vetted, refined and up-to-date definitions on each and every type of remote techniques. In tandem, there needs to be in place definitions of important terms, such as, *autonomy*, *robot*, *service robot*, and *mobile robot*. Template definitions exist. Examples are ripe in documents such as ISO 8373:2021, ISO 19649: 2017, ISO/IEC 17000 (2020), *Guidance Notes on the Use of Remote Inspection* developed by the American Bureau of Shipping; and *Guidelines for Use of Unmanned Aerial Vehicles* developed by China Classification Society. Whether template definitions are adapted or whether a completely new set of definitions are developed --- it is important to benchmark the term *autonomy* through a clear and distinct overarching definition. Closely connected to this aspect is a strand that calls for the need to follow the “degree of autonomy” thread that currently guides the state of affairs for maritime autonomous surface ships (MASS).

Table 7: Potential RIT Degree of Autonomy

Degree	MASS Definition	Potential Aquaculture RIT Definition
First Degree	Ship with automated processes and decision support with seafarers on board to operate and control the systems. Systems are partially automated, unsupervised with seafarers on board ready to assume control.	Underwater survey with divers operating remote inspection techniques that are semi-autonomous and semi-supervised, and could at any point witness intervention from surveyor/diver.
Second Degree	Remotely controlled ship with seafarers on board.	Underwater survey with divers. Survey controlled from a different location. Survey could at any point witness intervention from attending surveyor/diver.
Third Degree	Remotely controlled ships without seafarers on board.	Underwater survey without divers. Survey fully controlled from a different location.
Fourth Degree	Fully autonomous ship.	Remote inspection techniques with automated processes and Artificial Intelligence-based machine learning operating systems to support decision-making. No intervention required from the human-element.

Source: Adapted from IMO Doc. MSC 100/20/Add. 1, Annex 2

Identifying levels of autonomy and associating them with different classes of techniques could help keep track of the *autonomy-paradigm trajectory*. Again, the current system is not fully autonomous, i.e., systems that enable machines to interact with the environment (through built-in sensors) and respond/take decisions accordingly, and requires categorization so as to help review the extent of involvement of the human-element. This, in turn, has an explicit nexus to what is known as a well-calibrated “trustworthy ecosystem” that requires a form of constructive balance between the “human agency” and “autonomous modes”. Until the human stays “in-the-loop” or “on-the-loop”, carving out the degrees of autonomy is a vital stepping-stone to ascertaining, projecting and designing effective and efficient human-robot team for the conduct of survey and inspection.

The next strand that would apply to the aquaculture profile is the need to carve out *operational* and *technical* common minimum standards. Generally speaking, *operational* standards emanate from tests and risk-assessments that help narrow down all potential risks associated with the deployment of each and individual categories of technologies. Risk-information are relayed (by manufacturers) via *product information* notes for consideration by end-users or service suppliers. Different remote inspection techniques are marked by operational and technical differences. It is worth noting that surveys using aerial drones, unlike crawler and ROVs, can easily be compromised due to humidity, lighting, and air turbulence. Furthermore, hybrid techniques that have the potential to conduct underwater biofouling cleaning, in addition to survey operations, require limiting all possible risks prior to deployment.

Risks on air or underwater tend to range from dropped object risks to collision risks (with other remote inspection technologies) to lost link risks (that originate from network compromise), which could be an issue once technologies reach the *fourth degree*, i.e., full autonomy. “Stealth technology” is a term often ascribed to autonomous underwater vehicles (AUV) and the likes, and therefore, completion of tasks without disturbing underwater ecosystem is highly anticipated. Contingency plans, will nevertheless, need to be developed taking into account *operational* standards so that solutions could be forged before the occurrence of environmental damages.

Another important strand-of-influence corresponds to a feature innate to technological devices applied in observational work, and is aptly known as “data management”. Generally speaking, data acquisition lies at the heart of all technological interventions. Stakeholders involved in this process generally include non-human actors, e.g., technological tools and infrastructure, and human actors, i.e., service providers and companies (end-users). The latter is coined as “human-in-the-loop” with supervisors, operators and surveyors remaining engaged during data storage and verification of data collected through remote inspection technique-based inspections and surveys. In essence, the technological platform communicates data to “human-in-the-loop” via five independent layers: hardware, network, internet, infrastructure and application. The last layer, i.e., application mirrors implementation of decision.

Although the BUGWRIGHT2 regulatory-model considers survey and inspection data as belonging to the asset, i.e., the ship, thus forming a part of the owner’s proprietary rights --- this very theory on “ownership” might not apply verbatim in the field of aquaculture. Notwithstanding, the following questions may still be subject to further consideration from an aquaculture perspective:

- Who should retain the copyright of data gathered from underwater remote technologies?
- What are the secured ways through which data could be shared between end-users and stakeholders?
- To what extent to provisions on data control and security apply in the field of aquaculture survey and inspection?
- What is the duration of data-preservation, and should there be any mechanisms to safeguard service providers against third-party liability?

The final strand is tied to a critical aspect: in-water environmental consideration. Depending on the location of aquaculture method and practice (freshwater, brackish water, and marine), risk-assessments will need to be conducted at regular intervals to check for impacts and water conditions, more specifically should hybrid remote techniques be used to clean pen nets and cages. This begs the question whether those techniques are properly equipped with storage systems for storing debris collected during clean-up operations. In this regard, The Baltic and International Maritime Council (BIMCO)-developed standards for in-water cleaning could serve as a foundation for furthering control over impact of technology in-water. Although developed for in-water cleaning of vessel's hull and other niche areas, the ROV-cleaning standards encapsulated in the section titled "operating requirements of the cleaning system" contains an important checklist comprised of post-cleaning inspections (s. 9.3), post-cleaning safety and environmental requirements (s. 9.4), service reports after cleaning (s. 9.5) that serve as model provisions for consideration by the industry. The checklist may very well be pertinent to remote inspection technique-based operations underwater.

At this juncture, it is essential to ask one final question: why are the strands-of-influence discussed relevant? Technology is a terraforming practice; one that could possibly shape and structure the environment. Yet technology, in parallel, is merely a 'product'. Products can be defective. Defective products could give rise to unforeseen circumstances. Those are the circumstances that might inhibit end-users from untethering the full potentials of Industry 4.0 byproducts that are able to add strength in projects that purport to support sustainable actions. Standards embedded in previous discussions are strands that could positively influence technology deployment in maritime projects. Strands such as liability and in-water environmental damage will certainly have a bearing on the technologies that will be deployed in aquaculture so that companies may derive good results from automated farming practices.

Fragmentation must be avoided should there be any intention to transfer technology to other parts of the world, namely developing and least developed countries where aquaculture production is relatively higher than other parts of the world. Despite current practices, self-regulation does not always help set robust standards that determine the strengths and limits of a certain technology. By the same token self-regulation may not be a viable approach as different industries utilizing the same type of technology for different purposes contribute to the development of disparate standards. If the *status quo* is not rectified beforehand, collateral dormant problems will be transferred with the technology. Whatever pathways are explored, it is important to establish standard methodologies for technological platform to buttress adherence and compliance.

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5. Analysis of Strand 4: Recommendations for Reform and Enhancement of Regulatory Blueprint

Acronyms

ABS	American Bureau of Shipping
AI	Artificial Intelligence
AUVs	Autonomous Unmanned Vehicles
BIMCO	Baltic and International Maritime Council
CCS	China Classification Society
ESP	Enhanced Survey Programme
IACS	International Association of Classification Societies
ICT	Information and Communication Technology
IMO	International Maritime Organization
ISO	International Organization for Standardization
MS	Member States
MSC	Maritime Safety Committee
NDT	Non-destructive Testing
RAS	Robotic and Autonomous Systems
RO	Recognized Organization
ROVs	Remotely Operated Vehicles
UNCLOS	United Nations Convention on the Law of the Sea

5.1 Reform and Enhancement of Regulatory Blueprint

[*N.B.* This part of the report derives from Report Deliverable 1.4, updated in consultation with:

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4. Ms. Marina Papaiouanou; Training Manager, Det norske Veritas;
5. Captain Yoss LeClerc; President & CEO at Logistro Consulting International Inc.; President, International Harbour Masters Association;
6. Mr. Andrew Baskin; Vice President, Global Policy and Trade, General Counsel, HudsonAnalytix, Inc.;
7. Mr. Sean Pribyl; Senior Counsel, Holland & Knight LL, Washington, US;

8. Mr. David Knukkel; CEO at GDI and RIMS BV, Global Drone Inspection (GDI) of Robotics in Maintenance Strategies (RIMS), the Netherlands;
9. Mr. George Giazlas; Operations Manager DIVING STATUS Underwater Services;
10. Mr. Thomas Aschert; Senior Principal Surveyor, Lloyd's Register, Netherlands; and
11. Mr. Tasos Kartsimadakis; Vetting Manager Secondee, Intertanko, Greece.]

From autonomous automotive technologies to autonomous vessels --- the scale of Robotic and Autonomous Systems (RAS)-influence in both land-based and maritime-based transportation is staggering. The genesis of RAS emerged after a cascade of Artificial Intelligence (AI) technological breakthroughs (Johansson, 2022). In retrospect, the velocity, breadth and depth, and systems' impact of what is in fact a fourth industrial revolution has led to a conflux of innovative advancements shaping the modern technological environment (Schwab, 2016). Commonly referred to as disruptive technology, remote inspection techniques (RIT), an offshoot of RAS, is best described as "… a means of survey that enables examination of any part of the structure without the need for direct physical access of the surveyor" (IACS, n.d.1). But the absence of a human surveyor on-site does not preclude the need for oversight. This operational environment is known as the "supervised autonomy" paradigm.

Central to this modern maritime technological environment is intentionality (Sörlin & Wormbs, 2018). In this context, it is significant to point out that the underlying intention of contemporary innovations, such as bridging the gap between current and potential capacities of RAS-led vessel inspections, is among other things, a part of classification surveys, as well as statutory survey criteria. Satisfying the regulatory goals and objectives with minimum effort while maintaining the highest safety standards is a unique aspect of the modern maritime technological environment. RAS-regulation is, in fact, the conduit through which that balance can be achieved. A product of technology, RAS-regulation resides on the same continuum as techno-regulation. In this respect, it makes sense to term both as regulatory paradigms. The principal difference between them is that while techno-regulation is a theory that seeks to support Lessig's "code is law" (the fact that RAS deployment effectuates legal norms), RAS-regulation in contrast, is merely the promulgation of legal safeguards through the development of regulatory frameworks governing RIT (Leenes, 2011 p. 143; Brownsword, 2008, p. 247; Lessig, 2006, p. 124; Bayamlıoğlu & Leenes, 2018).

Common types of industry deployed RIT include unmanned aerial vehicles (UAV), remotely operated vehicles (ROV), and climbers or crawlers. The above comprise a multi-robot survey team programmed to follow a pre-determined algorithmic pathway for visual and acoustic inspection of a vessel structure to detect corrosion patches, buckling, cracking and deteriorated coatings. Structure-associated issues are a direct corollary of the marine environment. Biofouling or hull fouling increases the weight (of the vessel), reduces (vessel) speed, negatively impacts vessel performance as well as poses substantial operational and maintenance costs ship owners such as for dry-docking and additional remedial repair and maintenance. Research findings indicate that fuel costs increase by 10 percent for ships with lightly fouled hulls, and may increase up to 35 percent when hulls are heavily fouled (Munk, Kane and Yebra, 2009, p. 148). This occurs as a result of coating deterioration, which leaves hulls susceptible to biofouling, which can also affect the roughness of a vessel's hull, which in turn, escalates frictional resistance leading to more fuel consumption and increased emissions (Demirel et al., 2017, p. 819). These relevant findings and more were revealed during the United Nations Climate Change Conference (COP26) in 2021 (International Maritime Organization, 2021).

There are other instances where RIT can provide for better and perhaps safer modes of conducting surveys and inspections. For example, after being integrated, RIT can provide relief from tasks that are otherwise time consuming, strenuous and in some instances, fatal (due to lack of oxygen or polluted vapours in confined spaces of tanks and holds) (Poggi et al., 2020, p. 881-882).

In addition to technological advancements, global emergencies have also sporadically spurred a promulgation of new rules or amendments to existing ones. This dynamic has been exemplified by the Covid-19 pandemic, highlighting the need for establishing a methodological framework for remote surveys as human presence on board vessels was dramatically restricted. A variety of online publications grapple with the particulars of this emerging requirement (IIMS, 2020; Det Norske Veritas, 2020; Prevljak, 2020; Jallal, 2020; Safety4Sea; 2021; Hellenic Shipping News, 2021; Lloyd's Register, 2022; Bureau Veritas, 2022). But observations from key stakeholders' sheds light on the absence of harmonized efforts on the part of individual classification societies, ship owners and flag state administrations to regulate remote surveys (IIMS, 2020; Det Norske Veritas, 2020; Prevljak, 2020; Jallal, 2020; Safety4Sea; 2021; Hellenic Shipping News, 2021; Lloyd's Register, 2022; Bureau Veritas, 2022). Notably, classification societies are non-governmental organizations that promulgate rules and requirements governing vessel construction and supervision of such construction, inter alia, and also aim to provide services both classification and statutory to the maritime industry.

Markedly, there is no international guidance covering the conduct of remote surveys and/or inspections, remote audits or verifications. Individual classification societies are at liberty to develop their own rules and requirements. The existing regulatory landscape highlights examples of duplicative efforts. Moreover, the distinctions between remote surveys and remote inspections remains notoriously imprecise and unclear. To this end, submissions from International Maritime Organization (IMO) member states (MS) to the Maritime Safety Committee (MSC) are considered a stepping-stone for investigating the feasibility of: harmonized international guidance on remote inspection techniques, guidance on the application of remote surveys pursuant to the International Management Code for the Safe Operation of Ships, the Pollution Prevention (ISM Code), and the International Ship and Port Facility Security Code (ISPS Code).[1]

Within the foregoing context, this article revisits the Law of the Sea and IMO's Code for Recognized Organization (RO Code). Subsequently, a cursory overview of status quo regulations that govern the application of maritime RAS for inspection and survey, with a special emphasis on rules and requirements publicized by classification societies, will be detailed. Finally, the influences on remote performance transition are discussed with reference to issues faced during Covid-19 by classification RIT-surveys and statutory remote surveys.

5.2 Law of the Sea and RO Code Redux

Inspections conducted manually or via RIT are unavoidable prescriptive statutory obligations (Alexandropoulou et al., 2021). Verification of a vessel and its structures has a continual inspection and certification processes, at regular intervals, throughout its life cycle. All types of certificates pursuant to international conventions are issued for a 5-year period subject to yearly endorsements. For ship owners,

[1] See also European Commission submission on behalf of the European Union to the to the 8th session of the International Maritime Organization's Sub Committee on Implementation of IMO Instruments suggesting amendments to the HSSC Survey Guidelines and to the Revised Guidelines on the implementation of the ISM Code by administrations and principles of the Guidelines on remote surveys, ISM Code audits and ISPS Code verifications, SWD (2022) 79 Final, 7576/22, at pp. 3-4 (ref: Background).

certification serves as the ticket to international commercial voyages where compliance with safety standards must be ensured through inspections and surveys. Certification thus serves as proof that a vessel and its structures are in compliance with international regulations. For example, the International Ship Construction Certificate and accompanying documents, a requirement of SOLAS Chapter II-1, substantiates that the vessel is safe and seaworthy.

Scholars, taking into account judicial decisions, have scrutinized the scope and nature of what constitutes seaworthiness. [2] Although undefined, the United Nations Convention on the Law of the Sea (UNCLOS) in article 94 prescribes "seaworthiness" --- a term that is both referred to as a duty of flag states, as well as measure closely tied to the concept of "safety at sea" (United Nations, 1982a). Articles 219 and 226 are two other instances where the word "seaworthiness" surfaces, but neither provide a clear interpretation or insight into what the term embodies. Therefore, there is research to be done to help decipher the non-exhaustive list found in article 94 (United Nations, 1982b). Nonetheless, "construction" and "equipment" as an essential part of vessel structural integrity remain fundamental to seaworthiness. Therefore, it is safe to assert that what was an implied condition in the 18th century is now an express criterion under UNCLOS.[3]

To set the parameters for the legal status of RIT as an international legally binding treaty, reliance must be made on Part XIII of UNCLOS (Davenport, 2015; Johansson, Long and Dalaklis, 2019). The correlation is settled and established via the term Marine Scientific Research (MSR), which similar to "seaworthiness," remains undefined within the texts of UNCLOS. Nevertheless, scholars, after extensive research, have strategically placed MSR under the category of "ocean observation and corresponding work." (Wegelein, 2005) This family of classification has added greatly to this vital field of scholarship. Strikingly, all technologies used for MSR purposes, e.g., ROV, remotely piloted aircraft, profiling floats, unmanned underwater vehicles, have one key feature in common; they all are subject to the "consent regime" of coastal vis-à-vis researching States and competent International Organizations (IO), which applies in internal waters, territorial sea, and archipelagic waters (Salpin, 2013). Contrastingly, although possessing similar traits, the legal status of technologies deployed for surveys and inspection are free from debate for several reasons: first classification societies are authorized by flag states or duly authorized organizations representing flag states, the task achieved by RIT forms a part of existing statutory or classification tasks and therefore is not purely operational oceanography, and lastly integrating RIT into manual surveys and inspections is already regulated with common minimum standards developed by classification societies such as American Bureau of Shipping, China Classification Society, Bureau Veritas and Det Norske Veritas (Johansson, 2022).

The role of IOs in prescriptive and enforcement jurisdictions through "applicable rules and standards" has its roots in UNCLOS.[4] While general obligations are succinctly embedded in relevant parts, UNCLOS through "rule of reference" requests Member States (MS) to implement Generally Accepted International Rules and Standards (GAIRS).[5] In evaluating the role of GAIRS, Richard Barnes notes the word "compatible" found in

[2] For example, Diplock LJ in *The Hong Kong Fir* [1962] 2 Q.B. 26, at 71; Lord Blackburn, in *Steel v. State Line Steamship Co.* [1877] 3 App. Cas., at 86; Judge Channel in *McFadden v. Blue Star Line* (1905) 1 K.B. 697, at 706.
[3] See *Kopitoff v. Wilson* (1876) 1 QBD 377, 380; *Steel v. State Line Steamship Co.* (1877) 3 App Cas 72, 77, 84, 88; *Gilroy, Sons & Co v. W R Price & Co.* [1893] AC 56, 63 *Havelock v. Geddes* (1809) 10 East 554.
[4] Reference to "generally accepted international regulations, procedures and practices" for ensuring "seaworthiness" is found in art. 94(5) of the United Nations Convention on the Law of the Sea. Generic reference is found in art. 226(1)(c).
[5] For more information see the Report of the United Nations Secretary General (1997) Impact of the entry into force of the 1982 United Nations Convention on the Law of the Sea on related, existing, and proposed

articles 311(2) and 311(3) that "… seek to ensure coherence and consistency within the UNCLOS' system of rules" (Barnes, 2016). Undoubtedly, rules of reference proffers cohesion and adaptability, especially with IMO code, conventions and guidelines.

Adopted by Resolutions MSC.349(92) and MEPC.237(65), IMO's RO Code is noteworthy for two reasons (International Maritime Organization, 2013). First and foremost, the provisions of the IMO's RO Code assist in the comprehension of the invaluable roles played by other international bodies that are authorized by flag states. "Authorization" has been defined in the Code as "… the delegation of authority to an RO to perform statutory certification and services on behalf of a flag State …". (International Maritime Organization, 2013). However, as is observed from the texts found in "general requirements for recognized organizations" --- the focus then shifts from certification services to rule-development tasks defined and prescribed explicitly through the Code. Secondly and specifically, the Code, in a structured fashion through several sections, stresses the importance of the rules and requirements developed by organizations including classification societies.

It also merits brief notice that UNCLOS does not provide any reference to pandemic or force majeure when prescribing flag state duties in relation to evaluating vessels' structural integrity under article 94. Reference to force majeure (crisis response), can be found in two specific articles that are navigation-specific; Article18 that applies to the meaning of passage in the territorial sea, and Article 39 with regards to duties of ships during transit. Thus, in global emergencies, the focus of the industry shifts to existing provisions or special guidance notes issued in real time by concerned Ios (Letts, 2020).

5.3 IOs & RAS Governance

It also merits brief notice that UNCLOS does not provide any reference to pandemic or force majeure when prescribing flag state duties in relation to evaluating vessels' structural integrity under article 94. Reference to force majeure (crisis response), can be found in two specific articles that are navigation-specific; Article18 that applies to the meaning of passage in the territorial sea, and Article 39 with regards to duties of ships during transit. Thus, in global emergencies, the focus of the industry shifts to existing provisions or special guidance notes issued in real time by concerned Ios (Letts, 2020).

Axiomatically, the increasing complexity of the technology necessary for international shipping is standard-reliant (Hatto, 2010). While standards provide many advantages; their primary objective is to provide a secure foundation of support, means and basis for critical ongoing developments by "benchmarking". Benchmarking is key to establishing a measurable baseline to assess progress in relation to future developments (Hatto, 2010, p.6). In the maritime world "standards" are comprised of an entangled web of voluntary standards and regulatory standards, (Lindøe et al., 2019) which can create ambiguity and thwart stakeholders' capability to develop, maintain and amend, as appropriate, rules and requirements to keep pace with innovation-governance. Today, stakeholders within the maritime technology industry are dependent on organizations that have the mandate to implement four distinct categories of standards; national, regional, international and informal (Hatton 2010). With a view to promulgating uniform international standards, the International Organization for Standardization (ISO), founded in 1947, has had significant impact with "… publications, extending to over 17000 standards, and current work in over 200 Technical Committees [sic]" to date (Hatto, 2010).

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instruments and programmes, UN Doc. A/52/491, Section J, paras 8–9; 275(1)–(2); 276(1); 278; 297(1)(c); 319(2)(a); 275(1)–(2); 276(1); 278; 297(1)(c); 319(2)(a).

In the current context, we note the mandate of ISO Technical Committee 8 focuses on Ships and Marine Technology. The scope of the work undertaken by ISO TC/8 primarily revolves around standards that are exclusively technical in nature. Initially, standards published by the "marine environmental protection" (hereinafter ISO TC 8/SC 2) and "marine technology" (hereinafter ISO TC 8/SC 13) subcommittees were thought to contain the regulatory standards that govern marine and ocean technology, however, a careful examination of the 30 standards published by ISO TC 8/SC 2, and the 11 standards published by ISO TC 8/SC 13 reveal that the theme and content are, unfortunately, confined to the techno-regulatory-affair side of things.[6] We, therefore, segue, into the work of IMO, namely IMO's Harmonized System of Survey and Certification (HSSC).[7] Relevantly, through HSSC, IMO has addressed procedural matters by harmonizing similar survey and certification processes set as mandatory criteria under several different conventions.

Moving forward, HSSC, has indeed, resolved statutory survey matters that were, for a considerable period of time, considered by industry as repetitive, overlapping and redundant.[8] Evidently, an important feature of the HSSC is its seamless integration of standards that unify surveys pursuant to conventions that are integral to enhancing compliance with rules associated with safety as well as protection and preservation of the marine environment. While the goal of achieving uniformity is achieved to a great extent (through regular review), the objective of IMO's HSSC, nevertheless, does not entail furnishing the fundamentals of survey procedures. For those matters, annexes to the survey guidelines under the HSSC provide in a systematic matter direct references to the work of classification society standards. As noted earlier, RO Code thus bolsters advertence to classification society standards, which in turn guides analysis-transition towards the core procedures -regulations governing surveys of vessel structures.

Statistics indicate that the global cargo carrying fleet consists of approximately 100,000 vessels that range from crude carriers between 39,000 and 320,000 dead-weight tons (dwt), to bulk carriers between 39,900 and 100,000 dwt, to container ships with a capacity of 3,000 – 15,000 20-foot equivalent units (TEUs) (UNCTAD, 2020; UNCTAD, 2021). Tankers and bulk carriers include both "large" and "very large" vessels over the age of five years, and subject to IMO's Enhanced Survey Programme (ESP) (introduced by IACS in 1993). Other class standards, especially Unified Requirements (UR), have been the core of vessel structure (hull) and equipment survey and certification since the inception of the Register Society in 1760. Today the IACS- promulgated UR-Z family-of-recommendations enshrine common minimum standards and minimum technical requirements. Those standards and requirements, spread across twenty-nine documents, elaborately detail the scope of the vessel survey regime, regulating "90 percent of the world's cargo carrying tonnage" (IACS, n.d.1; IACS, n.d.2).

General RAS-integration schemes which contain the necessary conditions and procedures are embedded in IACS Recommendation 42 titled Guidelines for Use of Remote Inspection Techniques for Surveys (IACS,

[6] Those are the exact number of standards published by subcommittees as of 1 June 2022.
[7] Survey Guidelines under the Harmonized System of Survey and Certification, 2021, Resolution A.1156(32), adopted on 15 December 2021, supersedes Survey Guidelines under the Harmonized System of Survey and Certification, 2019, A.1140(31), which was amended and updated in 2019 to reflect amendments to International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004, Feb. 13, 2004, (IMO, BWM/CONF/36) (hereinafter BWM Convention), MARPOL and 1974 SOLAS.
[8] The conduct of statutory survey leads to the issuance of a statutory certificate, which is distinguished from class surveys that lead to the endorsement of a class certification although classification surveyors from classification societies are observed as carrying out those statutory surveys. The types of ship surveys found in the HSSC include initial survey, periodical survey, Renewal, intermediate survey, annual survey, inspection of the outside of the ship's bottom, and additional survey (under BWM Convention regulation E-1.1.5) (Resolution A. 1140(31), 2020).

2016). From an operational standpoint, RIT are used for data collection as well as data processing and visualization such as; 3D modelling through photogrammetry, laser point clouds, and image recognition. The above examples aligned are within the permissible limits for RIT deployment under IACS Recommendation 42which specifies; both external (surface) and internal (tanks and holds) examinations coupled with close-up surveys where structures and components are examined from a close range, and gauging (IACS, 2016). To detail and assess the principal RAS-integration schemes IACS UR Z17 (titled Procedural Requirements for Service Suppliers) serves as a baseline. Note: ostensibly, the purview of IACS extends beyond "human element" governance requirements which are the focus of several UR Z, including Z7.1, Z7.2, Z10.2, Z10.4, Z10.5, Z13 and Z16.

IACS UR Z17 was an important advancement in RAS-governance. It created a supervised-autonomy ecosystem through the merger of RAS-platforms with the human element. For a better comprehension of overlaps, the authors make use of the three-partite "dynamic governance" conceptual framework proposed by Markell and Glicksman for assisting "… policymakers seeking to design regulatory structures likely to produce effective governance in dynamic circumstances" (Pastra et al., 2022). The three-part framework conducts assessment using "three interlinked variables": actors, mechanisms and tools that are instrumental in enabling policymakers to "structure and administer" regulatory programs when faced with institutional change or "dynamic change" (Pastra et al., 2022).

Table 8: Dissecting IACS UR Z17 ROV and RIT Procedural and Special Requirements Utilizing the Theory of Dynamic Governance

Procedural Requirements for Service Suppliers and Firms Engaged in Statutory and Classification Surveys	
PRINCIPAL FOCUS	**Governing the Scope of Suppliers that Provide RIT Services**
ACTORS	**S. 3:** Manufacturers, Service Providers, Agent, Subsidiary and Subcontractor
MECHANISMS	**S. 4:** Permissible in Statutory Services and Classification Services except non-ESP ships <500 Gross tonnage (GT) and all Fishing vessels
TOOLS	**S. 4.1.3:** Verification and Accountability of Work Done by Third Party; **S. 4.2:** Approval of Service Provider by the Concerned Society; **S. 4.3:** Approval of Service Provider by the Concerned Society where the Society is Authorized by Flag Administration; **S. 5.1:** Procedures for Approval and Certification; **S. 5.2.1 to S. 5.2.10:** General Requirements for Suppliers; **S. 5.3:** Auditing the Supplier; **S. 5.4:** Conditions for Certification; **S. 5.5.1:** Supplier to Demonstrate Documented System Pertaining to Quality Management in accordance with ISO 9000 Series; **S. 5.5.3:** Application by Manufacturers' Endorsing Agents or Subsidiaries; **S. 5.6.1:** Service Suppliers Relations with the Equipment Manufacturer; **S. 6.1:** Conditions for Issuance of Certificate of Approval to Supplier and Content of Certificate; **S. 8.1 to S. 8.4:** Cancellation of Approval; **S. 5.2.11:** Reporting by Suppliers; **S. 5.2.12:** Documented Procedures and Instructions
ROV Special Requirements Pursuant to S. 3	
ACTORS (THE HUMAN ELEMENT)	**Supervisor:** qualified according to national or international industrial NDT standard **Operator:** qualified according to national or international industrial NDT standard **Training of Personnel:** Supplier is responsible for training of operator, supervisor with respect to training on handling equipment. **Verification**: The supplier must have the Surveyor's verification of each separate job, documented in the report by the
MECHANISMS	**S. 3.1:** In-water survey in lieu of a docking survey and/or the internal hull survey of compartments filled with water; and **S. 3.7.1 to S. 3.7.2:** Suppliers should have documented operational procedures and guidelines including "guidance for the operation of the ROV, if applicable"; as well as "methods and equipment to ensure the ROV operator can determine the ROV's location and orientation in relation to the vessel".
TOOLS	Tools involved in the Preliminaries: **S. 3.3:** A plan (developed by supplier) for training of personnel. Tools Involved after Completion of Task:

	S. 3.8: Verification is an important tool that confirms approval by surveyor for each job completed.
RIT Special Requirements Pursuant to S. 16	
ACTORS (THE HUMAN ELEMENT)	Supervisor & Operator: Similar to the former Training of Personnel: - Marine and/or offshore nomenclatures. - The structural configuration of relevant ships types and MOUs, including internal structure. - The remote inspection equipment and its operation. - Survey plans for examination of hull spaces of various configurations, including appropriate flight plans if using a UAV. - Thickness measurement (TM) and non-destructive examination (NDE) in accordance with a recognized National or International Industrial NDE Standard when these are part of the service.
MECHANISMS	Mechanisms involved in the Preliminaries: **S. 16.4:** Training Plan for Personnel; and Mechanisms Involved During Conduct of Task: **S. 16.2:** Close-up Survey of ships' structure and mobile offshore units' structure by deploying RIT.
TOOLS	**S. 16.4:** A plan (developed by supplier) for training of personnel; **S. 16.8:** The supplier shall ensure operational procedures and guidelines in place; Tools Involved During Conduct of Task: **S. 16.7:** High-definition display screen with live high-definition feed from inspection cameras as an integral part of the RIT; and Tools Involved after Completion of Task: **S. 16.10:** Verification is an important tool that confirms approval by surveyor for each job completed.

Source: IACS UR Z17, Procedural Requirements for Service Suppliers (Rev. 16 August 2021)

Applying the theory of dynamic governance two considerations serve as the rationale behind dissociating RIT from the human element (see Table 8). The first stems from the fact that standard rules developed by IACS, perceived as international standards, have already been subject to regular reviews and revisions. In other words, the rules have been subject to "change" --- a decisive factor that remains at the crux of dynamic governance. To exemplify this, the following revisions and corrections have been applied to UR Z family-of-requirements related to hull cleaning, inspection and maintenance for Bulk Carriers (as of 1 June 2022):

IACS UR Z3: Periodical Survey of the Outside of the Ship's Bottom and Related Items: 8 Revisions since 1984 and 1 Correction in 2002;

IACS UR Z7: Hull Classification Surveys: 27 Revisions since 1990;

IACS UR Z10.2: Hull Surveys of Bulk Carriers: 36 Revisions since 1994 and 1 Correction in 2006; and

IACS UR Z17: Procedural Requirements for Service Suppliers: 16 Revisions since 1997.

The second reason concerns comparing findings from table 1 against procedural requirements developed by individual members of IACS with a view to highlighting the unique additional provisions (not covered by IACS) that will require consideration as progressive autonomy progresses towards advanced autonomy.

5.4 Remote Performance Transition: Barriers & Ways forward

Remote performance transition defines progress towards off-site remote port state surveys using visual and audio technologies for classification and statutory flag state inspections as an alternative on-site human conducted surveys. While RIT-based inspections have developed methodically since the early 1990s, the move towards remote surveys has been exponential since the beginning of COVID-19 pandemic. Remote surveys have significantly helped the maritime industry press ahead in achieving "safe shipboard interface between ship and shore-based personnel" (Chu et al, 2023; Knukkel, 2023; Kartsimadakis, 2023). That being said, regulatory barriers remain as remote statutory surveys were not contemplated in the texts of ISM Code or the ISPS Code. IMO MS acknowledges that RIT may boost the usage of technologies for remote surveys and verifications by creating a level-playing-field for all maritime stakeholders. Hence, overcoming regulatory challenges associated with RIT is considered by the authors as the first step in facilitating remote performance transition, not only during global emergencies, but also when a normal steady state prevails.

Qualitative findings from thirty-three structured interviews conducted during the Covid-19 pandemic has helped underscore the pre-requisites, including the identification and removal processes of some particular difficult issues for transition. All respondents confirmed that the goals for transitional reform should centre on consideration of stakeholder opinion that uniformly demands the harmonization of individual classification society requirements while nonetheless adhering to common minimum standards. Respondents stressed that there are more than fifty classification societies highlighting the need for synchronization of individual class requirements since vessels are designed, constructed and maintained based on the requirements derived from common minimum standards.[9] Once RIT-requirements are streamlined, then it would be meaningful to supplement guidance on remote surveys, specifically for statutory surveys and audits for statutory verification (in line with IMO Conventions). Moreover, respondents noted that a majority of the classification societies that are members of IACS hail from the European Union (EU), and for that reason, harmonization through reform could help conceive good regulations on which good remote performance can be predicated (following completion of transition from manual to digital inspection and survey).[10] In short, harmonization of standards are underpinning principles for a successful performance transition --- and are the central theme of the regulatory blueprint developed under the auspices of project BUGWRIGHT2. A first-hand synoptic overview of the regulatory blueprint (covering bulk carrier hull RIT-survey and inspection and statutory remote survey (fifth strand)) is provided in the following sections.[11]

[9] With classification society representatives, service suppliers as well as flag and port state officials from China, Singapore, the Netherlands, Norway, Canada and the United States of America (US). Interviews formed a part of the quantitative research for BUGWRIGHT2 Project Report Deliverable 1.4.2 titled "National Comparative Analysis".

[10] This statement is based on document issued by the European Commission, Proposal for a Regulation of the European Parliament and of the Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts, Brussels, 21.4.2021, COM (2021) 206 final, 2021/0106(COD).

[11] Final work package 1.4 report deliverable titled *Overcoming Regulatory Barriers for Service Robotics in an Ocean Industry Context* developed by the World Maritime University-Sasakawa Global Ocean Institute.

5.4.1 First Strand: Compelling Evidence of a Concurrent RIT-survey & Statutory Remote Survey Paradigm Shift

For vessel survey and inspection, including maintenance of bulk carriers, stakeholders are currently focused on two distinct aspects: RIT and statutory remote surveys. As mentioned earlier, online publications as well as IMO MS submissions are evidence of the noteworthy shift towards technology-based alternative solutions (International Institute of Marine Surveying, 2020). "Capex and opex" benefits are derived from "[r]educed travel/accommodation costs; Shorter response times; Potentially quicker inspection and survey activities; Greater scheduling flexibility; Instant access to deep technical expertise; and less operational downtime" (Haukerud , 2020). Cost-benefit research conducted under transdisciplinary projects, such as ROBotics technology for Inspection of Ships (ROBINS), are evidence that stakeholders are considering the following economic values reaped from using UAV for close-up Inspection as well as from using magnetic crawlers for thickness measurement and ROV for close-up inspection/thickness measurement during hull inspection: Handymax Bulk Carrier SS1/IS2: € 22.714,19; Handymax Bulk Carrier SS2/IS3: € 100.525,18; Panamax Bulk Carrier SS1/IS2: € 28.828,59; Panamax Bulk Carrier SS2/IS3: € 129.073,90; Capesize Bulk Carrier SS1/IS2: € 35.357,99; and Capesize Bulk Carrier SS2/IS3: € 221.877,29 CORDIS EU (2020).

5.4.2 Second Strand: Template Definitions

RIT are products; products and procedures are interconnected. Vetted and refined definitions are imperative for harmonizing procedural requirements. To best understand the autonomous-trajectory of individual products, it is essential to establish these definitions using common language. Distinctions must be made between RIT and statutory remote surveys, as well as standardizing the definitions for specific RIT to allow for differentiation. In essence, no two RIT technologies are the same. The main equipment listed in s. 1.1 of IACS Recommendation 42 operate in different environments, e.g., air, water and steel surfaces. Nonetheless, determining which RIT require separate operational standards or additional prescriptive requirements may be still difficult. As can be seen below however, template definitions are currently available to begin the iterative process, and can be found in texts of documents produced by multiple relevant organizations.

Autonomy

Ability to perform intended tasks based on current state and sensing, without human intervention (ISO 8373:2021).

Robot

Actuated mechanism programmable in two or more axes (4.3) with a degree of autonomy (2.2), moving within its environment, to perform intended tasks (ISO 8374:2021).

~~**Service Robot**~~ Currently this degree is not available

~~Robot that performs useful tasks for humans or equipment excluding industrial automation applications (ISO 8373:2021)~~

~~**Mobile Robot**~~ Currently this degree is not available

~~Robot able to travel under its own control (ISO 19649:2017)~~

Inspection

An examination of a product, process, service, or installation or their design and determination of its conformity with specific requirements or, on the basis of professional judgment, with general requirements. (ISO/IEC 17000, 2020)

Survey

A systematic and independent assessment of a vessel, materials, components, or systems in order to verify compliance with the Rules and/or statutory requirements. (DNV GL, 2015)

Unmanned Aerial Vehicles (UAVs)

An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without a human pilot onboard. The UAV can be remotely controlled or programmed to fly a predetermined route using information on a specific asset's condition to target known areas of concern. It can collect visual data (such as still images, live-stream and recorded video) from difficult-to-reach structures and areas. (American Bureau of Shipping, 2022)

Remotely Operated Underwater Vehicles (ROVs)

An ROV is an unmanned unit designed for underwater observation, survey, inspection, construction, intervention or other tasks. Similar to UAVs, an ROV can be remotely controlled or programmed to travel a predetermined route using information on a specific asset's condition to target known areas of concern. It can collect visual data, perform Non-destructive Testing (NDT), and measure plate thickness in difficult-to reach areas. (American Bureau of Shipping, 2022)

Robotic Crawlers

A Robotic Crawler, commonly referred to as a "crawler", is a tethered or wireless vehicle designed to "crawl" along a structure by means of wheels or tracks. Crawlers are often equipped with magnets which allow them to operate on a vertical surface or hull structures in air or underwater. (American Bureau of Shipping, 2022)

5.4.3 Third Strand: Differentiating RIT-surveys from Remote Surveys

RIT refers to acceptable tangible technologies or techniques that could be used in situ when carrying out prescribed surveys in the presence of the surveyor --- the results of which require the acceptance of the "attending surveyor". In other words, s. 1.2 of IACS Recommendation 42 clearly stipulates that inspections using RIT should be conducted in the presence of a surveyor, which requires the attending surveyor to remain on board (IACS, 2016). Moreover, the verification/confirmatory part of RIT-based results pursuant to section 1.3 of IACS Recommendation 42 certainly requires surveyors to remain on site at selected locations (IACS, 2016). However, it is it is important to note that the above provisions are in sharp contrast with the definition of RIT found in IACS's proposed Amendments to the 2011 ESP Code that views RIT as enabling surveys "… without the need for direct physical access of the surveyor" (International Maritime Organization, 2019).

In the absence of an IMO-established definition, IACS has, through the recent addition of UR Z29 titled "Remote Classification Surveys" defined remote surveys as "… a process … where the verification is undertaken, or partially undertaken, without attendance on board by the surveyor" IACS (n. d.2). In other words, "remote survey" denotes a survey conducted via remote technology off-site, and does not necessarily require the physical presence of the concerned surveyor.

Although the common denominator is "remote" in both terms, it is important to preserve the inherent differences between RIT and "remote survey" so as to refrain from using the two terms interchangeably. Survey and inspection may appear to be the same due to the presence of "verification", however, both tasks are independent and separate with survey serving as a confirmation of the results of an inspection or a confirmation that all regulatory procedures have been satisfied. As will be discussed later, from a port state perspective, it refers to review of certificates, vessel's records and photographs from inspections. The above is known as Ship Inspection Report Programme (SIRE).

Again, new developments have made it is clear that previous issues have been resolved through the introduction of IACS UR Z29. Clearly, remote classification surveys, similar to statutory remote surveys, are conducted via Information and Communication Technology (ICT), such as, computer, telephone, satellite systems, whereby classification inspections are completed using RIT listed in IACS Recommendation 42. On that note, further distinctions may be required in the future so as to separate and clarify "verification" within the context of survey and inspection.

5.4.3.1 Third Strand Block 1 (RIT): Operational Considerations based on Variety

Observing the absence of a freestanding UR that covers individual RIT operational standards, it is presumed that the development of operational standards is currently outside of IACS's mandate. The authors assert that the importance of operational standards cannot be stressed enough. Dispatched services and performance criteria fall within the scope of operational standards which also can serve as a baseline for each specific currently available technology. The authors also seek to outline requirements, risks and safety performance criteria for RIT. Adopting a common methodological approach will also likely require developing operational common minimum requirements to harmonize categories of risk-assessments. Examples of this approach can be found in two different sets of requirements developed by ABS and the China Classification Society (CCS). Guidance Notes developed by ABS includes provisions on: explosion risks in hazardous areas, dropped object risks, collision risks (e.g., with other RIT), lost link risks (e.g., network compromise), other risks associated with high-risk working areas, and risks associated with parallel operations as well as emergency situations (American Bureau of Shipping (2022,). The other set of unique RIT operational standards are found in the Guidelines for Use of Unmanned Aerial Vehicles developed by the CCS which include: safety, operation performance, enduring capacity, data transmission and communication, data storage (e.g., video and image resolution and video and photo formats), as well as requirements for airborne cameras (China Classification Society, 2018).

5.4.3.2Third Strand Block 2 (RIT): Degree of Autonomy

Dissecting IACS UR Z17 ROV and RIT Procedural and Special Requirements utilizing the theory of dynamic governance (see Table 1), reveal that the current system is centred on human-robot interaction. Considering the definition of "autonomy" found in ISO 8373:2021, it can be held that RIT-based inspections are not fully autonomous, but rather encompass a "semi-autonomy/human-robot-autonomy/supervised-autonomy" interface (ISO 8373, 2021). What would help expedite future process reviews is a categorization of the RIT with consideration to the degree of autonomy (bearing in mind the differences between a "vessel" and a "technique/technological tool"). The degree of autonomy proposed needed to govern the ongoing regulatory developments for Maritime Autonomous Surface Ships (MASS) could serve as guidance (see Table 9).

Table 9: Categorization of RIT Based on MASS Degree of Autonomy

Degree/Level of Autonomy	MASS	RIT
First Degree	Ship with automated processes and decision support with seafarers on board to operate and control the systems. Systems are partially automated, unsupervised with seafarers on board ready to assume control.	RIT-survey conducted in the presence of the attending surveyor. This degree aligns explicitly with IACS Recommendation 42 and IACS UR Z17.
Second Degree	Remotely controlled ship with seafarers on board.	Remote survey with the possibility of surveyor to intervene, if necessary.
Third Degree	Remotely controlled ships without seafarers on board.	Remote survey without attending surveyor.
Fourth Degree	Fully autonomous ship.	RIT with automated processes and Artificial Intelligence-based machine learning operating systems to support decision-making.

Source: Adapted from IMO Doc. MSC 100/20/Add. 1, Annex 2 (IMO, n. d.)

5.4.3.3 Third Strand Block 3 (RIT): Data Management & Security

Data obtained from RIT includes information from close-up surveys and gauging. During an RIT-survey programme, visual data, such as still images, live-stream and recorded video, are collected for observing/examining the structural condition of the vessel, ship's holds and tanks to discover corrosion and to measure thickness. It should be emphasized that data from RIT and ROV are considered "non-personal data".

"Control of data" provision embedded in s. 5.2.6 of IACS UR Z17 highlights the responsibilities of service suppliers in relation to computer software's ability to acquire, record, report, store, measure and monitor data. While this does not conflict with laws on data protection, case-in-point EU's Regulation 2016/679 on the General Data Protection Regulation (GDRP), there is still the need to protect the data collected from a commercial asset (the vessel under inspection). According to s. 16.8 of IACS UR Z17, operational procedures for handling/operating equipment and guidelines on the collection, validation and storage of data rests with the service suppliers, which begs the questions of who should retain the copyright (ownership) of data gathered from RIT; what are the main characteristics of data quality, how should data be shared between the key stakeholders, what provisions on data control and security should be considered, what responsibilities do each party have to the other regarding data control and data security, what is the duration of preservation of data and image from close-up and in-water surveys, should there be any safeguard mechanisms for service providers against third-party liability? It is self-evident a trustworthy process built on adequate data management and security is in order. Fortunately, answers to some of the questions posed above can be found in guidelines developed by individual IACS classification society members, which should suffice during the initial reign of supervised-autonomy (see Table 10):

Table 10: Selected Classification Society Provisions on Non-personal Data Governance

Source	Section and Title	Observations/Remarks
DNV-GL, Approval of Service Supplier Scheme 2021 (online)	*In-water survey on ships and mobile offshore units by diver or Remotely Operated Vehicle (ROV)* S. 3.1 Reporting (Appendix A) *Firms Engaged in Survey using RIT as an alternative means for close-up survey of the structure of ships and mobile offshore units* S. 16.1.4 Reporting and data storage (Appendix A)	Important to note that provisions on "data storage" stipulates that all files containing data should be named according to the structure so surveyed, and should be stored by the service supplier and readily available at request from DNV for 5 years.
ABS, Guidance Notes on the Use of Remote Inspection, 2019 (online)	S. 4.9 Data Review S. 4.11 Data Post-Processing	S. 4.9 projects issues that may affect image quality including, poor image resolution, image focus, occluded camera lens, inadequate lighting, instable RIV, dark or shadowy areas, lost connectivity, glare from strong lights or sum etc. In addition to the recommendation that video footage, live streaming and recorded data should be uninterrupted, there are other stipulations found in s. 4.9, e.g., recorded data is to be made available to surveyor both on-site and off-site (within a specified period). In terms of data processing, ABS recommends advances image processing techniques for performing anomaly measurement; Artificial Intelligence for pattern recognition, cracks, fractures or corrosion; data analytics for anomaly trending and prediction; and 3D Model generation for data integration and recording.
CCS, Guidelines for Use of Unmanned Aerial Vehicles for Surveys, 2018 (online)		S. 2 includes provisions on …Data Transmission and Communication, Data Storage, S. 3 includes provisions on … Data and Information (Data Collection, Data Processing, Data Security) S. 4 includes provisions on Survey Data, Survey Report

Source: (top-down) DNV-GL, Approval of Service Supplier Scheme 2021 (online); ABS, Guidance Notes on the Use of Remote Inspection, 2019 (online); CCS, Guidelines for Use of Unmanned Aerial Vehicles for Surveys, 2018 (online)

5.4.3.4 Third Strand Block 4 (RIT): Liability

Ultimately, RIT is an innovative and integrating such transformative product, such as service robots, into traditional human-driven tasks calls for a safety-net to guard against third-party liability. At present, IACS UR Z17 does not provide any caveats that prompts necessary pre-emptive steps from service providers, flag administrators or classification society members. The authors emphasize that quality assurance schemes for protection against liability are not generic either in scope or nature, and that the current legal regime only requires service suppliers ensure that these elements are in place. As previously discussed, inspection and certification fall under the conditional assessment program that is a requirement of charterers and cargo owners. Through such assessment programs ship-owners can demonstrate "operational reliability" to their clients.

New forms of RIT liability emanating from dropped object or collision risks, or even unseaworthiness of a vessel due to deterioration or corrosion from biofouling, may seem far-fetched since current routine options, such as reverting back to manual inspections and checks through periodical surveys remain readily available. Even so RIT does have the potential to create some new and unforeseen risks due to the introduction of multiple new actors during an RIT survey (Alexandrapoulou et al., 2021). For example, input-material supplied by the asset owner to the service supplier prior to hull inspection (i.e., images, drawings and designs) could infringe on the copyright or other rights belonging to a third party. Hull survey data could be used for marketing by the service supplier without the prior approval of the asset owner. Therefore, the path forward should connect the RIT-survey regime to the liability laws of the flag state, referred to as a "liability clause" in the texts of classification society member state requirements. An alternative is to follow the example set by Lloyd's Register by including a provision that requires end-users to maintain third-party liability insurance in case of accidents or incidents (Lloyd's Register, 2022).

5.4.3.5 Fourth Strand Block 5 (RIT): In-water Environmental Consideration

Technological advancements now allow the conduct of in-water cleaning which signifies to the possibility that in-water cleaning could be conducted in tandem with in-water inspection. The applicable section 3 of IACS UR Z17 is limited to inspection procedures and does not currently encompass in-water cleaning. Deployment of intervention-class ROV with cleaning capacity however that would likely elevate concern for environmental protection. It should be noted that cleaning a vessel hull from biofouling also means scraping built up pollutants which leaves them exposed in the water.

Although not a contentious issue at this point, it may become a significant issue if dual-purpose ROV catches on as an alternative to more expensive dry-dock surveys. The Baltic and International Maritime Council (BIMCO) have taken the lead in the development of standards for in-water cleaning which can serve as common-minimum standards in this context. BIMCO's Industry Standard on In-water Cleaning with Capture was the result of a three-year effort to set strategic guidance for ship owners (BIMCO, 2021). It states that the standards so developed could help ensure "that the in-water cleaning of a ship's hull, and niche areas including the propeller, can be carried out safely, efficiently and in an environmentally sustainable way" (BIMCO, 2021). Specific ROV- cleaning standards are laid out in the section titled "operating requirements of the cleaning system" that stipulates important to-dos, such as, post-cleaning inspections (s. 9.3), post-cleaning safety and environmental requirements (s. 9.4), service reports after cleaning (s. 9.5), cleaning report.

5.4.3.6 Fifth Strand Block 6 (RIT): "Proof of Concept" via Regulatory Sandbox

Understandably, remote inspections conducted off site should be approved with the objective of achieving at least the equivalent results as in situ surveys, with "safety" being the primary consideration, especially during force majeure. Beforehand, adequate tests should be carried out through joint collaborative efforts in a controlled environment allowing for the strategic development of both methodologies for remote classification inspection operations (on the external and the internal areas of a vessel) as well as necessary rules and requirements. Survey respondents deemed this as an important step for determining "proof of concept" of the functionalities of remote RIT-surveys. Respondents also noted that flag states and classification societies could engage in extensive testing using the "regulatory sandbox" methodology to establish "proof of concept" for conducting RIT-surveys (with the possibility of a surveyor intervening as well as the possibility without a surveyor intervening) to ensure safer and even higher-quality evidence in the survey process offering optimum benefits to ship-owners and operators (Attrey et al., 2020). The authors propose that the survey findings could serve as the impetus to initiate an international scoping exercise.

5.4.3.7 Fifth Strand Block 7 (RIT): A Risk Assessment Framework for the Feasibility of Remote Surveys

A strategic risk-assessment framework could assist in determining whether a physical survey is necessary, or whether it is safe to proceed with a RIT-survey. In the process of developing a model risk-assessment framework for determining the eligibility for remote RIT-surveys, due consideration should be given to: the age of the vessel, hull condition, severity of corrosion on hull structure, type of survey, areas to be inspected, ship location, environmental conditions in the area and the availability of approved service suppliers and well-trained surveyors. As a second step, applications adhering to the above should then be assessed with on a case-by-case basis. For example, specific criteria should determine whether a bottom survey using ROV while the ship is afloat is a pragmatic alternative to a bottom survey in dry-dock.

5.4.3.8 Sixth Strand Block 8 (Statutory Remote Survey): Common Minimum Standards for Remote Surveys and Auditing

At the time of drafting this article in September 2022, proposals submitted (earlier in the year) by IMO MS including European Commission, provide a holistic understanding of government positions with respect to harmonizing statutory remote surveys with IMO conventions. These proposals indicate that MS are cognizant of the absence of international guidance covering the conduct of remote surveys, remote audits and verifications. Although it is reported that lifting of pandemic related travel restrictions and physical presence on board vessels has made manual surveys doable again, port state officers have been quick to realize the added advantages, e.g., “reduce{d} the time in port and also reduced overhead costs”, of statutory remote surveys (Kartsimadakis, 2023). To derive the benefits from such remote surveys, the following elements (extracted from the BUGWRIGHT2 regulatory blueprint) are well worth considering:

Preliminary Considerations

Remote surveys may be applied to satisfy both statutory and classification requirements during normal situations and existential emergency/force majeure. In normal situations, remote surveys could accompany the option of intervention from a surveyor. Should this be the case, IMO should consider amending HSSC 2021, where appropriate, with reference to IACS UR Z29 to streamline the usage of ICT. Furthermore, it may be advantageous to develop a matrix to indicate time-trajectory under the HSSC prescribed surveys, and confirm how much time is actually being saved, if any, using ICT.

Robustness of Systems

Remote systems for statutory surveys should be reliable whereby manufactures and developers of AI have the responsibility to ensure that technical robustness of ICT, as well as to foresee the potential risks associated with the design phase to the best of their capacity. Technical robustness is highly relevant to a robust system since the remote application should operate properly during a survey without glitches or interruptions.

Determining the Scope of Remote Audits

In the process of moving towards remote surveys, it could be useful to: amend the definition for determining the scope of remote audits and whether they should extend beyond the scope of the following (confirmed audits/verifications/inspections that could be conducted remotely):

- Renewal and annual Document of Compliance (DOC) audits at the company's office;
- Renewal and intermediate Safety Management Certificate (SMC) audits on board the ship;

- Renewal and intermediate International Ship Security Certificate (ISSC) verifications on board the ship;
- Renewal and intermediate Maritime Labor Certificate (MLC) inspections on board the ship;
- Verifications of interim SMC, DOC, ISSC and MLC audits; and
- Additional audits.

Protecting the Remote Audit Regime Against Cyber Threats

Sharing of confidential information and data by remote means requires adequate protection against cybersecurity threats. When developing common procedures through international guidelines, it is important to consider the five concurrent functional elements that serves as a concrete foundation to effective cyber risk management: identify, protect, detect, respond, and recover (International Maritime Organization, 2017).

5.5 Conclusions

RIT or ICT-fused inspections and surveys are not an aberration, but an amelioration towards a likely future of fully autonomous RAS. As manufacturers cut through design bottlenecks, there will be other challenges in developing synergy between regulation and technology, technology and commerce, as well as commerce and mass deployment (Knukkel, 2023) Regulatory developments through meaningful participation, transdisciplinary dialogue, discussion and consultation, and implementation could very well be the best way forward. It must be emphasized to manufacturers, bio-engineers, information technologists, and cybernetic developers, that developing regulations do not imply that potential breakthrough technologies are being restricted. On the contrary, those technologies and technological developments are being administratively projected so that innovation and development stays on track. But why does it need to happen in a niche area of the maritime domain?

International regulations for RIT, or top-down rules and requirements, if developed the right way, could help provide guidance and avoid a plethora of issues for a system marked by multiple echelons and diverse stakeholders. Procedural rules covering data management, liability, and operational standards, will all have a crucial bearing on the types of technology that will emerge in the not-so-distant-future. Transition from UAVs to hybrid Unmanned Aerial Underwater Vehicles (UAUV) capable of navigating and operating in both air and underwater water environments is in the making, and will soon be deployed in the offshore industry (Chu et al, 2023). This will further raise RAS-governance questions as both aviation and admiralty stakeholders will need to unravel complex layers to set new industry-based standards.

As of this writing the world is not yet entirely free from the deleterious grasp of the Covid-19 pandemic. The last three years has called attention to social-distancing, travel bans and quarantines. RIT and remote surveys served as a timely panacea to those engaged in vessel inspection and maintenance. A return to a normal operating environment might have pushed inspections and surveys back to the traditional manual-mode, but RAS tools have already been unbridled and demonstrated their worth.

The writers contend that the maritime industry and applicable government and organizational regulators will adapt to technological transformation. For that transformation to be triumphant --- consensus-based methodologically-sound all-embracing guidelines are indispensable (Kartsimadakis, 2023). Understandably, IMO MS are gearing up to harmonize existing rules and requirements (for safeguarding industry’s interest). The key strands of influence, as outlined in this article, will inevitably surface in forthcoming discussions, and therefore, will need to be appraised with due diligence at any given stages of development of international guidance on the topic. If carefully structured, the international guidance will enable the maritime industry to unleash the full potentials of RAS in the face of current and future global emergencies.

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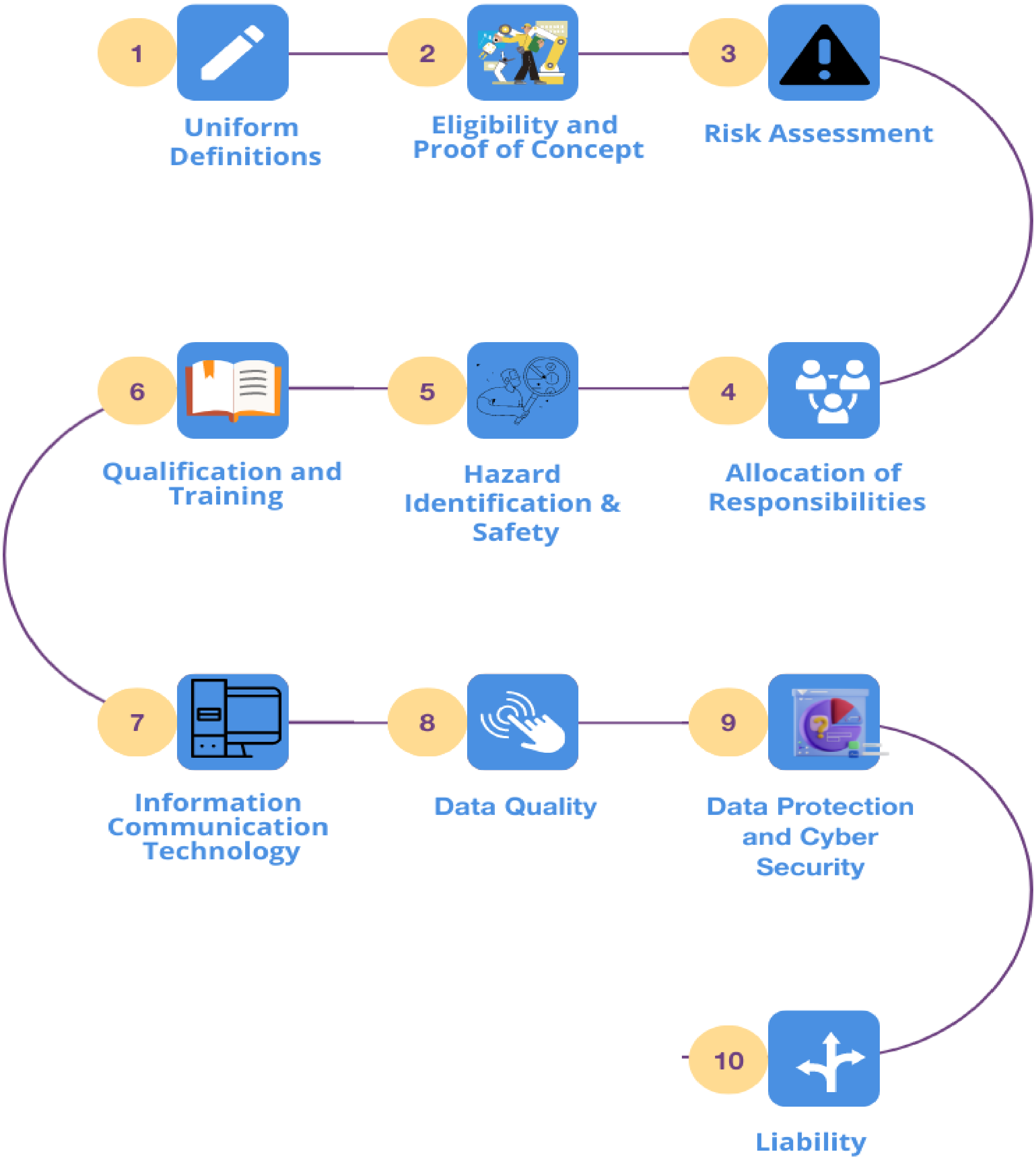
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ACRONYMS

AI	Artificial Intelligence
ABS	American Bureau of Shipping
AI	Artificial Intelligence
CAP	Condition Assessment Programs
EU	European Union
ESP	Enhanced Survey Programme
GVI	General Visual inspections
IACS	International Association of Classification Societies
IEC	International Electrotechnical Commission
ICT	Information and Communication Technology
IMO	International Maritime Organization
IoT	Internet of Things
ISO	International Organization for Standardization
LR	Lloyd's Register
RIT	Remote Inspection Techniques
RITS	Remote Inspection Techniques System
RO	Recognized Organization
ROV	Remotely Operated Vehicle
SMS	Safety Management System
SOLAS	International Convention for Safety of Life at Sea
UAV	Unmanned Aerial Vehicle
UTM	Ultrasonic Thickness Measurements

6.1 PREAMBLE

In recent years, the maritime industry has deliberated on the use of RIT for inspecting steel structures on ships and offshore platforms. State-of-the-art remote inspection techniques (RIT), namely unmanned aerial vehicles (UAVs), remotely operated vehicles (ROVs), and magnetic crawlers are the resultants of a cascade of technological innovation. Essentially, RIT are machine learning-based systems that potentially provide faster and more economical solutions than current manual inspection and maintenance procedures (Johansson et al., 2022).

From a specialized functionality perspective, UAVs can execute general visual inspections (GVI), ultrasonic thickness measurements (UTM), and close-up surveys on ships that necessitate statutory or classification evaluations. For steel plates, magnetic crawlers can carry out UTM scans and hull cleaning. Lastly, ROVs, which are tethered underwater robots with maneuverability, can undertake underwater tasks, with the potential to eliminate in the near future the need for divers. RIT may use a variety of sensors to examine the structure and discern defects.

Using real-time visual imagery to gather complex data, RIT is believed to offer safer and more efficient inspection services, paving the way for a digital transformation in the "ship survey" domain. RIT is currently linked to the consideration of the following benefits as identified by Pastra et al. (2023):

- Immediate access to and evaluation of the initial condition of the vessel, determining whether in-person attendance is necessary;
- Tracking data records and comparing them with previous maintenance records;
- Real-time data sharing with all relevant parties and stakeholders;
- Establishing databases to store this data, which can then be utilized for further research by entities like shipyards and classification societies; and
- Securing "flag state acceptance" for statutory surveys before any decision is made by a classification society.

Ships are subject to a through-life survey regime if they are to be retained in class. Each classed vessel is subject to a specified programme of periodic surveys after delivery, based on a five-year cycle, consisting of annual surveys, an intermediate survey and a class renewal/special survey. The rigor of each specified survey increases with the age of the vessel. Depending upon the age, size, type and condition of the vessel, the renewal/special survey may take several weeks to complete. The intermediate survey, typically scheduled at the midpoint between special surveys, might necessitate dry-docking. The duration of this survey can vary, ranging from several hours to a few days, depending on the specific requirements and scope of inspection. These timelines emphasize the possible advantages of utilizing robotic services. Considering the inherent risks associated with entering confined spaces, along with the necessity for sufficient ventilation time in these areas and the related costs, it becomes evident that the use of RIT is on the rise. Class societies have recognized the efficiency and safety benefits of drone technology, integrating it into their inspection services to enhance the process and reduce potential hazards. It's worth also noting that according to the analysis developed solely for the market of large bulk carriers, a staggering €190 million could be saved by shifting to RIT-based alternatives (ROBINS, 2021).

6.2 The Importance of Classification Societies in Statutory Surveys

Recognizing that normally periodical, annual, and intermediate surveys could be conducted with the use of remote technologies, the use of RIT by flag States and recognized organizations (ROs) has increased. The requirements of the statutory survey are governed by the flag administration and not only by classification society promulgated rules and requirements. The role of RO surveyors acting on behalf of flag administrations is befittingly reflected in the Protocol of 1988 relating to the International Convention for the Safety of Life at Sea (SOLAS, 1974). It is also stressed that the administration bears all responsibilities even when the work is delegated to a RO.

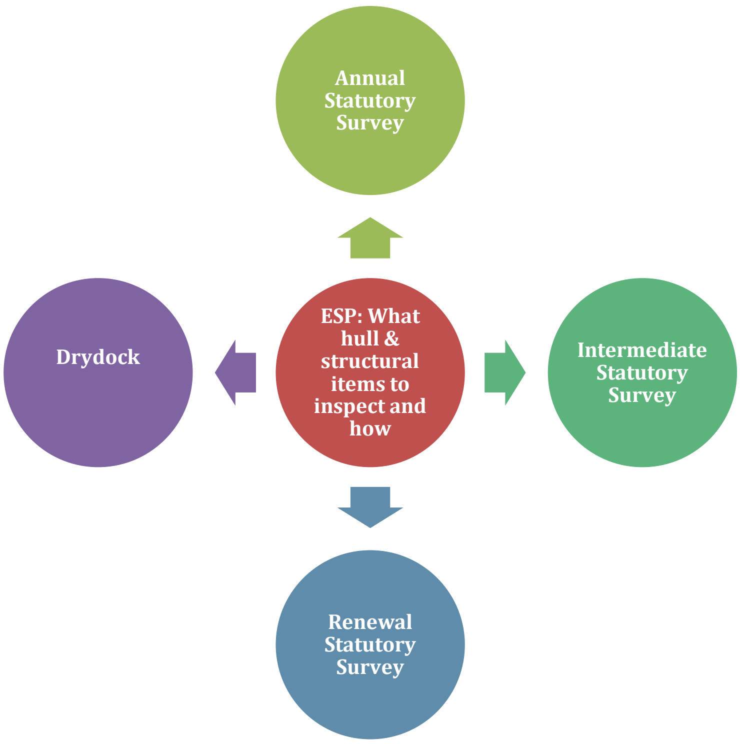
According to the International Association of Classification Societies (IACS), the objective of ship classification is to verify the:

- Structural strength of all essential parts of the hull and its appendages; safety and reliability of the propulsion and steering systems;
- Power generation and those other features and auxiliary systems which have been built into the ship in order to maintain essential services on board, establish and maintain basic conditions onboard, so that personnel and cargoes can be safely carried at all times.

Classification societies, as independent, self-regulating, externally audited, bodies aim to achieve this objective through the development and application of their own Rules and by verifying compliance with international and/or national statutory regulations on behalf of flag Administrations.

It should also be noted that within the Enhanced Survey Programme (ESP) or Condition Assessment Programs (CAP), IACS plays a pivotal role in shaping and implementing the standards and guidelines for bulk carriers and oil tankers. ESP mandates a detailed inspection of specific structures along with a comprehensive survey, including a number of scantling thickness measurements. Proper execution of these measurements necessitates advance planning to ensure that tanks and storage areas are adequately cleaned, ventilated, and accessible. ESP is not a separate survey in itself, but rather, it integrates into the existing framework of annual/intermediate/renewal statutory surveys and dry-dock that ships must undergo.

Figure 22: Enhanced Survey Programme



6.3 The Challenge

Despite the benefits from the use of RIT for statutory surveys and their utilization by class societies, there is a lack of uniformity in respect of scope, procedures and conditions, which are required for remote surveys to be widely accepted.

Due to the experience and knowledge gained during and after the COVID-19 pandemic and the advancement in Information and Communication Technology (ICT), a wider use of RIT is expected. That wider use catalyzes the development of guidance in order to facilitate the conduct of remote surveys in a harmonized way and in a manner that would allow demonstration of the same level of safety, environmental protection and security as in the case of traditional surveys. The establishment and adoption of consistent international standards are essential for the seamless integration of RIT for the conduct of dull, dirty and risky tasks (Johansson et al., 2022; Pastra et al., 2023).

The multi-robot (ship-hull) survey platforms explored under the auspices of European Union (EU) Horizon 2020 project titled "Autonomous Robotic Inspection and Maintenance on Ship Hulls and Storage Tanks" (BUGWRIGHT2) have the potential to alter the manner in which massive structures are inspected and maintained. The project's findings are poised to enhance the competitive edge of the shipping industry, thereby setting the stage for the establishment of improved and more rigorous safety regulations and standards.

6.4 The Methodology for the Development of Guidelines

In addition to the previously indicated methodology for developing these guidelines, processes included the formation of a subject matter advisory working group consisting of 19 global policy and technical subject matter experts in the RIT field (Table 11).

Table 11: Working Group for the Development of Guidelines

Name	Organisation
Damoulis Xydous	Lloyd's Register, The Netherlands
Andrew Baskin	HudsonAnalytix, USA
Frode Rødølen	VUVI AS (West Underwater Inspection Ltd), Norway
Cody Warner	Deep Trekker Inc. Canada
Mona Swoboda	Inter-American Committee on Ports (CIP) , Organization of American States (OAS), USA
Aschert, Thomas	Lloyd's Register, Germany
Yoss Lecrec	Logistro Consulting International, Canada
Anastasios Kartsimadakis	TSAKOS Shipping and Trading, Greece
Christoph Thieme	SINTEF, Norway
Nikolaos Polymeris	Danaos Shipping, Greece
Ersin Eren	Bureau Veritas Marine & Offshore, North Asia Zone
Alessandro Maccari	RINA Marine Research and Development, Italy
Nikoleta Trivyza	RINA Marine Research and Development, italy
David Knukkel	Global Drone Inspection, Netherlands
George Gazlias	DIVING STATUS Underwater Services, Greece
Vera Alexandropoulou	Thalassa Foundation, Greece
Vinia Kontaxaki	Alexandropoulou Law Firm, Greece
Sean Pribyl	Holland & Knight LLP, USA
Thomas Klenum	The Liberian Registry, Germany

6.5 Guidelines on Remote Inspection Techniques (RIT)

Scope

IMO International Conventions set out uniform requirements to facilitate the acceptance of a ship registered in one country in the waters and ports of another and define mandatory provisions for the safety at sea and the protection of the environment. These requirements, commonly referred to as 'statutory' requirements, broadly cover four distinct areas:

- Aspects of the ship's design and its structural integrity – load line and stability in the intact and damaged condition, essential propulsion and steering equipment;
- Pollution control with regard to normal ship operation;
- Accident prevention, including navigational aids and pollution and fire prevention;
- The situation after an accident (fire, flooding) including containment and escape.

The effective implementation of the IMO International Conventions is ensured through statutory surveys.

These guidelines specify acceptance criteria for utilizing the capabilities of a Remote Inspection Technique System (RITS) toward the credit of surveys as required by flag States. In case the survey is delegated to an RO, the RO should consult the flag State on a case-by-case basis for review and acceptance, along with any possible additional instructions from the flag State, if considered necessary. A remote survey with robotic technologies should only be undertaken, provided the level of assurance is not compromised. The survey should be carried out with the same effectiveness and be equivalent to a traditional survey conducted by a surveyor.

The type of surveys that can be performed with the use of RIT may include:

- The general external surveys with the purpose to identify and quantify defects of steel structure. The defects may entail identification of cracks, structural deformation, coating breakdown and corrosion;
- Overall survey of cargo holds – hatch covers open;
- Overall survey of enclosed spaces;
- Close-up survey of cargo holds and enclosed spaces;
- Thickness measurement of enclosed spaces and non-enclosed spaces;
- In-water surveys and in-water mooring chain visual inspection up to a depth (to be stated); and
- Cleaning of steel structure.

RIT hull inspection and maintenance processes by ROs will contribute valuably in building predictive analytics that will enable the optimization of vessel maintenance and operational performance.

Nevertheless, an RITS shall be considered a highly valuable complementary tool during vessel inspections and not a full substitute for traditional vessel inspection.

The results of the surveys by remote inspection techniques, when used towards the crediting of surveys, are to be acceptable to the class surveyor. In case the surveyor, according to their professional judgment, deems that the remote survey does not provide the same level of assurance as a traditional survey, the surveyor may decide not to credit the use of RIT.

1. Definitions

1.1. Close-Up Survey

A Close-Up Survey is a survey where the details of structural components are within the close visual inspection range of the surveyor (i.e. normally within reach of hand) (ref: IACS UZ17, s. 16.1).

Note 1: In the definition of the close-up survey by IACS is stated that 'components are within the close visual inspection range of the surveyor, i.e., normally within reach of hand' (ref: IACS UZ17, s. 16.1). However, the phrase 'within reach of hand' should be omitted, considering that inspections are increasingly conducted with the aid of robotic technologies.

In general, RIT can be used as an alternative means for the close-up survey of marine and offshore structures in compliance with IACS UR Z17.

1.2. Degree of Autonomy

Degree of autonomy is the level of interaction between a human and a robotic system.

Note 2: The degree of autonomy can be categorized into different levels, ranging from fully manual (where a human operator directly controls the inspection process) to fully autonomous (where the system can perform inspections without any human input). For RIT the following four levels have been defined, mirroring the approach taken for maritime autonomous surface ships (MASS) as per IMO Doc. MSC 100/20/Add. 1, Annex 2:

- First Degree: RIT-survey conducted in the presence of the attending surveyor. This degree aligns explicitly with IACS Recommendation 42 and IACS UR Z17;
- Second Degree: Remote class survey with the possibility of surveyor to intervene, if necessary.
- Third Degree: Remote class survey without attending surveyor;
- Fourth Degree: RIT with automated processes and Artificial Intelligence-based machine learning operating systems to support decision-making.

1.3. Hazardous Areas

Hazardous Areas are areas where flammable or explosive gases, vapors, or dust usually are present or likely to be present (ref: ABS, s.7).

1.4. Information and Communication Technology (ICT)

Information and Communication Technology (ICT) are the technologies used in the scope of remote surveys for gathering, storing, retrieving, processing, analyzing, and transmitting information which includes both software and hardware (ref: IACS UZ29, 1.2.2).

1.5. Metadata

Metadata is data that provides information about other data.

1.6. Pilot

Pilot is the operator who directly controls the RIT.

1.7. Remote Inspection Techniques (RIT)

Remote Inspection Techniques (RIT) is a means of survey that enables examination of any part of the structure without the need for direct physical access of the surveyor (ref: IAC UZ17, s. 16.1).

RIT may include: divers, unmanned robot arm, remotely operated vehicles (ROVs), climbers, drones, or any other means acceptable to the Society (ref: IACS Rec. 42, s. 1.1 and IAC UZ17, s. 16.1);

Note 3: According to IACS (Rec. 42, s. 1), remote inspections should be carried out in the presence of the surveyor. IACS Recommendation 42 should be revised and/or complemented with other IACS instruments to allow remote surveys using RIT to be conducted without the physical presence of the surveyor being mandatory, for classification purposes. Nevertheless, surveyor presence should be required during RIT process in being onboard or on-shore to verify the process. Therefore, the word “attending” should be omitted in IACS Recommendation 42, and the word “may” be replaced with “should” so as to provide sufficient flexibility. Given that remote surveys could be surveys conducted using RIT, it is advised that RIT procedures concerning the engagement of surveyor be left open-ended to apply to the physically attending surveyor or remote surveyor.

Note 4: For vessel survey and inspection, including maintenance, stakeholders use interchangeably two technology-related terms: RIT and remote survey. However, their conceptualization should be distinguished. Remote survey is a “process of verifying that a ship and its equipment comply with the rules of the Class where the verification is undertaken, or partially undertaken, without attendance on board by a surveyor’’ (IACS UR Z29, s 1.2.1). In summary, RIT refers to robotic platforms whereas remote surveys is about being survey via ICT, and as such does not entail mobile robotic platforms. Remote survey is part of a digital service for ship owners allowing the possibility for class surveyors to perform certain types of surveys through a remote technique.

1.8. Remote Inspection Technique System (RITS)

A remote inspection technique system (RITS) is a system that utilizes the techniques specified in 1.7 and any other associated support equipment (equipment, ground control station, data links, telemetry, communication system and navigation equipment), sensors and any data analytics capability (ref: LR 1.4.7).

1.9. Remotely Operated Underwater Vehicle (ROV)

Remotely Operated Underwater Vehicle (ROV) is an unmanned unit, remotely controlled or programmed, designed for underwater observation, survey, inspection, construction, intervention, or other tasks (ref: ABS, 2022, s. 1.3).

1.10. Robotic Arm

A robotic arm is a programmable mechanical device designed to mimic the movements and functions of a human arm.

1.11. Robotic Crawler

A robotic crawler, commonly referred to as a “crawler”, is a tethered or wireless vehicle, often equipped with magnets, designed to “crawl” along a structure using wheels or tracks (ref. ABS, s.1.5)

1.12. Sensor

A sensor is an apparatus that identifies and quantifies physical properties from the environment (e.g. heat, light, sound) and transforms them into signals which can be interpreted by a person or a machine. Typical sensors deployed by RIT, as specified by LR) include: normal visual light range cameras, infrared/thermal cameras, • stereoscopic (3D) cameras, Light Detection and Ranging (LiDAR), ultrasonic testing thickness measurement (UT TM) probes and sonar (ref: LR, S.1.3.2).

1.13. Service Supplier

Service Supplier (may be referred to here after simply as ‘supplier’ or ‘provider ‘) is a person or company, who at the request of an equipment manufacturer, shipyard, vessel’s owner, RO or other client acts in connection with inspection work and provides RIT services.

1.14. Standard Operation Procedure (SOP)

Standard Operation Procedure is a detailed organizational document consisting of explicit instructions to guide employees through the consistent execution of routine tasks.

1.15. Statement of Capability

Statement of Capability is a formal document prepared by the attending surveyor upon completion of the survey to state that the inspections of steel structure is in accordance with the rules and standards of class society.

1.16. Survey

Survey is the examination of structure, with the results being compared against a specified standard. Results falling outside the specified limits are considered and decisions are made on the repairs required, deferment of repairs and the continued use of that structure (ref: LR, 1.4.9). A survey determines the extent of additional Close-up Surveys.

1.17. Survey Planning Document

Survey Planning Document is the document prepared by the owner/operator to support the survey preplanning requirements for carrying out class-related surveys. (ref: ABS, s.7).

1.18. Traditional Survey

A traditional survey is a survey conducted by a class surveyor with physical examination of the ship's structure, systems, and equipment to verify the vessel's seaworthiness and maintenance.

1.19. Ultrasonic testing thickness measurement (UT TM)

Ultrasonic testing thickness measurement UT TM is gauging the thickness of material using an ultrasonic probe (ref: LR 1.4.10)

1.20. Unmanned Aerial Vehicle (UAV)

Unmanned Aerial Vehicle (UAV) is an aircraft with no human pilot on board. A UAV controlled remotely or can fly autonomously based on a predefined flight route and/or using dynamic automation systems (ref: ABS, s. 1.1).

Note 5: The industry may refer to Unmanned Aerial Vehicles as “drones”, Remotely Operated Aerial Vehicles (ROAVs), or Unmanned Aircraft Systems (UASs).

1.21. Visual Line of Sight (VLOS) Operation

Visual Line of Sight (VLOS) are operations that always keep the UAV in the visual line of sight of the pilot. For example, UAVs are not flown into clouds or behind structures (ref: ABS, s.7).

2. Eligibility and Proof of Concept

2.1 The eligibility of the RIT with the use of UAV, ROV, crawler, drones and other means acceptable to the Society should be decided based on the type and scope of the requested survey. Equivalency of a remote survey to a traditional survey is obtained when, with the use of suitable robotic technologies and ICT, the flag State or their authorized recognized organization (RO) can perform the survey remotely to their satisfaction and being able to:

i. obtains the supporting and technical evidence required according to the applicable regulations;

ii. verify applicable survey items and relevant tests;

iii. provide the same level of assurance obtained with attendance on board by a surveyor.

Eligibility should be made based on the risk assessment criteria specified in Section 3.

Before commencing the remote survey, the RO should clearly assert its right to terminate the process if it becomes evident that the survey cannot maintain equivalence with traditional survey, particularly concerning safety standards and thoroughness.

2.2 Proof of Concept

The functional "proof of concept" for remote inspections can be accomplished through more live trials within a regulated setting. Once remote inspection technologies are widely implemented, classification societies must guarantee their strength, ensuring these technologies enable faster, safer, and more efficient ship assessments. In essence, the efficacy of these systems will be solidly affirmed once their technical robustness and data quality is demonstrated. For technical robustness, systems must operate correctly and yield consistent, exact results across repeated operations, especially if they are to be included in future "confirmatory surveys". The final step could be to initiate validation of final output through a series of tests on different types of vessels during close-up inspections and statutory surveys. The results should be compared and contrasted with data gathered through results gathered from physical surveys.

Overall, tests are to be performed in order to demonstrate that the RITS is capable of being used to find/identify the specified defects, and if applicable, is capable of quantifying/measuring those identified defects. The "proof of concept" should follow the methodology commonly known by Class Societies as the Technology Qualification Process.

3. Risk Assessment

A risk assessment approach is part of the RO's Technology Qualification Process, which should be adopted before the beginning of the RIT process, considering at least the following elements:

- Safety performance of ship, type and age of ship, records of deficiencies;
- Degree of autonomy of the RITS;
- The scope of the remote survey, with consideration to those items that could be verified remotely for compliance with the applicable requirements, to achieve the same level of assurance and equivalence when compared to physically attended surveys;
- The type of ICT to be used, including confidentiality, security of information and data protection;
- The certification of service suppliers;
- The qualification of the surveyors performing remote surveys;
- The roles and responsibilities of on-board personnel/crew, if any;
- The reporting of the remote survey as per flag State's requirements;
- Environmental conditions.

Upon completion of the risk assessment, specific procedural and technical requirements may be defined, if considered necessary by the flag State, in order to consider the proposed remote survey equivalent to a traditional survey.

It is the duty of the owner, or its representative, to inform the class society of any events or circumstances that may affect the continued conformance of the ship with Class Rules.

4. Allocation of Responsibilities

Throughout the various phases of the remote inspection process—planning, execution, and reporting—each stakeholder must have defined responsibilities and duties (ref: ABS, Section 3). The main elements to be taken into consideration by all participating personnel during the three stages of the inspection process are described below.

4.1 Pre-inspection planning phase

In the pre-inspection planning phase, a decision regarding the suitability of RIT should be made jointly between the ship owner/operator and the classification society. If the RIT is deemed appropriate, a certified service supplier should be selected. The chosen service supplier bears the responsibility for developing a comprehensive inspection plan that integrates the selected RIT tools, along with a detailed risk assessment framework. The classification society has the critical role of reviewing the "Survey Planning Document" provided by the ship operator, ensuring it adheres to established standards and rules.

In general, the following elements should be taken into consideration during the discussion session of the pre-inspection stage between the owner/operator, class, and service supplier:

- Coordinate logistical aspects of the inspection, obtaining work/site permits;
- Clarify the responsibilities of owner/operator, surveyor, and service supplier and ensure that contact information of all relevant parties has been disseminated among the team;
- Confirm the work scope of the intended RIT operations and assess the field conditions;
- Identify hazards and mitigation plans (see Section 5);
- Assess the condition of structure (clean/dirty; coated/uncoated; cargo residue, etc.);
- Confirm that enclosed spaces are free of sediments (for ROVs);
- Confirm the inspection area/tank surface is clean and devoid of mud;
- Review weather forecast and environmental conditions at the port;
- Ensure that robotic technologies have an onboard camera that provides adequate visual quality of still images, live-stream videos, and recorded videos (see Section 8);
- Initiate a test stream from the service supplier to remote surveyor to determine actual network latency;
- Verify that the ROV or robotic arm provides and maintain an interference-resistant communication channel;
- Identify sources of possible radio frequency (RF) interference, such as microwave antennas and high voltage lines;
- Consider a spectrum or Receiver Autonomous Integrity Monitoring (RAIM) analysis to determine frequency strength, integrity, and areas of possible interference;
- Specify the certified safe type electrical apparatus/smartphones which are allowed to be used for the remote surveys in hazardous areas;

- Prepare a Hazard Assessment Report before beginning the inspection, ensuring it adheres to the vessel's hazardous area plan;
- Develop an action back-up plan if the connection is lost and specify alternative forms of contact.
- clarify terms about data ownership, security and liability (see Section 9.1);
- consider data security (see Section 9.2).

For underwater inspection/in-water survey, the following elements should be additionally considered:

- Detailed plans of the hull and hull appendages (all shell openings, stem, rudder and fittings, sternpost, propeller (with identification of each blade), anodes and securing arrangements, bilge keels, welded seams and butts);
- Rudder arrangements;
- Tailshaft arrangements;
- Identification marks on the hull to facilitate the in-water survey (in particular, the positions of transverse watertight bulkheads);
- Full photographic documentations;
- Thickness readings, close-up and non-destructive testing.

The service supplier shall have documented operational procedures and guidelines for how to plan, carry out and report inspections; how to handle/operate the equipment; collection and storage of data. These shall include:

- Requirements for preparation of inspection plans when UAVs are part of the equipment flight plans;
- Operation of the remotely operated platforms;
- Operation of lighting;
- Calibration of the data collection equipment;
- Operation of the data collection equipment;
- Two-way communication between the operator, platform, surveyor, other personnel such as support staff and ships officers and crew:

The service supplier shall have a Safety Management System (SMS) providing a systematic approach to managing safety to incorporate system descriptions, risk assessment, and risk controls in their service planning documents.

4.2 Operation Phase

In the operational phase, the chosen service provider is obligated to execute the inspection according to the guidelines set forth in the “Survey Planning Document.” Simultaneously, the class surveyor on-site is tasked with supervising the RIT operations team, guaranteeing adherence to all requisite protocols and standards.

The following elements should be taken into consideration during operation phase:

- Recording of the inspection with the vessel’s name/IMO number in frame and ensure that the remote surveyor confirms before starting;

- Ensure that the Service Supplier has in place a Standard Operation Procedure (SOP) for each RIT operation that, amongst others, includes: checklist clearance for inspection condition checks, personnel readiness checks, communication checks, equipment checks;
- RIT launch and recovery zones;
- Documentation of conditions that may affect the class;
- Visual Line of Sight for UAVs to be maintained even if no regulatory requirement applies;
- Deconfliction for UAVs;
- Integrity of the raw data should be maintained during the data storage process;
- Related metadata of the raw data should be captured and stored properly.

In cases where the communication signal experiences significant interference, the operation should be aborded.

4.3 Reporting Phase

In the reporting phase, the service supplier shall send the report and data to the asset owner and class to assess if a physical or additional inspection is required. Upon satisfactory completion of the testing, as per the attending surveyor's approval, a Statement of Capability may be issued by the class. This statement should outline the specific performance criteria that the RIT system has met. The Statement may encompass various elements, including: inspection types for classification survey, inaccessibility of areas, data collection, lighting type, condition of structure, defect type, defect type quantification and automation capabilities relating to navigation, data collection and analytics.

The following elements should be taken into consideration during reporting phase:

- RIT operational details should be logged, including launch time, duration, recovery time, description of any malfunctions, anomalies, parts needing replacement and the type of work completed;
- Statement of Capability by the class;
- Battery checks should be conducted and documented.

5. Hazard Identification

Mitigation of all potential hazards that could emanate from the deployment of RIT should be addressed. Main hazards before, during and after the remote inspection are described below (ref: Pastra et al. 2024).

Hazards before the remote inspection:

- Poor familiarization of the operator and inadequate training with robotic platforms;
- Lack of a comprehensive setup of the navigational plan for the robots;
- Unsuccessful drone localization;
- Miscalibration of the drone;
- Low battery power capacity and improper storage;
- Non-regulatory compliance of drone;
- Insufficient ROV deployment;
- Transfer and adhesion of the magnetic crawler.

Hazards during the Inspection:

- Drone can turn into a falling object;
- Risk of injury from the drone propellers;
- Loss of sight of the drone;
- Recovering the ROV and magnetic crawler if the cable is tangled;
- Loss of adhesion of a wall-climbing crawler;
- Lack of water supply for the magnetic crawler;
- Damage of the hull’s paint from the magnetic crawler.

Hazards after the remote inspection

- Data quality (see Section 8);
- Data security (see Section 9).

Psychosocial hazards

- Stress of the surveyor;
- Surveyors’ knowledge may be considered obsolete;
- Cognitive inattention and errors of judgment for operators;
- Communication hazards.

Robotic technologies used in hazardous areas should be certified safe as defined in International Standards IEC 60079 that specifies the construction and testing of intrinsically safe apparatus intended for use in explosive atmospheres and for associated apparatus that is intended for connection to intrinsically safe circuits that enter such atmospheres. In hazardous areas, only certified safe type electrical apparatus/smartphones can be used for the remote surveys. In particular, they must have an explosion group and temperature class (at a reference ambient temperature of 45°C) equal to or higher than those required for the products the ship is allowed to carry.

The ship-owner/operator, class society, and service supplier must reach a consensus on the Hazard Assessment Report before beginning the inspection, ensuring it adheres to the vessel's hazardous area plan.

6. Qualification and Training

6.1 Qualification and Training of the Surveyor

The surveyors engaged in remote surveys with robotic technologies should be trained and qualified as per standard procedures of the flag State or their authorized RO.

Additional training should be carried out, covering the ICT used for the RIT, in relation to the applicable remote survey scope and methods, in order to qualify surveyors engaged in remote surveys. The additional training should include at least the following aspects:

i. knowledge of the technologies used in the survey;

ii. knowledge of the operation of the remote survey software, if applicable;

iii. knowledge of the technical and procedural aspects related to remote surveys; and

iv. knowledge of the connectivity and data/screen sharing aspects related to remote surveys.

6.2 Qualification and Training of the Firms engaged in survey using Remote Inspection Techniques

The Service Supplier is responsible for the qualification of its divers, RIT operators and supervisors and for their training in the use of the equipment utilized when carrying out inspection as specified in IACS Z17.

The supplier is to maintain a documented training plan for personnel. The plan shall include requirements for training in the minimum rule requirements for the structure of relevant ships types, the recognition of structural deterioration (including corrosion, buckling, cracking and deteriorated coatings) and use of the reporting system.

The operator carrying out the inspection, as specified in IACS Z17, shall be certified according to the recognized national requirements or an equivalent industrial standard and have had at least one year of experience as an assistant carrying out inspections of ship's, including participation in a minimum of five different assignments. The operators who are required, according to international and national legislation, to be licensed for RIT shall hold valid documentation issued by the appropriate bodies (e.g., UAV pilots are to be qualified and licensed in accordance with applicable national requirements).

6.3 Qualification and Training of the Crew Members

Remote surveys may require the cooperation of crew members; therefore, the master should ensure that crew is familiar with the remote survey process and able to understand the process with respect to tests and gathering of evidence on the condition of the vessel. The implementation of remote surveys should not constitute an undue burden to ship crew and shore-based personnel.

Suitable procedures related to the performance of remote surveys should be included in the company's Safety Management System (SMS), addressing at least the following aspects:

i. responsibility, impartiality and liability of the Company and crew/personnel involved in remote surveys;

ii. knowledge of the operation of the ICT used for remote surveys, as applicable;

iii. knowledge of the technical and procedural aspects related to remote surveys as applicable;

iv. record of training of crew/personnel involved in remote surveys for the aspects listed in the above items.

7. Information Communication Technology (ICT)

This section outlines the minimum requirements for the use of ICT that can capture images, record video and/or live stream video or other data from a ship as considered acceptable to the flag State.

7.1 Hardware

The service provider is responsible for the availability of the hardware which can be requested for the ICT used during RIT. The use of ICT should facilitate a remote collaboration between the ship, the surveyor and service supplier. Portable equipment should be equipped with a power capacity suitable for the intended scope and duration of the survey.

For live streaming two-way audio and video or other means, the following devices are normally used for effective collaboration between the operator and the surveyor, ensuring the surveyor can coordinate and drive the remote survey:

- Smart device compatible with the applicable software/technology. The smart device may be a smartphone, tablet, computer, wearable device, smart glass, digital camera, drone, or any other device which can be connected to the network and capable of transmitting the necessary video/data/images to a remote location; and
- Communication accessories like headphones and microphones for the noisy environment as applicable and as deemed necessary.

Maintenance and regular checks that the equipment is working satisfactorily should be part of the planned maintenance system of the service provider and should be recorded accordingly.

Surveyors performing remote surveys should use a computer normally with one or more screens of sufficient size, enabling them to view the evidence received from the ship to their satisfaction.

7.2 Software

The software applications for live streaming, to be downloaded onto smart devices, should provide a secure channel through which image/video/data can be shared and in accordance with the provisions of Section 9. Overall function and ability of such software applications should ensure that data security is part of the risk assessment.

The software used to perform the remote inspection may also be provided with technologies that support the surveyor in the process of decision-making, such as:

- Artificial Intelligence (AI) for the review of data;
- Internet of Things (IoT) for collecting parameters and evaluating acceptability/working condition of machinery and equipment;
- Data driven verification and self-testing systems method; or
- Sharing of ship's integrated control, monitoring and alarm system in order to view and assess data in real-time.

The above software and technologies should be evaluated and accepted by the flag State as part of the ICT.

7.3 Internet connectivity requirement

The communication system should have sufficient capacity to ensure efficient and stable online communication for the required direct color image/video streaming and voice communication from the service supplier to the attending or shore remote surveyor.

The network used to transmit data for the remote survey should have the required bandwidth in order to provide sufficient stability of the connection and allow colour video streaming of adequate resolution and frame rate from applicable locations. The communication equipment between the service supplier and surveyor, when performing live streaming, should have the following functionality in almost real time:

- Surveyor should see the same image/videos framed by the smart device;
- Delivering high-definition (HD) video;
- Delivering high-resolution photos; and
- Record videos and photos.

8. Data Quality

Digital data such as photos, live-streams, and recorded videos are the predominant outcomes of conducting RIT inspections.

The underpinning success of remote surveys is contingent on the veracity of the data collected, which refers to the extent that data is accurate, precise, and trustworthy. Veracity becomes crucial when dealing with large datasets, as the probability of encountering noise, abnormalities, and inconsistencies increases significantly.

High-veracity data ensures that assessments of a vessel's condition are correct and defects are properly identified. Ensuring data veracity requires high-definition cameras, artificial lighting and high precision sensors. Advanced image and data processing can be achieved with data localization, defect recognition and 3D scene reconstruction. 3D scene reconstruction of particular damages, via the use of high-resolution visual, thermal, LIDAR and SONAR images, facilitates the identification of crack or damage localization and thicknesses in the hull structure.

Robust drones/ROVs/crawlers and sensors can compensate for or resist environmental distortions. The resolution and sensitivity of sensors must be sufficiently high to detect minute structural anomalies, and their calibration must be regularly verified. Utilizing sophisticated data analytics tools can assist in cleaning, processing, and verifying the accuracy of data. Investing in data literacy for all the stakeholders in the inspection process ensures that those handling data understand the importance of its quality, leading to informed decision-making.

The value of “metadata”- data about data- hinges also entirely on its veracity. Metadata that includes time/date stamps, GPS location, camera orientation, focal length, shutter speed, aperture setting, ISO level, camera type, lens type, ROV orientation and depth can be generated. Veracious metadata ensures that data can be archived, retrieved, or deleted in line with the provisions specified by the involved stakeholders.

The quality/resolution of the image and video should be evaluated by the surveyor based on the items being surveyed remotely. In cases where a surveyor views data in a live format, tests should be carried out in advance to demonstrate that the presentation of data is of a quality that enables the detection of any defects.

Stored data should be geolocated and presented in a format acceptable to the Surveyor.

The flag State may also apply and define a minimum standard for the videos/photos.

9. Data Protection and Cyber Security Requirements

Remote surveys require the transfer of photos, videos, and other data across global networks. All the relevant stakeholders involved in the planning, operation, and reporting stages are advised to utilize a trusted data platform to safeguard the data generated through the systems.

The remote process should ensure that data security should be considered in advance during the pre-inspection phase. The software/application used to perform the remote survey should be compatible with the applicable technical requirements; in addition, the software used should be in compliance with the applicable:

1. Data protection and confidentiality requirements for the transmitted data; and

2. Cyber security requirements.

9.1 Data Protection

Data quality, data ownership, preservation entity, security measures, sharing, data lifecycle, copyright and data liability should be included in a contract form executed by ship owners, classification societies and service suppliers during the pre-inspection phase.

It should be noted that in cases of data streaming, the data is often in transit and may not be stored long-term; instead, it is typically stored temporarily in a transient state. Streaming data can be configured to deliver only the essential information required for a specific function or analysis, thereby reducing unnecessary exposure. This means that the hazard of access by unauthorized entities is substantially limited. In contrast, data storage solutions may present a more appealing target for unauthorized access, since they consolidate large volumes of potentially valuable data in a single location, often retained indefinitely.

9.2 Cyber Security Requirements

For cyber security, the three principles of CIA triad- Confidentiality, Integrity and Availability- should serve as the fundamental blueprint that encapsulates the core principles essential to any robust cybersecurity strategy. As cyber threats continue to evolve in sophistication, adherence to the CIA triad remains the essential strategy to defend against the myriad of risks threatening the sanctity of the data and information systems.

i. Confidentiality: measures used to ensure data privacy by preventing unauthorized access. These measures may include passwords, biometric verification, cryptographic keys, regular updating and patching of security systems to ward off intrusions.

ii. Integrity: measures to maintain the accuracy and reliability of data throughout its lifecycle. The measures may include version control to keep track of modifications, access restrictions to prevent unauthorized personnel from modifying sensitive data, utilization of cryptographic hash functions to detect unauthorized changes.

iii. Availability: measures to ensure that the authorized users should be able to access data whenever needed. Measures may entail backups to provide access to information even during hardware failures or cyberattacks.

To mitigate unexpected issues related to non-personal asset data, five simultaneous functional components should be taken into account as specified by resolution MSC.428(98) on Maritime cyber risk management in safety management systems and MSCFAL.1/Circ.3/Rev.1 on Guidelines on maritime cyber risk management.:

- Identify: Define personnel roles and responsibilities for cyber risk management and identify the systems, assets, data and capabilities that, when disrupted, pose risks to ship operations;
- Protect: Implement risk control processes and measures (i.e. cryptographic mechanisms), and contingency planning to protect against a cyber-event and ensure continuity of shipping operations;
- Detect: Develop and implement activities necessary to detect a cyber-event in a timely manner;

- Respond: Develop and implement activities and plans to provide resilience and to restore systems necessary for shipping operations or services impaired due to a cyber-event; and
- Recover: Identify measures to back-up and restore cyber systems necessary for shipping operations impacted by a cyber-event (IMO, 2017).

Cyber security should also be reviewed against vessel's systems vulnerabilities and limitations. Navigation, cargo and main engine electronic equipment are sensitive and the interaction with RIT may affect their performance.

10. Liability

10.1 The Evolving Legal Regime for Liability

It is imperative to situate inquiries concerning the legal liability of RIT within the broader context of risks and hazards identified in section 5.

1. RIT are operated using (battery-produced) “electricity” – that is viewed as a product pursuant to Article 2 of Directive 85/374/EEC (ref: Johansson et al., 2022 and Article 4 of (COM (2022) 495)). Although this needs to be further substantiated, the preliminary connection is clear. The Directive, common rules on the liability of economic operators for damage suffered by natural persons caused by defective products. Article 10 of the Proposal for the revised Directive gives resort to the defense mechanism of manufacturers, stating that the manufacturer shall not be liable as a result of this Directive if he is able to prove that:

a) he did not put the product into circulation; or

b) having regard to the circumstances, it is probable that the defect which caused the damage did not exist at the time when the product was put into circulation by him or that this defect came into being afterwards; or

c) the product was neither manufactured by him for sale or any form of distribution for economic purpose nor manufactured or distributed by him in the course of his business;

d) that the defect is due to compliance of the product with mandatory regulations issued by the public authorities;

e) the objective state of scientific and technical knowledge at the time when the product was placed on the market, put into service or in the period in which the product was within the manufacturer’s control was not such that the defectiveness could be discovered; or

f) in the case of a manufacturer of a component, that the defect is attributable to the design of the product in which the component has been fitted or to the instructions given by the manufacturer of the product.

2. Nevertheless under Art. 10 para 2, by way of derogation from paragraph 1, point (b) above, an economic operator shall not be exempted from liability, where the defectiveness of the product is due to any of the following, provided that it is within the manufacturer’s control: (a) a related service; (b) software, including software updates or upgrades; or (c) the lack of software updates or upgrades necessary to maintain safety.

3. Accordingly, in the EU AI Liability Directive, where it is excessively difficult for the claimant to prove the causal link between the fault and damage, the causal link is presumed. In particular, when it comes to high-risk AI systems as defined in the Proposal for a Regulation laying down harmonized rules on Artificial Intelligence (Artificial Intelligence Act/ AI Act) COM/2021/206 final). Art 4 of the AI Liability Directive

establishes the fault consisting in the non-compliance with a duty of care laid down in Union or national law directly intended to protect against the damage that occurred is presumed in the following circumstances:

a) the AI system is a system that makes use of techniques involving the training of models with data and which was not developed on the basis of training, validation and testing data sets that meet the quality criteria referred to in [Article 10(2) to (4) of the AI Act];

(b) the AI system was not designed and developed in a way that meets the transparency requirements laid down in [Article 13 of the AI Act];

(c) the AI system was not designed and developed in a way that allows for an effective oversight by natural persons during the period in which the AI system is in use pursuant to [Article 14 of the AI Act];

(d) the AI system was not designed and developed so as to achieve, in the light of its intended purpose, an appropriate level of accuracy, robustness and cybersecurity pursuant to [Article 15 and Article 16, point (a), of the AI Act];

or

(e) the necessary corrective actions were not immediately taken to bring the AI system in conformity with the obligations laid down in [Title III, Chapter 2 of the AI Act] or to withdraw or recall the system, as appropriate, pursuant to [Article 16, point (g), and Article 21 of the AI Act].

3. In the case of a claim for damages against a user of a high-risk AI system subject to the requirements laid down in chapters 2 and 3 of Title III of [the AI Act], the condition of paragraph 1 letter (a) shall be met where the claimant proves that the user:

(a) did not comply with its obligations to use or monitor the AI system in accordance with the accompanying instructions of use or, where appropriate, suspend or interrupt its use pursuant to [Article 29 of the AI Act]; or

(b) exposed the AI system to input data under its control which is not relevant in view of the system's intended purpose pursuant to [Article 29(3) of the Act].

10.2 Liability of original equipment manufacturers (OEMs)

The original equipment manufacturers (OEMs) of RIT could follow internationally agreed and accepted requirements for safe commercial operations, such as standards developed by the International Organization for Standardization (ISO). Whether a manufacturer is liable will depend on the circumstances and whether relevant international or industry product specification standards have been violated.

During the design phase, manufacturers of RIT should exercise due diligence to ensure that connectivity will, under no circumstances, compromise safety (of the product) or data accuracy. In tandem, manufacturers should ensure transparency, accountability, and responsibility for all intelligent information systems that are developed. Certified products following international standards should be provided by manufacturers and subsequently, deployed by end-users. From a RIT perspective, service suppliers should ensure prescribed equipment safety standards for hardware and software. All systems should be rated against intended operational environment (intrinsically safe in hazardous areas, operational wind speed, etc.).

It is important to note that any progress in terms of “degree of autonomy” inevitably raises the question of who is responsible if RIT should violate a contractual obligation; therefore, clarity on responsibility in connection with the use of remote systems is a requisite. Clearly embedded provisions in the contract should specify the liable party (manufactures, developer of the AI system or pilot of the drone) in different scenarios when a RIT operated by a pilot, or a fully autonomous RIT drops, crashes and causes damage. The different scenarios include but are not limited to collisions with asset structures, collisions due to malfunction of the equipment or unexpected or unforeseen incidents occurring in cases where visual line of sight (VLOS) is not maintained.

Regardless of how provisions on liability take shape in the long run, service suppliers should secure third-party public liability insurance and professional indemnity insurance for protect against legal liability for third party property damage or injury whilst using RIT.

7. Conclusions & Ways Forward: Extracting key International Stakeholder Recommendations from WMU-GOI-BUGWRIGHT2 Forum

7.1 Introduction: Forum Background

The BUGWRIGHT2 Forum was conducted on 16 February 2024, in accordance with the Chatham House Rule, as part of the culminating efforts of the WMU-GOI BUGWRIGHT2 project, a member of the consortium established by the European Union Horizon 2020 (under Grant Agreement no. 871260), concluding on 31 March 2024. The Chatham House Rule reads as follows, "When a meeting, or part thereof, is held under the Chatham House Rule, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed". Therefore, in the spirit of upholding the rule this report will not disclose the identity of the panelists and moderators.

The Forum, convened at the venue provided by the DANAOS Research Centre, aimed to extend to consultation and engagement with maritime national and international high-level experts for the European Union's Horizon 2020 (H2020) funded project titled "Overcoming Regulatory Barriers for Service Robotics in an Ocean Industry Context" (BUGWRIGHT2), to enhance the competitiveness of the European robotics technology.

The aim was also to deliberate upon the strengths, weaknesses, obstacles and prospects stemming from implementing technology and techniques within the maritime and oceanic realm. The Forum was in the format of moderator-led panel discussions with the experts.

7.2 Keynote Addresses

7.2.1 Maximo Q. Mejia, Jr, Professor, President, World Maritime University

The WMU BUGWRIGHT2 Forum witnessed a momentous keynote address delivered by President Max Mejia, President of the World Maritime University (WMU). President Mejia commenced his speech by expressing heartfelt gratitude to the panel speakers, esteemed participants, and the gracious hosts at the DANAOS Research Centre for their invaluable support in ensuring the success of the forum. Special acknowledgment was extended to Dr. John Costas for his presence. In his role as President of WMU, President Mejia welcomed attendees to the forum, emphasizing its significance as a platform to address a timely and crucial topic. The overarching theme focused on the intersection of innovation, technology, and collaboration in shaping the future of maritime industries.

President Mejia eloquently underscored the historical context of embracing innovation as a catalyst for progress, from the industrial revolution to the digital age. Positioned at the threshold of a robotics revolution, he painted a vision of a future where machines collaboratively enhance human lives, with a particular emphasis on the maritime and ocean domains. The vast challenges and opportunities presented by the oceans were acknowledged, highlighting the potential of integrating service robotics in underwater exploration, offshore operations, and environmental monitoring. The crucial role of data acquisition in enhancing the intelligence of these machines was emphasized, positioning it as a cornerstone for navigating dynamic environments and complex tasks. The President articulated the broader promise of service robotics in addressing global challenges, including critical data acquisition for decision-making, disaster response, and resource management. However, he equally emphasized the responsibility to wield these technologies ethically, equitably, and sustainably. A significant portion of President Mejia's address focused on addressing regulatory barriers hindering the integration of service robotics in ocean industries. He called for a collective effort to bridge the digital divide between developed and developing nations, emphasizing the importance of universal access to digital resources.

Within the context of the BUGWRIGHT2 Forum, President Mejia highlighted the research undertaken by WMU-Sasakawa Global Ocean Institute on vessel survey and inspection, providing a comprehensive overview of the findings. As the forum transitioned into discussions, President Mejia encouraged active participation from the distinguished speakers, emphasizing the wealth of knowledge and expertise in the room. He urged collective efforts to formulate strategies that would not only navigate the regulatory seascape but also contribute to reshaping it for the betterment of industries, societies, and the planet. In conclusion, President Mejia emphasized the critical juncture at which the participants stood, emphasizing the need for collective wisdom, determination, and shared vision to bring about transformative changes. The overarching theme of trust was brought to the forefront, urging participants to deliberate on ways to ensure that innovations uphold cherished values and ethics.

President Max Mejia's keynote address set a tone of optimism, collaboration, and responsibility, positioning the BUGWRIGHT2 Forum as a pivotal moment in shaping the future of maritime industries. The discussions that followed were marked by insightful contributions from international experts, fostering an environment of shared knowledge and collaborative action.

7.2.2 Leonidas Dimitriadis-Evgenidis, IMO Goodwill Maritime Ambassador, Chairman of Management Committee (Eugenides Foundation)

The WMU BUGWRIGHT2 Forum witnessed a thought-provoking address by Mr. Leonidas Dimitriadis-Evgenidis, the IMO Goodwill Maritime Ambassador. Acknowledging President Mejia, Professor Ronan Long, the distinguished audience, and expressing gratitude to Aspasia for orchestrating the event, Mr. Dimitriadis-Evgenidis set the stage for a discourse on the transformative era underway in the maritime industry.

With a nod to the Sasakawa approach, he lauded the collaborative synergy between academia and industry. The Ambassador underscored the critical role of impactful studies and strategic planning in Greek shipping, emphasizing their pivotal role in shaping successful outcomes. Mr. Dimitriadis-Evgenidis delved into the central theme of the maritime industry's evolution, propelled by autonomous ships, sophisticated robotics, and the revolutionary power of artificial intelligence (AI). He articulated the potential of these technologies to redefine maritime operations, introducing unprecedented efficiency, sustainability, and safety. Of notable mention was the Ambassador's emphasis on the paramount importance of safety, cautioning against its oversight in the pursuit of environmental objectives. Safety, he contended, must remain a pivotal consideration in all maritime operations.

Addressing the advent of Maritime Autonomous Surface Ships (MASS), Mr. Dimitriadis-Evgenidis advocated for a balanced transition that complements human involvement rather than rendering it obsolete. He staunchly affirmed the ongoing significance of human insight, judgment, and intervention capabilities, particularly in complex or unforeseen maritime scenarios.

The Ambassador explored the diverse applications of robotics in the maritime setting, extending beyond hull inspection to encompass tasks such as cleaning biofouling and monitoring underwater infrastructure. He underscored the potential of AI in automating decision-making processes, reducing the burden of routine tasks, and optimizing operational efficiency. Recognizing the vast opportunities presented by these technologies, Mr. Dimitriadis-Evgenidis also highlighted the imperative to address challenges, including cybersecurity, legal liability, ethical considerations, and the societal impact of automation. He stressed the need for a multifaceted approach, collaboration with industry stakeholders, and the development of robust legal and ethical frameworks. Acknowledging the International Maritime Organization's commitment to fostering innovation while upholding safety, security, and environmental protection standards, the Ambassador emphasized alignment with the IMO's efforts. He particularly noted the organization's active engagement in developing a regulatory framework to address the unique challenges posed by autonomous ships and AI. In conclusion, Mr. Dimitriadis-Evgenidis touched upon the imperative of addressing employment and skill evaluation in light of technological advancements. He advocated for comprehensive reskilling and upskilling programs, underscoring the role of vocational training in preparing the maritime workforce for the future.

The Ambassador concluded by expressing optimism and unity in navigating the complexities of technological evolution, guided by the IMO and the collective will of the maritime community. The address set the stage for rich discussions and innovative solutions as the maritime industry strives for a more efficient, safe, and sustainable future. Furthermore, Mr. Dimitriadis-Evgenidis provided insights into the Eugenidis Foundation's active engagement in technological projects, particularly its involvement in the Hydro-robots project with MIT and collaboration with companies in various initiatives related to inspection and underwater cleaning.

7.2.3 Ronán Long, Professor, Director, WMU-Sasakawa Global Ocean Institute, World Maritime University (WMU)

In a highly anticipated and insightful address, Ronan Long, the Director of WMU – Sasakawa Global Oceans Institute, expressed gratitude to Ambassador Dimitriadis-Evgenidis and commenced his remarks by acknowledging the distinguished participants, especially President Mejia, who took valuable time out of his busy schedule to join the forum in the Hellenic Republic.

Highlighting the significance of convening the forum in the birthplace of global shipping, Long extended an invitation to all participants to visit the World Maritime University in Sweden, underscoring its role as a global institution dedicated to maritime education and research. Despite the challenges imposed by the pandemic, the event marked a crucial juncture in the BUGWRIGHT2 project. Director Long extended his appreciation to the DANAOS Corporation for hosting the event, acknowledging the valuable insights shared by the President and CEO during discussions the previous night. The interconnectedness of the Hellenic Republic and the International Maritime Organization was emphasized, framing the forum within the context of the global maritime community. Ambassador Hasanathi from Sri Lanka received a warm welcome for contributing valuable time to the event. Special mention was made of the local host, Nikos, and the meticulous preparations evident throughout the months leading up to the forum.

The Director also recognized the contributions of Cedric and Laura, acknowledging their leadership in steering the project. Expressing gratitude to Elnaz, Flavia, Mercedes, and the support team for their organizational efforts, Long extended a welcome to the global audience participating virtually, emphasizing the forum's global significance. Long extended a special welcome to the director of IMLI, Norman, acknowledging the challenges faced in attending the event and expressing anticipation for the insights to be shared. Before delving into the subject matter, Long presented a disclaimer, clarifying that the views expressed were academic and not indicative of the European Union or the International Maritime Organization. He recognized the substantial European funding for the project and applied the Chatham

House rule to academic endeavors. Reflecting on the project's inception, Long recounted its alignment with discussions at the European Parliament on enhancing the competitiveness of European shipping. He highlighted the critical role of robotics in the future of shipping, setting the stage for the BUGWRIGHT2 project. He emphasized the project's contribution to eco-friendly, smarter, and safer shipping, resonating with Ambassador Dimitriadis-Evgenidis's emphasis on safety. He underscored the role of these technologies in decarbonizing the industry and their crucial role in conserving biodiversity, citing the BBNJ agreements.

The Director highlighted the urgency of addressing the triple planetary crisis, integrating discussions on climate change, loss of biodiversity, and marine pollution. He emphasized the pivotal role of technology in mitigating these challenges and the importance of technology transfer mechanisms. Addressing the audience, Long posed a question about the BBNJ agreement, introducing its significance in international law and its potential connection to the BUGWRIGHT2 project. He reported the current status of the agreement and its focus on capacity building and technology transfer.

Long conveyed the project's commitment to empowering women in science, emphasizing the role of women scientists in international agreements. He acknowledged ongoing projects related to land-to-sea interfaces, empowerment of women, and the results to be presented at upcoming conferences. In conclusion, Professor Long expressed gratitude to the consortium, especially Tafsir and Aspasia, for their leadership. He praised their efforts and achievements in bringing together such a distinguished group. Long eagerly anticipated the ensuing discussions and insights from the participants. The address by Ronan Long set a comprehensive foundation for the forum, combining gratitude, acknowledgment of key stakeholders, project context, legal disclaimers, and a deep dive into the thematic areas of the BUGWRIGHT2 project.

7.2.4 Tafsir Matin Johansson, Assistant Professor, WMU-Sasakawa Global Ocean Institute, World Maritime University (WMU)

In an august gathering, Assistant Professor Tafsir Matin-Johansson, the Principal Investigator of the BUGWRIGHT2 Project, extended his gratitude to the Honorable President, the Director, moderators, distinguished panel speakers, and the esteemed audience. Commencing with a quote attributed to Niccolò Machiavelli, he remarked, "There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things."

With palpable anticipation in the air, Tafsir Matin-Johansson painted a vivid picture of the forum as more than a mere confluence of minds. It emerged as a convergence of diverse perspectives, a crucible for ideas, and a celebration of innovation dedicated to progress. The BUGWRIGHT2 Project, in his eloquent portrayal, transcends the ordinary, projecting a future where technology is not a predetermined solution but an outcome of a co-evolutionary process within a dynamic environment. Citing examples from the maritime domain, Dr Johansson delved into impactful statistics about the global fleet, elucidating the environmental implications of a thin layer on the hull surface. With a clear vision of the future, he quoted the BUGWRIGHT2 objective, envisioning teams of robots inspecting and cleaning ship hulls with minimal downtime, promising safety and enhanced competitiveness. Acknowledging the formidable challenges, ranging from technological disruptions to global disparities, Dr. Johansson posed essential questions about the indispensability of technology and the sufficiency of human efforts. These questions, he emphasized, guided the development of thematic strands for the panel discussions, creating a framework for nuanced exploration.

Furthermore, Dr Johansson quoted a notable objective from BUGWRIGHT2, articulated by Cedric, envisioning a future where teams of robots inspect and clean ship hulls efficiently during docking, anchoring, or mooring, leading to safer and more competitive ships. He supported this vision with compelling data, mentioning that a mere 0.5 millimeters layer on 50% of the hull surface could increase greenhouse gas emissions by 20 to 25%, highlighting the urgency for technological intervention. Concluding with humility and gratitude, Dr. Johansson extended sincere thanks to the attendees, both physical and virtual, and expressed particular appreciation for the DANAOS Research Centre for warmly opening its doors to the World Maritime University and honored guests. Concluding with hopes for a successful event, he thanked everyone for their presence and engagement, leaving a thoughtful and appreciative note to resonate in the minds of the audience.

7.2.4 Key Take-aways & Recommendations

President Max Mejia's keynote address at the WMU BUGWRIGHT2 Forum laid the groundwork for a transformative and collaborative discussion on the future of maritime industries. Mejia's expression of gratitude to panel speakers, participants, and hosts underscored the collective effort behind the forum's success. Emphasizing the significance of addressing the timely theme of innovation, technology, and collaboration, President Mejia painted a vision of a future where service robotics enhance human lives, particularly in the maritime and ocean domains. He highlighted the potential of integrating service robotics in underwater exploration, offshore operations, and environmental monitoring, stressing the importance of ethical and sustainable implementation. The President's call to bridge the digital divide and address regulatory barriers showcased a commitment to universal access and responsible technology deployment.

The discussions transitioned to the research undertaken by WMU-Sasakawa Global Ocean Institute on vessel survey and inspection, demonstrating the practical implications of the forum's theme. President Mejia encouraged active participation, emphasizing the wealth of knowledge in the room. His concluding remarks focused on the critical juncture at which participants stood, urging collective wisdom, determination, and a shared vision for transformative changes. The overarching theme of trust was emphasized, reinforcing the need for innovations aligned with cherished values and ethics.

Mr. Leonidas Dimitriadis-Evgenidis, IMO Goodwill Maritime Ambassador, provided a thought-provoking address, acknowledging collaboration between academia and industry in Greek shipping. His exploration of the maritime industry's evolution, driven by autonomous ships, sophisticated robotics, and AI, highlighted the potential for unprecedented efficiency, sustainability, and safety. The Ambassador stressed the ongoing importance of human insight, judgment, and intervention capabilities, particularly in complex maritime scenarios. He addressed challenges, including cybersecurity, legal liability, and ethical considerations, advocating for collaboration, robust legal frameworks, and alignment with IMO efforts. Mr. Dimitriadis-Evgenidis concluded by emphasizing the imperative of comprehensive reskilling and upskilling programs for the maritime workforce in the face of technological advancements.

Director Ronan Long expressed gratitude and acknowledged key stakeholders at the BUGWRIGHT2 Forum, positioning the event in the birthplace of global shipping. Long highlighted the interconnectedness of the Hellenic Republic and the International Maritime Organization, emphasizing the global significance of the forum. He recognized contributions from the project leadership, support team, and virtual participants. Long provided a comprehensive overview of the BUGWRIGHT2 project's inception, aligning with discussions on enhancing the competitiveness of European shipping. He stressed the project's contribution to eco-friendly, smarter, and safer shipping, aligning with global goals such as decarbonization and biodiversity conservation. Long posed questions about the BBNJ agreement, connecting it to the project's thematic areas and emphasizing the urgency of addressing the triple planetary crisis. He concluded by expressing gratitude to the consortium, anticipating insightful discussions and contributions from participants.

Overall, the addresses by President Max Mejia, Mr. Leonidas Dimitriadis-Evgenidis, and Director Ronan Long set a tone of collaboration, responsibility, and optimism, establishing the BUGWRIGHT2 Forum as a crucial platform for shaping the future of maritime industries.

7.3 Panel One: Rise of Maritime Robotics: Because Humans Were not Sufficient?

7.3.1 Moderator's Remarks

The moderator, extending greetings to the esteemed participants on-site and the virtual audience of 250 individuals, set the stage for an engaging morning. With a warm acknowledgment to all present, including dignitaries, colleagues, and participants, the moderator embarked on the unveiling of the distinguished panelists.

The panel boasted a diverse line-up, including an academic luminary renowned for robust research in robotics and autonomy, specifically serving as the coordinator of the esteemed European Union BUGWRIGHT2 Project. Complementing this academic prowess was a professor of business psychology, another key contributor to the BUGWRIGHT2 project. Additionally, the panel featured an international law expert and an industry veteran with extensive experience in maritime workforce training.

To guide the audience into the heart of the discussion, the moderator emphasized the focus on the robotic technologies within the BUGWRIGHT2 project. Drones took center stage, with a spotlight on their inspection capabilities for vessel hulls and enclosed areas. Underwater drones designed for hull inspection and magnetic rollers equipped for hull cleaning from bio-fueling showcased the multifaceted applications of these technologies, extending beyond maritime to sectors like port security and monitoring.

7.3.2 Discussions

The session unfolded with a brief round of questions, beginning with an inquiry into the current level of autonomy of these technologies.

The academic panelist, acknowledging the context-dependent nature of autonomy levels, indicated a range of two to three in industry settings. Conversely, academia showcased higher autonomy levels of five to seven, albeit within controlled testing environments.

Shifting gears, the international law expert delved into the readiness of the regulatory framework to integrate these technologies. Emphasizing the reactive nature of law to technological advancements, considerations of control, decision-making, and responsibility were highlighted. On a scale of one to seven, the regulatory framework was cautiously positioned between five and six, underscoring the necessity for thoughtful implementation and comprehensive training.

The floor then opened to the human experts, with a statement on the integration of robotics potentially leading to significant job displacement in the maritime industry. The expert in psychology diplomatically expressed that while there would be a shift in tasks between humans and robots, it wouldn't necessarily lead to displacement. The sentiment echoed by the industry expert, who envisioned a transformative shift rather than outright displacement, grounded in the understanding that humans play a pivotal role in creating the very robots that might redefine their roles.

The moderator, heralding positive news for the human element, steered the discussion into the realm of necessity. The question posed to the panelists was direct – why do we need robotics when humans are not deemed insufficient? Each panelist provided a nuanced perspective on the benefits these robotic technologies bring to the maritime sector.

The first speaker elucidated on the three D's – Dull, Dangerous, and Dirty tasks, emphasizing that robots excel in scenarios where human intervention might pose risks. Highlighting the hazards associated with ship hull inspection, especially in hard-to-reach places like ballast tanks, the speaker underscored the need for traceable, repeatable, and exhaustive tasks – qualities inherent in robotic systems. The human, far from being deemed insufficient, was positioned out of harm's way.

From a human factor perspective, Speaker Three accentuated safety and performance increase as major benefits. While acknowledging the benefits, the speaker delved into the "automation conundrum" in psychology, emphasizing the delicate balance between benefits and limitations, especially as humans are gradually removed from the decision-making loop.

The legal expert emphasized safety as a paramount benefit, extending beyond the ship to include the personnel involved in operations. Stressing the historical link between labor rights and working conditions, the expert acknowledged the potential for technology and robotics to enhance safety. However, a cautionary note was sounded – the ultimate control over robots' rests with humans, and intervention might be necessary in precarious situations.

Speaker Four, representing a classification society, enumerated safety as the foremost advantage, emphasizing the minimization of risks for surveyors in challenging scenarios. While drones guided by humans streamlined inspections, environmental aspects and economic savings were deemed crucial pillars of benefit. The human's integral role, even in the guidance of drones, was reiterated.

As the dialogue unfolded, the panelists collectively reiterated the perpetual presence of the human element in the deployment of autonomous systems. Contrary to envisioning a future devoid of human operators, the consensus was that humans would retain a crucial role in managing and overseeing these technologies.

With the foundation laid, the moderator pivoted to the next question – an exploration of the limitations accompanying the deployment of these technologies.

The first speaker initiated the discourse by touching upon engineering aspects and legal regulations. Noting the current challenges, including the intricate balance between cost and benefits and the difficulty for SMEs to deploy complex systems, the speaker emphasized the necessity for democratizing access to technology. Moreover, the sensitivity around sharing data in the maritime industry emerged as a limitation, especially when data plays a pivotal role in conducting inspections. The need to establish secure mechanisms for data sharing within an ecosystem of users was highlighted.

In the discussion on limitations, the third speaker, representing the Human Factors perspective, shed light on the creation of new stressors induced by automated scenarios. Challenges included stress from leftover tasks, potential boredom in mundane automated activities, and the shift to high-stakes responsibilities in uncertain situations. The need to balance and evolve human skills within the evolving landscape of automated tasks was also emphasized.

The second speaker delved into foreseeability as a key challenge in automated situations, emphasizing the unpredictability of real-world scenarios and the need for swift reactions to unexpected situations. Complacency was identified as a potential issue, with focus placed on the ability of individuals accustomed to automated processes to adapt to deviations from the norm.

The fourth speaker underscored the absence of standardization in creating drones and automation systems, emphasizing the challenge posed by divergent setups without standardized norms. Data sensitivity within the maritime industry, hindering the sharing of crucial information for inspections, was recognized as a significant limitation.

Transitioning to the topic of trustworthiness, the first speaker, focusing on the engineering side, delineated three pillars: reliability, precision, and efficiency/understandability. Cautioning against over-trust, the speaker highlighted the importance of avoiding the elevation of technology to an infallible entity. The human factor was stressed, emphasizing the need for users to comprehend and build a mental model of the technology's operations.

The third speaker, with extensive research on trustworthiness, delved into different levels and perspectives of trust. The trustee roles, including inspectors, surveyors, operators, and ship owners, were identified, each with distinct perspectives on trust. Calibrated trust, avoiding both over-trust and distrust, was considered vital. Factors influencing trust included cognitive aspects like performance, understanding processes, and purpose, as well as design factors such as the level of control.

The international law expert simplified trustworthiness as reliability and risk management from a legal standpoint. The focus on the management of risk, including calculating potential malfunctions and their impact, aligned with the legal approach of creating rules based on data provided by technology experts. Safety and liability were deemed paramount, with the possibility of avoidance if risks reached untenable levels.

Continuing the discourse, the fourth speaker took the baton and addressed the institutional aspects surrounding the integration of robotics in the maritime sector. Drawing attention to the proactive or inept nature of institutions, the speaker highlighted the absence of incident reporting mechanisms for robotic applications. The crucial need for a comprehensive database to document incidents and facilitate corrective measures was emphasized. The speaker echoed the sentiment of the first speaker regarding data management, transparency, and trust. Proposing the establishment of a database accessible to organizations for the collective benefit of the industry while safeguarding commercial interests and competitiveness.

The issue of data ownership and intellectual rights surfaced in the discussion, pointing out the necessity to determine who owns the results of the process and ensuring ethical governance of artificial intelligence. Aligning with global sustainability targets, the speaker underscored the importance of ethical considerations in deploying artificial intelligence as a tool and enabler.

The moderator acknowledged the complexity of data integration and ownership, particularly in the context of diverse classification societies maintaining separate databases. The need for a unified approach to leverage data for the industry's benefit was recognized as a significant challenge.

Transitioning to the final question, the moderator acknowledged the richness of the discussion and the potential for extended discourse. However, time constraints led to the pivotal question: What have we learned from the BUGWRIGHT project over the past four years, and how can these learnings pave the way for future projects?

The inquiry delved into the accumulated knowledge and experiences derived from the project, inviting the panelists to distil insights that could guide and enrich subsequent endeavors in the evolving landscape of maritime robotics. Speaker One reflected on the meta-level observations, highlighting the yet unproven value for money in robotics autonomy, specifically in uncontrolled inspection scenarios. Expressing concerns about the prevailing complexity in robotic inspection technology, the speaker emphasized the need for simplicity to make such systems accessible to Small and Medium-sized Enterprises (SMEs) and various stakeholders. Envisioning an ecosystem of SMEs collaborating seamlessly on different aspects of tasks, the speaker underscored the importance of traceability and localized history for effective risk management.

From the perspective of a work psychologist, Speaker Three provided three key points. Firstly, advocating for a task-specific approach rather than general discussions on the benefits and limitations of robots.

Stressing the importance of focusing on the primary task, Speaker Three emphasized the need to avoid excessive secondary tasks that may introduce hassle and stress. Secondly, highlighting the human aspect within a social-digital system, the speaker underlined the complexity of interactions, needs, skills, and knowledge within the entire system, extending beyond the technological realm.

Lastly, Speaker Three emphasized the need for experiential learning, acknowledging the value of mistakes, setbacks, and practical applications to move forward and overcome limitations.

Speaker Two, who was not part of the project, shared insights on the importance of asking the right questions rather than seeking definitive answers. Emphasizing the role of ethical considerations, the speaker stressed the need to consciously choose directions that align with ethical standards. Proposing a series of projects, Speaker Two highlighted the enduring nature of certain questions while acknowledging the evolving content and strategies necessary for new projects.

Building on the previous discussions, Speaker Four delved into the specificity of automation levels required for distinct tasks. Expressing agreement with previous sentiments, the speaker emphasized the need for a targeted approach to automation in various tasks.

The Moderator, summarizing the discussion, reiterated the paramount importance of the human element in conjunction with technology. Envisioning a future where robots collaborate with humans, freeing them from mundane and unsafe tasks, the Moderator expressed hope for a more sustainable industry in the impending fifth industrial revolution. Appreciating the attendees for their participation, the Moderator concluded the session.

7.3.3 Key Take-aways & Recommendations

• Emphasizing the perpetual presence of the human element in the deployment of autonomous systems, there is a need to balance and evolve human skills within automated scenarios;

• The challenges induced by automated scenarios include stress from leftover tasks, potential boredom, and the shift to high-stakes responsibilities in uncertain situations;

• The challenge of foreseeability in automated situations, emphasizing the unpredictability of real-world scenarios and the need for swift reactions to unexpected events. Complacency among individuals accustomed to automated processes was noted as a potential issue;

• The absence of standardization in creating drones and automation systems, pointing out the challenge posed by divergent setups without standardized norms. Data sensitivity within the maritime industry, hindering the sharing of crucial information for inspections, was recognized as a significant limitation;

• The importance of experiential learning was emphasized, recognizing the value of mistakes, setbacks, and practical applications to move forward and overcome limitations. Specificity of automation levels required for distinct tasks was highlighted;

• Envisioning a transformative shift rather than outright displacement of jobs, the discussions were grounded in the understanding that humans play a pivotal role in creating the very robots that might redefine their roles.

The panel discussion provided valuable insights into the current state of autonomy in maritime robotics, shedding light on diverse perspectives from academia, industry experts, psychologists, and legal authorities. One key takeaway is the nuanced understanding of autonomy levels, with industry settings leaning towards lower autonomy (two to three) compared to the higher levels (five to seven) observed in controlled academic environments. This disparity underscores the context-dependent nature of autonomy, urging a tailored approach in different domains.

A crucial aspect explored was the readiness of regulatory frameworks to integrate these technologies. The consensus positioned the regulatory framework cautiously between five and six, emphasizing the need for thoughtful implementation and comprehensive training. The discussion highlighted the dynamic nature of law, which responds reactively to technological advancements, necessitating continuous adaptation to ensure effective control, decision-making, and responsibility.

The concern over potential job displacement in the maritime industry due to robotics was addressed with a balanced perspective. Experts indicated a transformative shift rather than outright displacement, emphasizing the integral role of humans in creating and overseeing the very robots that redefine their roles. This sentiment aligns with the broader theme that emerged throughout the session - the perpetual presence of the human element in the deployment of autonomous systems.

The benefits of integrating robotics in the maritime sector were thoroughly explored by panelists. The three D’s - Dull, Dangerous, and Dirty tasks - were highlighted as scenarios where robots excel, emphasizing the need for traceable, repeatable, and exhaustive tasks. Safety and performance increase were underscored from a human factor perspective, with a cautious exploration of the “automation conundrum” in psychology, stressing the delicate balance between benefits and limitations.

On the topic of limitations, the discussion touched upon engineering challenges, legal regulations, and foreseeability issues. The need to democratize access to technology, establish secure mechanisms for data sharing, and address new stressors induced by automated scenarios were emphasized. Standardization in creating drones and automation systems, coupled with challenges in data sensitivity, were recognized as significant limitations.

Trustworthiness emerged as a critical theme, with a focus on reliability, precision, and efficiency in engineering. The importance of calibrated trust, considering different perspectives within the maritime ecosystem, was highlighted. Legal experts emphasized trustworthiness as reliability and risk management, aligning with a safety-first approach and the creation of rules based on technology expert data.

The institutional aspects surrounding robotics integration were discussed, emphasizing the need for incident reporting mechanisms and a comprehensive database to document incidents. The issue of data ownership and intellectual rights surfaced, emphasizing the importance of ethical governance in deploying artificial intelligence.

Insights derived from the BUGWRIGHT project over the past four years were distilled by panelists to guide future projects. These insights included the unproven value for money in robotics autonomy in uncontrolled scenarios, the necessity for simplicity to make systems accessible to SMEs, and the importance of experiential learning. The significance of a task-specific approach, understanding the human aspect within social-digital systems, and the enduring nature of ethical considerations in asking the right questions were also highlighted.

In conclusion, the panel discussion reinforced the centrality of the human element in the integration of maritime robotics, envisioning a collaborative future where robots and humans work together for a more sustainable industry. The rich exchange of perspectives and the identification of challenges and opportunities provide a solid foundation for future endeavors in the evolving landscape of maritime robotics.

7.4 Panel Two: Confronting Global Environmental Challenges with Innovation

7.4.1 Moderator's Remarks

The Moderator opened Panel 2 with a warm welcome to the attendees, acknowledging the significance of addressing global environmental challenges through innovation. Expressing gratitude for being part of the scientific committee and recognizing the venue's importance in Piraeus, the heart of Greek shipping, the Moderator highlighted the role of innovation in history and the historical context of ancient Greece while facing environmental issues even in the past.

Drawing parallels with ancient Athens, the Moderator emphasized the innovative solutions adopted, particularly in naval design with the introduction of triremes, to overcome environmental challenges such as deforestation. The Moderator also alluded to the strategic victory of Greece in the naval war of Salamis against Persia, showcasing the importance of innovation.

Introducing the session's focus on contemporary environmental challenges, especially climate change, the Moderator invited esteemed panelists to explore the pressing need for technological innovation in the face of these challenges. The emphasis was on understanding how innovation can play a pivotal role in mitigating the impact of climate change, aligning with the broader theme of confronting environmental challenges through technological advancements.

7.4.2 Discussions

The Moderator initiated the first question addressed to the first speaker of the panel, acknowledging the prominent role of Greek shipping in global trade and its commitment to international regulations through the International Maritime Organization (IMO). With a focus on the extensive experience of the speaker in the shipping sector, the Moderator inquired about the significance of international regulations compared to national and regional ones in the shipping context. The question delved into the reasons behind Greek shipping's advocacy for international regulations, particularly through the IMO. The Moderator further sought insights into the potential impact of implementing international harmonization of environmental regulations, specifically pertaining to the pressing issue of greenhouse gas emissions. The question aimed to explore the implications and importance of a unified global approach in addressing environmental challenges within the maritime industry.

The panelist began by expressing gratitude to the hosts for the opportunity to discuss the pivotal role of in the future of shipping as much as it is known for the history of shipping. They highlighted the importance of international regulations, emphasizing the challenges associated with fragmented approaches and the need for harmonization, particularly in the context of emerging technologies such as robotics.

The response circled back to the theme of the day, emphasizing the crucial role of data in addressing environmental challenges. The panelist underscored that robotics could significantly contribute to reducing emissions and enhancing environmental protection but stressed the necessity of standardized data and harmonization. They pointed out the potential dangers of uncoordinated efforts and stressed the importance of understanding each other's actions to ensure effective and safe implementation of technologies.

In addressing the question about greenhouse gas emissions, the panelist emphasized the need for standardized data collection within regulatory frameworks. They acknowledged the ongoing efforts at regional and national levels while advocating for a global perspective facilitated by the International Maritime Organization (IMO). The panelist concluded by highlighting the essential role of international collaboration and the ratification of standardized regulations to achieve stability in addressing environmental concerns.

The moderator directed the second speaker's attention to the prevailing discussions and concerns surrounding Maritime Automated Surface Ships (MASS). Admitting the widespread apprehensions about the impact of MASS on the seafaring profession, the moderator sought insights into the current stage of legislative development at the International Maritime Organization (IMO). Specifically, the moderator inquired about the potential implications of the evolving regulatory framework for MASS on liability and compensation regimes within the maritime industry.

The second panelist highlighted that the regulatory development for Maritime Automated Surface Ships (MASS) is still in its early stages. Emphasizing the principle of not reinventing the wheel, the speaker mentioned that the focus has been on exploring how the existing legal framework within the International Maritime Organization (IMO) can be applied to MASS. The IMO, having a robust maritime legal infrastructure, covers a wide range of aspects related to shipping. The panelist noted that while the exploration of maritime safety standards under the current legal regime has been a primary concern, discussions about liability and compensation are still evolving. A regulatory scoping exercise has taken place to examine how the existing legal framework can be extended to address issues related to MASS. The IMO has established a joint working group across different committees to delve into these matters, underscoring the organization's commitment to the development of rules in this domain.

The panelist continued to provide a comprehensive analysis of the considerations regarding liability and compensation in the context of maritime automated surface ships (MASS), emphasizing different levels of automation and the continuing role of human elements onboard. The paramount consideration discussed was the principle of strict liability, aligning benefits with risks, highlighting existing conventions like the

Bunkers Convention, which lacks channeling liability, and the oil carriage convention, where only the ship-owner can be sued. The argument was made that this model should persist with MASS, maintaining the ship-owners' primary responsibility. However, complexities arise regarding recovery from other entities, such as remote operators, software developers, or manufacturers. The question of how far the concept of an operator can be extended became a crucial point, delving into the grey areas of liability.

Regarding recovery, the panelist suggested that, depending on the level of automation, the concept of an "off-operator" might need consideration. Traditionally, "operator" referred to the commercial entity in charge of operations, but exploring extensions to include roles like crew managers or even software developers was proposed. Reference was made to the LLMC convention's paragraph, addressing persons for whose acts, neglect, or default the ship-owner is responsible, with ship repair cited as an example due to the non-delegable duty of ensuring the vessel's seaworthiness.

The speaker further elaborated on the issue of safety in the context of Maritime Automated Surface Ships (MASS), emphasizing the paramount importance of seaworthiness. The responsibility for the seaworthiness of the vessel was suggested to lie with developers and remote operators in the case of MASS. This led to the consideration of extending liability limits for these entities, aligning with the principle that whoever gains benefits should bear the associated risks.

The complexity of adopting new conventions was mentioned, citing the cost and the need for convincing all governments. Emphasis was placed on the practical implementation of conventions, highlighting the significance of states becoming parties to ensure effective legal regimes. While major amendments might require a conventional approach, the speaker suggested that in cases of minor amendments, a unified interpretation of existing paragraphs in the limitation convention could be pursued. Reference was made to an IMO resolution adopting a unified interpretation on the basis for losing limitation of liability. The overall sentiment conveyed was that, considering the early stages of development, a nuanced and strategic approach is needed to address evolving challenges in the maritime industry.

The moderator presented a query to the third panelist, recognizing their substantial experience handling clients in the shipping and chartering sector, the question aimed to explore the integration of advanced autonomy within the spectrum of operational and environmental challenges faced by ship-owners and charterers.

The third panelist highlighted the central theme of "challenges" in the discussion. From a legal standpoint, the emphasis was on the challenges arising from predictability and investment in operations. The response underscored the complexity of regulations built on the assumption of human involvement, prompting the need for a critical evaluation of their fitness for the evolving landscape. The speaker pointed out the dilemma of maintaining the status quo versus a fundamental overhaul of legal frameworks to accommodate new technologies. In addressing these challenges, collaboration among industry, government, and academia was emphasized as crucial. The role of legal counsel was portrayed as the interface facilitating communication and understanding among these diverse components.

The panelists expressed the view that addressing challenges involves examining predictability and navigating the uncertainties associated with new technologies. The current focus on learning the benefits of these technologies is driven by decarbonization efforts, serving as a catalyst for change. The absence of clear regulations poses a challenge, especially for ship owners planning for the long term, as predicting future regulations becomes intricate. The importance of public acceptance, encompassing both the general public and seafarers, was emphasized. Acknowledging potential fears and uncertainties surrounding reduced or unmanned crews, the speaker highlighted the need for effective policies and education to address these concerns in the transition toward autonomy in the maritime industry.

Moderator's question to the fourth speaker: With extensive experience in hydrography, the current focus on data collection and its harmonization is evident. Could you elaborate on the current state of innovation in hydrographic data collection? Moreover, how can advancements in this field serve as an enabler to enhance safety, efficiency, and sustainability in maritime activities within marinas?

The International Hydrographic Organization, since its inception, has been dedicated to ensuring the surveying and charting of all sea waters, oceans, and navigable waters—a fundamental aspect in the environmental context of marine and maritime activities. This commitment has been upheld through a standardized approach to navigation throughout its history. The first panel discussions highlighted a lack of standardization in robotics, contrasting with the IHO's strength in approaching marine geospatial data, including hydrographic and bathymetric data, crucial for generating nautical charts and documents. The IHO follows a highly standardized approach, guided by the UNGGIM principles—an umbrella framework established by the United Nations Committee of Experts on global geospatial information management. This framework ensures the standardized management of geospatial data at the global, regional, and national levels.

Since the early 2000s, particularly in 2005, the IHO has been actively engaged in developing an innovative and standardized approach to represent the marine environment—the Universal Hydrographic Data Model S-100. This framework, initiated with the issuance of its first edition in 2005, serves as the foundation for producing all marine products, ranging from nautical charts to various services related to the marine environment, in alignment with ISO standards. The IHO's commitment to this holistic approach aims to advance technology for safe and efficient navigation, promote interoperability, and facilitate a diverse array of services.

The other notable strength lies in the active involvement of major international maritime organizations in the development of this new standard. These organizations include the IMO, which has acknowledged the employment of new standards starting from the beginning of 2026. Additionally, other international bodies such as the IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities), the WMO (World Meteorological Organization) for meteorological information, and the IEC (International Electrotechnical Commission) for accuracy test standards are engaged in this collaborative effort. The IHO oversees the development of products and services related to navigation and beyond. As of January 1, 2026, upon approval from the IMO, hydrographic offices responsible for S-100 production and end users, including seafarers, will benefit from this innovation. This format goes beyond ensuring the safety of navigation, offering a comprehensive four-dimensional picture that supports innovation with safety, efficiency, and sustainability in marine and maritime activities.

The moderator directed the question back to the first speaker, focusing on the topic of alternative fuels. In the ongoing collaboration with the World Maritime University and METAVASEA in the Eastern Mediterranean, a new project titled "People-centered Transition in Maritime Decarbonization" has been initiated. The significant challenge faced in this region pertains to the scarcity of individuals with expertise in the use of new fuels for ships, as discussed in the recent HELMEPA training committee meeting. Bearing in mind, the extensive experience of the first speaker in the realm of hydrogen, especially in the context of the current project involving an autonomous vessel running on hydrogen, the moderator inquired about the environmental benefits of hydrogen innovation in shipping. Additionally, there was an exploration of the speaker's perspective on the feasibility of a broader adoption of hydrogen and corresponding bunkering infrastructure in major ports like Piraeus, considering the associated safety considerations in the mid to long term.

The first panelist emphasized the historical usage of hydrogen, highlighting its presence as a fuel in shipping and submarines, as well as its application in extreme scenarios like rocket propulsion. While acknowledging its familiarity in various contexts, including liquefaction and transport since the 1960s, the panelist underscored the need for standardization and training in the maritime sector. Referring to the United States' advanced cryo-faction of hydrogen, the panelist stressed that although hydrogen is novel to shipping, it is not a new fuel overall. Addressing a crucial concern, the panelist touched upon the lack of training for seafarers, emphasizing that despite existing courses, dissemination and standardization at the International Maritime Organization (IMO) level are paramount. The discussion extended to equipment standardization, particularly in bunkering systems. The panelist emphasized the importance of sealed couplings for handling hydrogen gas, acknowledging ongoing efforts to establish standards in this regard while acknowledging the time required for such developments.

From an environmental standpoint, the speaker, delving into the role of renewably produced hydrogen, emphasized that hydrogen serves as an energy vector. The key advantage lies in its capability to store renewable energy captured globally, offering an alternative to batteries, which are comparatively heavier and experience energy loss over time. The speaker highlighted that when hydrogen is utilized, it emits oxygen and H2O, mitigating greenhouse gas impacts. While acknowledging that hydrogen, when released, can be a secondary greenhouse gas, the speaker questioned the likelihood of intentional hydrogen release due to its high cost. The detailed explanation underlined the environmental benefits of harnessing hydrogen as an energy vector, especially in conjunction with renewable energy sources. In addition to the this, hydrogen holds the potential to enable shipping to entirely eradicate its tailpipe greenhouse gas emissions, emphasizing the significance of this achievement. Exploring the timeline for the availability of hydrogen, the speaker acknowledged its current applicability for return-to-base vessels in short sea shipping, particularly in settings like wind parks. The speaker advocated for initiating and testing this technology in such environments, fostering crew training, and establishing standardization that can be globally shared, leveraging the existing international offshore renewable energy industry. Emphasizing that this is not an entirely new industry, the speaker noted that key players are already at a high commercial readiness level, awaiting the shipping sector’s impetus to justify investments in the required infrastructure. This approach positions hydrogen as a viable and impactful solution for short-term implementation with the potential for broader adoption in the medium to long term.

In discussing safety considerations, the panelist addressed the safety issues associated with new fuels, particularly hydrogen. Depending on the hydrogen storage size, safety zones would be necessary, and ongoing developments are being made to address these safety concerns, both within the industry and at the IMO. The discussion then shifted to the context of remote robotics and autonomous vessels. The speaker emphasized two key points. Firstly, in the case of autonomous vessels, the absence of crew onboard eliminates associated dangers. Secondly, the speaker highlighted a significant advantage, noting a substantial reduction in energy consumption with autonomous vessels. This reduction implies that kilograms of hydrogen can accomplish the same tasks that would require tons of hydrogen on a crewed vessel, adding a noteworthy dimension to the conversation on this subject.

The moderator passing on the question to the second panelist, highlighting the significance of training amidst the transitional phase. Emphasizing the considerable challenges and grey areas discussed, the moderator mentioned the pivotal role of liability and compensation in this regard. The question sought a brief elucidation on the role of the International Maritime Law Institute (IMLI) in contributing to training initiatives and advancements in these domains.

International conventions are typically crafted with broad language to maximize acceptance, providing room for reservations, options, and obligations. While States become parties to conventions, they may lack the capability to develop corresponding national legislation. Both IMLI and WMU play pivotal roles in assisting countries, offering expertise in legal, policy, and technical aspects to facilitate effective implementation of conventions. The focus on standardization was brought out in the panel, underscoring the need for a uniform approach to shipping. As an illustration, the IMO's plan to develop a non-mandatory code on MASS, with the aspiration for it to become mandatory, underscores the crucial role of States in development. WMU and IMLI contribute significantly to ensuring effective implementation of international law by assisting in capacity-building for States.

Following the discussion of robotics and hull cleaning, the moderator posed a question to the third panelist on the potential consequences with non-compliance of hull fouling and hull cleaning standards.

From a very high-level perspective on that question, the response indicated that, based on the speaker's industry experience, compliance was usually more of an economic decision than non-compliance. Some ship owners believed that attempting to operate outside of the existing regulations might be a sound investment. However, in the United States, environmental non-compliance penalties were noted to be very extreme. To simplify, the types of questions related to environmental compliance were often framed as inquiries about why one can’t comply and how one can comply. This encapsulates the essential nature of the daily challenges dealt with by the speaker.

In terms of hull fouling, hull cleaning, and other environmental compliance measures, the discussion emphasized the significance of understanding various compliance regimes. The speaker outlined the complexity inherent in these regimes, ranging from international to national and even more localized levels, particularly in the United States. The U.S. context was highlighted as challenging due to the existence of environmental laws at both the federal and state levels. The absence of alignment between national agencies, waiting for guidance from the IMO, added to the complexity. This situation posed challenges for regulating both U.S. flag vessels operating domestically and foreign-flag vessels calling on U.S. ports. The interaction with agencies like the U.S. Coast Guard was noted as essential to grasp the evolving regulatory framework. The added layer of complexity came from states like California, which imposed regulations sometimes stricter than international standards.

In their professional capacity, the speaker noted that a substantial portion of their time is dedicated to collaborating with clients to comprehend the intricacies of compliance, particularly in the context of international shipping. The ongoing challenge revolves around addressing violations related to environmental compliance, such as hull fouling. The speaker underscored the severity of penalties, which could encompass detaining a ship. This, in turn, led to complications under Charter parties, involving issues of delay, detention, demurrage, and lay time. The associated costs and disruptions were highlighted, emphasizing the adverse impact on the reliability of scheduling and the overall efficiency of maritime trade. In examining more severe instances in the United States, the speaker commented on the imposition of civil and, in some cases, criminal penalties. They characterized the process of entering the United States as a challenge, anticipating increased complexity in the future. This complexity is expected to escalate as the nation endeavors to formulate a national-level decarbonization plan, implement evolving IMO regulations, and navigate through the diverse regulatory frameworks established by individual states.

The last question of the panel went to the fourth panelists, who was requested to briefly explain the concept of the digital twins of the ocean in detail which is heard often and how a holistic approach to knowledge of the oceans combines technology with environmental stewardship.

The panelist explained that, DITTO, an acronym for "Digital Twins of The Ocean" aims to create a consistent, high-resolution, multi-dimensional, and near-real-time virtual representation of the ocean, making ocean knowledge openly accessible to everyone. The initiative gave importance to fostering a platform for global cooperation. In the ocean environment, DITTO has significance as it underscores the interconnection between hydrography and oceanography, considering them as two sides of the same coin. The speaker cited GEBCO, the "General Bathymetric Chart of the Ocean", as a pertinent example that illustrated the successful collaboration between two prominent international organizations, namely the IHO and the IOC, in association with UNESCO. Furthermore, the panelist alluded another crucial challenge outlined in the UN ocean decade, specifically challenge number eight, presents the imperative of creating a digital representation of the ocean. This challenge stressed on the need for a dynamic ocean map encompassing all oceanic characteristics, accessible to a wide audience.

The speaker concluded by affirming that DITTO can effectively address hypothetical scenarios and that the key to success lies in a holistic approach. The holistic approach, as previously mentioned, involves the active and effective engagement of all stakeholders interested in the initiative. Referring back to the discussion on S 100 in response to the initial question, the speaker noted that, after more than 20 years of efforts and leveraging over 100 years of experience from The International Hydrographic Organization, the anticipated fruits of these endeavors are expected to materialize in the coming years. This underscores the speaker's assertion that the key to success lies in fostering global cooperation, with the collective anticipation of the positive outcomes resulting from this innovative approach.

7.4.3 Audience Interaction

Question:

There was a question posed in reference to the alternative fuels, as to whether or not the industry is going too fast without a solid assessment plan in place?

Responses:

Panelist One, expressed the perspective that, despite the perceived rapid pace of developments, the implementation of new fuels is contingent on the establishment of robust regulations and standards. The panelist drew the attention of the Forum to the ongoing efforts within the International Maritime Organization (IMO) and on an international level to address this crucial aspect. While acknowledging the speed of advancements, the statement underscored the importance of regulatory bodies taking the necessary time to ensure safety before the widespread introduction of these fuels into the international shipping market.

Panelist Three, contributed insights on the U.S. context, expressing the challenges faced in defining the decarbonization strategy for maritime. The panelist highlighted the impending release of a new blueprint, acknowledging the industry's aspirational goals while navigating the absence of clear regulations. The statement reflected the inherent dilemma of investing in technology without established standards and developing technology without conformity guidelines. In the U.S., the panelist noted challenges related to regulator qualifications and emphasized the “design basis” approach for alternative fuels, requiring tailored regulations. The mention of workforce issues and the suggestion for potential acceleration conveyed the nuanced perspective on the timing of developments in the U.S. maritime sector.

Panelist Four, aired that the pace of progress is actually not fast enough, suggesting a potential lag in global initiatives. The panelist referred to the Agenda 2030, initiated a decade ago, emphasizing that despite the launch of the UN Ocean Decade, the attainment of sustainable development goals has seen relatively low percentages. This observation led the panelist to advocate for a more accelerated approach within the international community to meet the targets outlined in the 2030 agenda. The response conveyed the speaker's viewpoint on the need for swifter advancements to address global challenges. The acknowledgment of the 2030 agenda's slow progress added a critical dimension to the discussion.

Comment:

There was a concern about the rapid progression, similar to the query earlier, regarding hydrogen and green fuels. Emphasizing hydrogen as the precursor to green methanol and ammonia, the audience member cautioned against viewing hydrogen as the holy grail for decarbonization without thoroughly assessing its various aspects. Highlighting hydrogen's characteristics as an indirect greenhouse gas with high escape propensity due to its molecular size, the audience member referenced research findings. Until 2020, studies suggested a global warming potential of 11.5 over a 100-year period, but recent studies indicated potentially more severe impacts, with estimates ranging from 60 to 200 times worse than CO_2 after 2020. The speaker urged further research and comprehensive evaluation before declaring hydrogen as a definitive solution for decarbonization. The statement underscored the need for careful consideration and in-depth exploration of potential environmental consequences associated with hydrogen adoption.

Responses:

The Panel responded swiftly by stating that, in discussing hydrogen containment methods, employing nitrogen is a preventive measure to avoid hydrogen escape. Ship-based systems utilize double-walled piping with a nitrogen barrier, ensuring compartmentalization within fuel cell compartments to eliminate the possibility of hydrogen leakage. In addressing concerns upstream in the supply chain, the panel urged collaboration with stakeholders to devise strategies for preventing such issues. Additionally, wind as mentioned as the fuel that is the shipping industry's "holy grail." Wind propulsion, with zero greenhouse gas impacts across scope one, scope two, and scope three, presents as a pivotal solution to reduce onboard energy requirements, thereby diminishing overall upstream greenhouse gas impacts. This perspective underscored the significance of wind as a transformative element in mitigating environmental impacts in maritime operations.

Additionally, the panel also brought in the perspective on the extensive work required and clarified that, concerning timing, the focus should be on securing government incentives to facilitate necessary investments. The panel recognized the need for substantial testing before implementing these technologies, stressing that the industry is actively seeking increased government support to encourage investment, design, and testing of these alternative fuels. The critical role of incentives in addressing the challenges faced by the maritime industry was underscored, emphasizing the urgency of exploring viable options and promoting the adoption of alternative fuels.

7.4.4 Key Takeaways & Recommendations

• Consensus prevailed in the panel on establishing an international regime and standardizing data collection processes as they are imperative components of navigating these challenges effectively. The focus on global cooperation emerged as a recurring theme, underscoring the interconnected nature of environmental issues and the need for collaborative efforts on a worldwide scale.

• The importance of open access to data, both in its collection and processing, was highlighted as a key factor in advancing innovative solutions. This emphasis on transparency and accessibility contributes to a more inclusive approach, allowing a diverse range of stakeholders to benefit from the wealth of information related to maritime and environmental activities.

• Technical assistance to developing countries emerged as a crucial aspect of the discussion. Acknowledging the vast number of seafarers requiring training, there was a consensus on the need for targeted support and capacity-building initiatives. This aligns with the broader goal of ensuring that all nations, regardless of their developmental stage, can actively contribute to and benefit from evolving global standards.

• Predictability and public acceptance, particularly among seafarers, were identified as essential elements. Recognizing the human factor in the maritime industry, it was emphasized that establishing predictability in regulations and fostering public acceptance are pivotal for the successful implementation of innovative solutions.

• This extends to the realm of new fuels, where the challenge lies not just in their novelty but in scaling up their usage.

• The importance of prioritizing the well-being and readiness of seafarers and onboard workers, who are at the forefront of utilizing these advancements, was underscored throughout the discussion.

• Overall, the panel highlighted the multi-faceted nature of the challenges at hand and the interconnected strategies required to navigate them successfully.

The discussions within the panel provided valuable insights into the multifaceted challenges and opportunities facing the maritime industry, particularly in the realms of international regulations, automation, alternative fuels, compliance, and digital representation of the ocean. Drawing from the shared expertise, several recommendations emerge to address these complex issues and navigate the future of the maritime sector.

Firstly, the significance of international regulations cannot be overstated. The panel underscored the importance of harmonizing regulations, especially in the context of emerging technologies like robotics and Maritime Automated Surface Ships (MASS). Recommendations include continued advocacy for international collaboration through organizations like the International Maritime Organization (IMO) to establish standardized regulations that transcend national and regional boundaries. Such harmonization is crucial to fostering a unified global approach in addressing environmental challenges, particularly greenhouse gas emissions, and ensuring the effective and safe implementation of new technologies.

Secondly, the discussions highlighted the pivotal role of data in addressing environmental challenges, especially in hydrography. The development and adoption of standardized approaches, such as the Universal Hydrographic Data Model S-100, should be encouraged. Recommendations include promoting collaboration among major international maritime organizations, like the IMO, IALA, WMO, and IEC, to ensure a comprehensive and standardized approach to marine geospatial data. The integration of such standardized data can enhance safety, efficiency, and sustainability in maritime activities within marinas

Thirdly, the transition towards advanced autonomy and alternative fuels, such as hydrogen, requires a concerted effort in training and standardization. Recommendations include prioritizing training programs for seafarers at the international level, with a focus on the safe handling of new fuels. Additionally, efforts should be directed towards establishing global standards for equipment, like sealed couplings for hydrogen bunkering systems, to ensure safety in the maritime industry.

Fourthly, compliance with environmental standards, particularly in hull fouling and cleaning, demands a nuanced understanding of the diverse international, national, and local regulations. Recommendations include fostering collaboration between industry stakeholders, governments, and educational institutions, such as the International Maritime Law Institute (IMLI) and World Maritime University (WMU), to provide expertise and support in navigating compliance regimes. Efforts should be made to streamline regulations at both national and international levels to reduce complexity for ship owners and operators.

Lastly, the concept of Digital Twins of The Ocean (DITTO) presents an innovative approach to ocean knowledge. Recommendations include encouraging global cooperation in creating a dynamic and comprehensive digital representation of the ocean. Stakeholders, including governments, international organizations, and private entities, should actively participate in initiatives like DITTO to ensure the accessibility of oceanic data for diverse applications, aligning with the goals outlined in the UN ocean decade.

In conclusion, the recommendations emphasize the need for global collaboration, standardized approaches, and ongoing training to navigate the evolving landscape of the maritime industry. By addressing these aspects, the industry can foster innovation, enhance sustainability, and effectively tackle the challenges posed by emerging technologies and environmental concerns.

7.5 Panel Three: Technology & Industry Perception: Are We Ready?

6.5.1 Moderator's Remarks

Welcoming the participants to the panel discussion, expressing the hope that the ensuing conversation and shared thoughts would provoke further contemplation about the impact of technology on the future of shipping, the moderator laid out the objective, which was to delve into the advancements in high-tech, particularly in service robotics, within the maritime industry. The panel aimed to evaluate how the industry is incorporating technology into its daily operations and address questions regarding readiness, legislative frameworks, and the ongoing processes. Each participant in the panel discussion was acknowledged for their expertise in technology within their respective roles.

7.5.2 Discussions

The moderator initiated the discussion by posing the first question, focusing on monopolies and incorporating the BUGWRIGHT2 project as an illustration of notable research endeavors in technology from an academic perspective. The inquiry sought insights into the benefits of EU-funded collaborative projects for the economy and the socio-economic advantages associated with the utilization of high-tech solutions.

The first panelist outlined how the European Union heavily invests in projects like BUGWRIGHT2 because it interested in promoting technology and fostering collaboration among academia, society, and businesses.

The panelist highlighted the promising contributions of such projects, stressing the importance of considering various aspects beyond technology and inventions. While welcoming all projects, the panelist emphasized the need for clear exploitation plans, addressing questions about who benefits, the return on investment, and the social return of these investments. The panelist underscored the essential role of these projects in enhancing competitiveness across European Union firms, academia, and the shipping industry, emphasizing the necessity of exploring benefits for both academia and society.

A question on determining the role of service robotics and the receptive nature of the maritime sector towards this end was posed to the panel by the moderator.

The panelists made an intervention by commencing from the ship-owners' perspective, expressing that ship-owners' enthusiastically welcome progress in remote inspections and robotics. The panelists, having insights from holding positions within shipping associations, emphasized that this viewpoint represents not just personal opinion but the collective sentiment of approximately 100 technical managers and another 100 associate members from Greek shipping companies. The panel assured that the industry is ready for automation, and further details about the reasons behind this positive stance would be elaborated on during the panel discussion.

As operators of ships their preference for remote inspections comes from the significant advantage of conducting inspections when the ship is not in port. The key benefit identified was the ability to perform essential annual inspections, including those related to classification and flag requirements, during periods when the onboard crew is occupied with various tasks at sea. This flexibility in timing was regarded as a major positive aspect by the ship operators on the panel. Further reference was made to the advantages of close-up inspections, particularly when utilizing technology like drones for examining enclosed areas such as fuel oil tanks. The reduced safety risks, absence of human entry into confined spaces, and the ability to capture high-quality visuals for later analysis were emphasized. The permanent record generated, whether in the form of a CD or USB, allows for a detailed examination and the possibility of seeking expert opinions remotely. The benefits of using robotics for hull cleaning were also underscored, emphasizing the convenience of performing such tasks while the ship is enroute to its destination, even in open sea conditions where traditional anchorage might not permit such activities.

Another intervention was made pertaining to the importance of embracing remote inspection techniques, both as a flag State and on behalf of the International Maritime Organization (IMO). Despite the enthusiasm for these technologies, it was emphasized that the regulatory framework, particularly within the IMO, is not fully prepared to universally accept remote inspection techniques. However, a proactive approach is being taken to address this gap. The panel shared insights from the recent IMO SDC 10 (Sub-committee of Ship Design and Ship Construction) meeting where a proposal by IACS (International Association of Classification Societies) for remote inspection techniques was discussed. As a result, an agreement was reached to establish a correspondence group tasked with developing draft guidelines for remote inspection techniques, with a primary focus on hull structure inspections. The panel elaborated that the intention was to present these guidelines at the next SDC meeting the following year, aiming for a holistic approach that can be applied across various IMO sub-committees to permit remote inspection techniques for mandatory surveys and inspections per ship.

There was a call for action from panel towards the commitment to embracing technology while prioritizing safety, aligning with the overarching sentiment that safety is paramount in the maritime industry. Acknowledging the potential of technology to enhance safety, particularly in the context of close-up surveys where drones can replace traditional scaffolding methods, the panel advocated for a careful and safe integration of these advancements. The current phase was characterized as an experimental and experiential stage, wherein remote inspection techniques are permitted on a case-by-case basis for flag demonstration. The flag State allows classification societies to conduct remote inspections when a robust safety case justifies such an approach. However, the panel also clarified that this is not a blanket acceptance and pushed for the anticipation of broader acceptance once finalized and approved guidelines are in place.

Additionally, concerns were raised about the lack of clarity and uniformity in the regulatory framework governing robotics, emphasizing the need for a unified approach that addresses the evolving landscape of innovations. Expressing uncertainty about which regulatory framework prevails, the panelists noted variations across different regions, such as the European Union and the United States. Transitioning to the readiness for technology adoption, there was a stress upon the importance of collective preparedness. In particular, attention was drawn to the pivotal role of seamen and seafarers in the adaptation process, highlighting that everyone must actively engage and be involved in embracing these technological advancements.

The moderator led the panel to next phase of the discussion by requesting their perspective on: What are the training requirements for the remote inspections performed by the hull cleaning robots?

One of the panelists drew the broad contours of a training-based approach with a focus on two key aspects. First and foremost, the speaker highlighted the operational benefits and safety considerations associated with the use of remote inspection and underwater drones. Emphasizing safety as a top priority, the speaker underscored the reduced risk in scenarios involving both human and robotic presence, aligning with the commitment to safety of life at sea. The second positive aspect highlighted was cost management. Through remote inspection, the ability to control expenses by minimizing the need for global travel of human resources was emphasized. Additionally, the efficiency of obtaining quick data from inspections was noted. Furthermore, the speaker pointed out the positive impact on decarbonization efforts, as the use of remote inspection contributes to minimizing CO2 emissions by reducing hull cleaning needs and travel-related costs.

Despite receiving the responses in a positive spirit and appreciating the receptive nature and the general consensus that existed in the panel, the moderator brought in a tone of skepticism about the opposition to robotics and enquired the existing pushbacks vis-à-vis service robotics.

One of the panelists mentioned that based on the preliminary research to understand the project's nature, funding, and internal users, the European Union emerged as the primary funding entity with the overarching goal of safeguarding the competitiveness of the European Union. The key players, included ship owners and relevant stakeholders, who are acting in tandem with regulators and flag States cooperating within a common regulatory framework. In assessing support and opposition, the panelist pointed out the International Maritime Organization (IMO) as the most significant ‘nay-sayer’ to the project. Despite initial concerns from classification societies, such as DNV, their subsequent alignment with the project, highlighting the onboard support from various classification societies and operator flags like Liberia, Panama, Malta, among others was duly noted in the panel. The caution and resistance primarily stem from the International Maritime Organization and its sub-committees, where the most notable hesitancy is observed. In November, the III (Implementation of IMO Instruments Subcommittee) presented a report to the assembly, expressing reservations about remote inspections and audits, especially for ISM (International Safety Management) issues. The report suggested limited acceptance, allowing it only under force majeure circumstances. Recognizing that the IMO, at the end of the day, comprises member states, many governments exhibit heightened caution. The Marine Technical Association, as a response, attempted to instigate changes to the report, highlighting the potential hindrance to the adoption of remote inspections. The ongoing process involves correspondence groups and working groups, with future engagements expected in subcommittees like PPR (Pollution Prevention and Response), which also exhibits reservations, particularly in areas like hull cleaning equipment under biofouling control guidelines. Therefore, the panel recommended that the stakeholders involved in this project should direct their attention to addressing concerns raised by regulatory bodies. A recent development noted in the forum was the announcement from the Australian Marine Safety Agency (AMSA), which declared a categorical refusal to accept any remote inspections moving forward. The decision, stemming from instances where deficiencies were found remotely but not closed during subsequent onboard inspections, underscores the skepticism surrounding the effectiveness of remote inspections compared to live inspections. This stance by AMSA adds to the overall negative sentiment seen in other states, including New Zealand, reflecting the challenges and resistance within the IMO.

There was an opposition raised within the panel on the point relating to the ban by AMSA where another panelist mentioned that the guidelines issued by AMSA restricting the use of remote server inspection pertains only detainable deficiencies and the restriction was not a complete ban on remote inspections or surveys; rather, it specifically targeted deficiencies that result in detention. The understanding was that AMSA's intention was to utilize remote methods to close out deficiencies related to detentions. However, further clarification was proposed to confirm this interpretation.

Following the discussion on the interpretation on the AMSA ban, the panel moved on to conceptualize how in discussing service robotics, the focus extends beyond remote inspections and in to broader innovation and technology. The key emphasis was on enhancing technology to bolster the European Union's competitiveness in the global arena. The panel underscored the importance of technology advancements driving the industry forward and reminded the need for active involvement from all stakeholders, particularly seafarers, highlighting the importance of marine academies as an equal partner in research teams. The integration of onboard personnel's understanding of different technology readiness levels was highlighted as crucial element for realizing the industry's potential and ensuring simultaneous advancements in technology and manpower.

Furthering the discussion on to the issue of integration, the moderator posed the following question: “How would the ship owners and ship operators help the seafarers and the people around the seafarers adapt to these new technologies?”

The panel came up with a set of responses as follows,

Firstly, in agreement with the points already raised, there was a call for clarifying the regulatory framework, expressing reluctance to invest in a situation lacking clarity. From the training department's perspective, there was a readiness to enhance the skills of individuals working with such equipment.

Secondly, recognizing the current lack of experience in using this technology, the need for active involvement and hands-on experience to identify challenges and weaknesses was highlighted. This approach was supported to develop the workforce, ensuring preparedness to embrace and adapt to evolving technologies.

Thirdly, in discussing the regulatory landscape, the historical reliance on prescriptive rules within the IMO framework, examples like SOLAS, after the Titanic incident and MARPOL after the Torrey Canyon were cited. However, the occurrence of a significant shift in 2016 was highlighted, when IMO introduced a goals-based standard, incorporating provisions for a risk-based approach in most instruments. This shift, encouraged innovation and the adoption of new technologies, while being in contrast with the traditional prescriptive approach. This regulatory evolution in allowing for the acceptance of remote inspection techniques, was said to be undertaken on a case-by-case basis. The shift towards a risk-based approach was seen as a crucial development that aligns the regulatory framework with technological advancements, fostering a more agile response to emerging innovations.

Fourthly, adding on to the previous point, the need for caution when transitioning from prescriptive regulations to more ambitious, goal-based approaches with concerns about potential ambiguities and the risk of compromising safety aspects was stressed upon. The challenges of developing effective goal-based regulations, particularly in ensuring safety without relying only on formal safety assessments (FSA) was recognized. Citing an IMO guideline, mentioned earlier, sent to the assembly that would hinder the progress of remote inspections, the panel advocated for collective efforts to safeguard and promote the acceptance of robotic innovations within the IMO, urging against premature dismissal due to the overcautious attitude of a few member States.

As part of the final remarks before the conclusion of the discussion, certain points were either brought out or reiterated. The BUGWRIGHT2 project was commended, highlighting the importance of investing in technology for the future since it plays a leading role in shaping the future and stress the significance of adhering to proper procedures, certification, and comprehensive training. In order to maximize the return on investment, the inclusion of stakeholders, fostering awareness about the technological initiatives was suggested as the optimal way forward. The recurring theme of the interplay between robots and humans, was viewed with apprehension, especially referring to the crucial role of humans in utilizing data generated by robots. The institutional affirmation of avoiding unnecessary delays and questions, asserting that human involvement remains essential for handling and controlling various situations was reiterated. Additionally, the concept of due diligence in the era of new maritime technology, highlighting the need for clarity in responsibilities was introduced. Having considered the significance of risk assessment, and underscoring the importance of the data and reports generated by these technologies, the requirement for a certified qualified conductor for remote inspections was proposed.

7.5.3 Audience Interaction

Question:

What kind of financial incentives are available to support this technological transition?

Response:

Among the various incentives, the existence of both tangible and intangible incentives within the discussed context was recognized. The financial resources provided by the European Union was noted as an example of such incentives. Additionally, the response included another form of incentive related to academia, encouraging members of the research team to reflect on their satisfaction in presenting their scientific contributions through journals and papers.

Considering the user's perspective, the panel pointed out the financial incentives associated with utilizing robots instead of humans, highlighting the cost-effectiveness of automation compared to human labor. The panelists also mentioned various additional incentives, such as risk reduction for human workers, mitigating fatigue, and improving overall efficiency and that the assertion of these incentives contributes to the positive reception of automation by users.

Question: Following up the previous question, the panel was asked whether the reduction in costs extends to the accommodation of the surveyor and whether such an assertion has undergone testing or verification through an evidence-based survey?

Response:

One of the panelists disclosed that the expense incurred when engaging a surveyor for a ship inspection costs approximately $8,000. Considering the potential avoidance of two or three such inspections and redirecting the cost towards covering an investment in a drone, appears to be a clear and logical proposition. Adding to this, the remarks made earlier in reference to the BUGWRIGHT2 Project was mentioned highlighting the potential of achieving a 20 to 25% reduction in fuel consumption serves as a concrete and tangible incentive, providing a clear example.

Comment:

One of the participants who attended meeting of the IMO subcommittee SDC 10 in January 2024 provided an update on the discussion regarding remote inspection techniques had not been dismissed and in fact had garnered positive response at the IMO. However, the subcommittee faced challenges in adopting guidelines as there were contrasting proposals. The participant shared that the Bahamas submitted a proposal, suggesting the need to determine the specifications and technology details before adopting the guidelines. The outcome was a decision to address these technological specifics, such as camera resolution, in the next subcommittee session.

Response:

The panel responded by supplementing the comment from the audience by stating that the discussion at SDC 10, where draft guidelines from IACS on remote inspection techniques were submitted and deliberated upon. Acknowledging the supplementary paper from the Bahamas, which added precautions, the panelist added that the decision was made to establish an intersessional correspondence group which was expected to compile a report for submission to the SDC in the coming year, aiming for conclusive outcomes on the matter.

Question:

Considering the factors such as traceability and long-term maintenance, does the advancements in technology have an impact on insurance premiums in the form of a financial incentive?

Response:

The panel replied negative and was inconclusive on such impacts on insurance premiums.

Question:

What was the result of testing the technology? There are restrictions on flying of drones in certain countries, is there a similar effect on these technologies?

Response:

The panel referred to the example of challenges related to drones, particularly in the context of close-up inspections in a cargo hull. The challenges mentioned involved issues with connectivity and accuracy of drones during surveys. This was highlighted as a representation of potential risks associated with the use of such technology.

This question also received an additional response from an audience member who by referring to the insurance aspect made a comparison akin to smart insurance for cars where in the case of a liability, of any kind, the drone manufacturer would apportion the costs for various components of a drone such as wires, image sensors and wings, and distribute it across the production/supply chain.

7.5.4 Key take-aways & Recommendations

• The panel collectively called for action towards a commitment to embracing technology in the maritime industry, with a strong emphasis on prioritizing safety as a paramount concern.

• Concerns were expressed about the lack of clarity and uniformity in the regulatory framework governing robotics. The need for a unified approach to address the evolving landscape of innovations in the maritime sector was underscored.

• The efficiency of obtaining quick data from inspections was highlighted, with a positive impact on decarbonization efforts. Remote inspection was acknowledged for its contribution to minimizing CO2 emissions by reducing hull cleaning needs and associated travel-related costs.

• The approach of fostering innovation and the adoption of new technologies was encouraged, signaling a departure from the traditional prescriptive approach in the maritime industry.

• To maximize the return on investment, it was suggested that stakeholders include and engage various parties, fostering awareness about technological initiatives as the optimal way forward.

• Recommendations were made for stakeholders involved in the project to direct their attention toward addressing concerns raised by regulatory bodies, ensuring a collaborative and regulatory-compliant approach to technological advancements in the maritime sector.

The discussion on EU-funded collaborative projects, exemplified by the BUGWRIGHT2 project, shed light on the multifaceted benefits of investing in high-tech solutions. The emphasis on collaboration among academia, society, and businesses reflects the EU's commitment to promoting technology and fostering innovation. The panelists underscored the need for clear exploitation plans, emphasizing the importance of considering not just technological advancements but also their broader implications, such as return on investment and social impact.

Regarding service robotics in the maritime sector, the panelists, drawing from ship-owners' perspectives, highlighted the industry's readiness for automation, especially in remote inspections. The ability to conduct inspections when ships are not in port was deemed a significant advantage, emphasizing the flexibility in timing and reduced safety risks associated with using technology like drones. The panel also addressed the regulatory challenges within the IMO, acknowledging the current lack of universal acceptance for remote inspection techniques. However, the proactive steps, such as the establishment of a correspondence group for developing guidelines, demonstrate a commitment to addressing these gaps.

The call for action from the panel towards embracing technology while prioritizing safety resonates with the overarching sentiment that safety is paramount in the maritime industry. The acknowledgment of the experimental phase and the case-by-case acceptance of remote inspection techniques underscore the cautious and safe integration of technological advancements. Concerns were raised about the lack of clarity and uniformity in the regulatory framework governing robotics, urging a unified approach to address the evolving landscape of innovations.

The discussion on training requirements for remote inspections performed by hull cleaning robots emphasized the operational benefits, safety considerations, and cost management associated with the use of technology. The positive impact on decarbonization efforts through reduced CO2 emissions was highlighted, contributing to the overall benefits of embracing remote inspection techniques.

The panel's exploration of existing pushbacks and opposition to robotics revealed skepticism from the International Maritime Organization (IMO) and some member states. The recommendation to address concerns raised by regulatory bodies, such as the IMO, reflects a proactive approach to foster broader acceptance and integration of technological advancements.

The discussion extended beyond remote inspections to encompass broader innovation and technology. The panel stressed the importance of technology advancements driving the industry forward to enhance the European Union's competitiveness globally. Active involvement from all stakeholders, particularly seafarers, was emphasized, highlighting the crucial role of marine academies in research teams.

In response to the question of how ship owners and operators can help seafarers adapt to new technologies, the panel emphasized the need for a clarified regulatory framework, active involvement, hands-on experience, and a shift towards a risk-based approach in the IMO's regulatory landscape. The importance of collective efforts to safeguard and promote the acceptance of robotic innovations within the IMO was urged.

In conclusion, the panel highlighted the significance of investing in technology for the future, stressing the importance of adhering to proper procedures, certification, and comprehensive training. Maximizing the return on investment was suggested through the inclusion of stakeholders and fostering awareness about technological initiatives. The interplay between robots and humans was viewed cautiously, affirming that human involvement remains essential in handling and controlling various situations. The concept of due diligence in the era of new maritime technology and the need for clarity in responsibilities were underscored, emphasizing the requirement for certified qualified conductors for remote inspections.

7.6 Panel Four: Global North v. Global South: Bridging the Digital Divide

7.6.1 Moderator's Remarks

In the panel discussion focused on the “Global North versus Global South: Bridging the Digital Divide”, the moderator expressed gratitude to the World Maritime University for the invitation and the honor of moderating the session with the distinguished panel. Acknowledging the existing gaps in global knowledge, the discussion aimed to be practical and inspiring.

7.6.2 Discussions

The moderator began the panel discussion by posing the question to the first panelist: What is your experience regarding maritime digitalization around the world particularly related to or technology?

Having been actively involved in the maritime sector for an extended period, the first panelist, presented the observation of increasing integration of technology into daily operations. Recalling experiences from the late '80s, they noted how the vessels were twice the size but half the crew a due to technological advancements, by the late '90s. Also stressing on how the maritime sector is not afraid of technology, rather embraces it with the added value of the human element in ensuring its effectiveness. From the personal experience of transitioning to ports, particularly in harbor mastering, they highlighted the utilization of technology for safety, addressing global challenges, and enhancing competitiveness and efficiency through key performance indicators. The panelist shared an example of the single window requirement from IMO. They pointed out that while some ports in Canada, which part of the Global North, still lacked this mandatory system, ports in West Africa, in countries such as Kenya and Nigeria, were already implementing it. Stressing that the global divide is not black and white, they suggested there are numerous shades of grey, and later discussions would delve into the associated challenges.

What challenges do developing countries face in implementing digitalization of processes in the maritime industry?

The second panelist noted, referencing their co-panelist's discussion on ports and the advancements in single window systems and smart ports, that further exploration was needed on their functionality and the appropriate technological approaches. Shifting the focus to the North-South divide, they recalled the European Union's directives in 2010, which mandated the implementation of the single window system by 2015, leading to substantial progress in digitalization. They highlighted the recent IMO mandate in January 2022, making the single window system mandatory globally. However, they pointed out that recent research indicates 30% of global ports face challenges in implementing this system, emphasizing the need for deeper examination into the underlying reasons.

In addition, the second panelist elaborated on the existing divide, highlighting that a significant gap persists. They referenced a study conducted by the International Association of Port and Harbors, which explored the reasons behind challenges in implementing technological advancements. Contrary to common misconceptions related to technology availability or budget constraints in developing countries, the study's findings pointed towards issues of cooperation. The reluctance to share autonomy among different agencies and organizations was identified as a key hindrance, with concerns about digitalization being perceived as a threat to existing power dynamics, control, and monopolies. In their view, addressing these issues through streamlined regulations is crucial.

In your region (the Americas,) who are some of the champions in port digitalization and why?

The third panelist responded by highlighting the disparity in the timeline of digital transformation within the maritime industry. They noted that while Europe initiated this transformation over two to three decades ago, ports in the Americas are just beginning this journey. Over the past decade, there have been significant advancements in port digitalization, with notable progress in countries like Chile, Brazil, Mexico, and Jamaica. The panelist specifically drew attention to the journey of a small Member State, Barbados. The panelist further explained that they had the opportunity to lead a technical assistance project in Barbados, financed by the Caribbean Development Bank, where the project focused on establishing a Port Community

System, a digital platform for real-time, paperless information sharing among all port community stakeholders. The panelist updated the forum that Barbados has already implemented its maritime single window and is now in the process of establishing the port community system. Despite being a small port with low trade volumes, Barbados successfully engaged all stakeholders in the planning phase of their digital transformation. This inclusive approach ensured buy-in from various stakeholders, contributing to the project's success. Additionally, Barbados had integrated cyber resilience into the planning phase, recognizing its significance in the context of automation and digitalization.

The panelist continued that the outcome of Barbados' successful digital transformation has positioned it as a “poster child” for the Caribbean region. Several countries, including Belize, currently working on their electronic single window, as well as Dominica and St. Lucia, are seeking guidance from Barbados. The knowledge exchange between these countries is significant, with Barbados serving as an example of effective digitalization. This demonstrates that cooperation and learning can occur not just from the Global North to the Global South but also through valuable south-south collaboration.

How do you see the use of robotics in the shipping industry and the current scenario of digital divide between Global North and Global South and what are the barriers that need to be overcome for bridging the digital divide?

The fourth panelist began by addressing the utilization of robotics in the shipping industry within the current context of the digital divide between the Global North and the Global South. The discussion then transitioned to the barriers that need to be overcome, particularly in the Global South. The panelist made the forum conscious of the pivotal nature of the topic, situated at the intersection of technological innovation and global economic disparities focusing on the maritime and shipping industry as a vital component of global trade, undergoing a technological revolution propelled by robotics. The panelist highlighted the potential of robotics to automate tasks, improve efficiency, and reduce risks in the maritime and shipping sector. Specific examples mentioned include ship hull cleaning, ship inspection, fire detection on ships, shipbuilding, and the recent introduction of salvage ships and drones. The panelist continued by observing the divide between the Global North and the Global South, firmly convinced that the Global North enjoys ample access to advanced technologies and digital infrastructure, while the Global South faces barriers, including limited internet connectivity, inadequate infrastructure, a shortage of digital literacy, and financial constraints which make the adoption of robotics in the Global South challenging.

In conclusion, the panelist reiterated that the use of robotics presents significant potential for revolutionizing the maritime and shipping industry. To fully harness this potential, there is a need for collaborative efforts to bridge the digital divide between the Global North and South. Addressing challenges such as limited internet connectivity, inadequate infrastructure, the lack of digital literacy and financial resources is crucial. The panelist affirmed that by tackling these issues, a more inclusive and equitable future can be created, ensuring that the benefits of robotics are accessible to all.

Following the fourth panelist’s intervention, the moderator poses a question to each member of the panel urging them to give a short answer on whether they were happy with the current mode of technology transfer?

The panelists collectively noted that there have been successful projects worldwide. One of them cited examples such as Canada's commendable efforts in technology integration throughout the supply chain. While acknowledging the impressive ideas behind many projects, they emphasized that the real challenge often lies in the implementation phase. Expressing a cautious stance, one panelist mentioned that saying "yes" might imply that the work is complete, but they believe more efforts are required to meet expectations. Despite not fully meeting expectations, there is a positive outlook on the progress being made. Another member of the panel intervened by stressing on the importance of technology transfer for developing countries. They suggested that while assistance from developed countries can be beneficial, it is crucial for developing nations to invest in their own research and technology innovation. The idea was put forth that relying solely on the Global North might not be the best approach, and developing countries should collaborate among themselves or seek support from leading nations. Examples were cited, such as China's progress over the past two decades and India's ongoing technological advancements. The panel encouraged a focus on nurturing start-ups within individual countries and urged them to prioritize technology development

Moving on to the next round of questions, the moderator asked what are the current main challenges and opportunities in maritime digital isolation considering the global digital divide?

The panelist highlighted the significance of understanding cultural nuances when addressing challenges in the Global South. They shared an example from their team's experiences, emphasizing that communication channels vary across regions. For instance, in some African countries, people rely heavily on WhatsApp for communication, contracts, and other interactions, rather than conventional email or document-based communication. This insight underscored the importance of adapting work approaches to align with the cultural practices of each country.

Recognizing another crucial aspect, it was noted that many systems developed in the Global North often carry specific values and cultural considerations without fully understanding the intricacies of the foreign organizations that will implement them. Through their experiences in auditing various aspects like safety management and ISPs, the panelist had discovered instances where systems were in place but remained unused. The panelist further highlighted the opportunity for manufacturers to develop flexible systems that can adapt to different ways of working, incorporating input from the end-users to ensure practicality and usability.

Further deploring into the issue, the panelist underscored the importance of considering the local infrastructure, sharing an example from Africa where generators were essential due to unreliable electricity supply. Emphasizing that neglecting such factors could render even the most advanced systems impractical in certain regions.

How do regulatory frameworks of developing countries to address deployment? And what are the challenges in updating regulations to accommodate autonomous systems in shipping?

The panelist emphasized the role of classification societies in establishing rules and regulations for industry standards. However, they also pointed out that governments play a crucial role, highlighting existing gaps in areas like data definition, storage, and limitations. The panelist stressed the need for clear rules on data-related aspects and a robust legal system to address disputes. In developing countries, it was suggested that specific mechanisms, such as arbitration, should be implemented to facilitate timely resolution of issues.

The moderator conducted another round of questioning common to the panel by asking how much would the rate technological know-how in Global South on a scale of one to ten, ten being the highest?

The panelists opined that measuring the progress of the Global South on a uniform platform would pose challenges. They noted that while some countries may compete with developed nations like, others, particularly small island developing states (SIDS), may lack the capacity to do so. They recommended an approach through a tailored criterion, based on each nation's capabilities, skills, and resources to accurately assess their progress in adopting technology and implementing initiatives. Furthermore, the panel emphasized that a singular figure could not accurately represent the progress, considering the varying capabilities of different countries, highlighting the reality of a global divide between the north and the south, with further divisiveness within the Global South. Consequently, they expressed reluctance to assign a single number to gauge the progress due to these inherent differences.

If a poor country decides to undergo a digital transformation, what are some of your recommendations on how to begin this process?

The panelist said that digital transformation or any digitalization initiative, whether involving a port community system, port management system, or a single window, transcends being merely an IT project. They asserted that it constitutes a “change management” endeavor, necessitating a reassessment and reengineering of processes to align with digital paradigms. They advocated commencing such initiatives with a comprehensive assessment to discern the current state, future objectives, and avenues for enhanced competitiveness and efficiency. In such assessment, the panelist recommended a thorough examination of processes along with the scrutinization of institutional frameworks, and legislative structures. They elaborated on the significance of aligning digital initiatives with existing legislative frameworks, citing instances where a private port in the region championed digitalization, including digital signatures, only to encounter challenges since the port State did not recognize digital signatures in its legislations and the digital solution could not be implemented until the corresponding legislation was updated. They further emphasized the importance of studying the legislative framework alongside operational and institutional assessments to ensure that digital solutions align with and enhance existing processes and concluded by reiterating the value of initiating digital initiatives with a comprehensive assessment.

Connectivity is of paramount importance for robust and successful telecommunication services using digital technologies, what can be done to ensure greater resilience in connectivity for the Global South in order to bridge the digital divide?

Guided by the critical role of connectivity in modern telecommunications, especially in the era of digital technology, the panelist advised that robust and reliable connectivity is vital for facilitating communication, accessing information, and fostering economic development. This was illustrated by highlighting instances where individuals may lack access to communication due to inadequate connectivity, underscoring the need to ensure connectivity for all, including remote and rural areas and underserved communities. In addressing the question about ensuring greater resilience in connectivity for the Global South, the speaker emphasized the need for a comprehensive approach, extending beyond the Global South to encompass a broader global perspective. They highlighted key measures that should be implemented, including infrastructure development, regulatory reforms, and the formulation of effective policies and strategies. Drawing from their experience in auditing IMO membership, they shared insights into the misconception that developed countries are immune to findings, revealing that even some developed nations lack adequate policies and strategies for implementation. They stressed the importance of going beyond mere regulations and focusing on the development of robust policies and strategies, emphasizing that this challenge is not exclusive to the Global South but extends to parts of the Global North as well.

Discussing the next issue of capacity building, the speaker presented its significance, particularly in the Global South, highlighting the importance of cross-border collaboration, which could occur within the Global South or involve collaboration between the Global South and Global North. Ensuring greater resilience in connectivity was identified as a crucial step in bridging the digital divide and unleashing the full potential of digital technologies, with a specific focus on the Global South. The proposed approach involved investment in infrastructure development, the implementation of regulatory reforms, the enhancement of local capacity through training initiatives, and the promotion of cross-border collaboration. This comprehensive strategy aimed to create a more inclusive and interconnected world, according to the panelist.

The moderator made a swift intervention by asking the panel whether investing in smart port infrastructure is a key point in service of robotics in ocean industry context.

The panel answered in the affirmative, in unison.

What could be done to enhance the overall situation to bridge this gap between the global north and Global South?

The panelist responded by sharing- and drawing insights from their personal experience. They observed a lack of awareness among countries in the Global South due to the challenges they face in their day-to-day operations. To address this, concrete action was taken by creating the African Harbour Master Committee. The initiative aimed to cater to the specific issues faced by African countries, offering a platform for communication and collaboration. This committee served as a bridge between the International Association, headquartered in London, and the African Harbour Master Committee based in Morocco, facilitating the sharing of information, projects, and support. The committee has proven effective in raising awareness and addressing various maritime issues, including those related to single-window systems and ballast water regulations. The panelist cited this instance as an example that could inspire to develop other models to bridge the digital divide.

To what extent does the rapid advancement of drones in the shipping industry outpace the ability of regulatory bodies in developing countries to keep abreast of emerging challenges and effectively regulate the safe and responsible use of these technologies?

The speaker recognizing the rapid pace in technological advancements highlighted the need for a tacit acceptance procedure similar to that in the IMO for developing countries. The first step, according to the speaker, involved defining ships, especially considering the broader definitions used by many countries that could cover autonomous ships. Issues related to liability, technology, limited resources, lack of an established framework, and competing priorities, such as addressing poverty and hunger, were mentioned as significant challenges for developing countries. Additionally, the speaker mentioned the importance of addressing data security and privacy, enacting laws for traffic management, and ensuring safety and security in the face of evolving challenges. Keeping regulations updated and embracing these extensive areas through statutes were noted as crucial for overcoming these challenges.

What are some of the general challenges, ports in Latin America and the Caribbean face as it relates to digitalizing their processes?

The panelist underscored the main challenges, particularly emphasizing the lack of financial and technical resources and highlighted the paramount importance of human resources. Addressing the challenge of quality capacity building and training was noted as essential. The speaker expressed interest in potential synergies with other institutions that were present in forum to collectively address the training needs of member states for mutual benefit. In further elaborating, the speaker laid out a third challenge, emphasizing stakeholder management and buy-in. Acknowledging the diverse industries represented, the speaker highlighted the human tendency to resist change and embrace new approaches. Stakeholder buy-in emerged as a significant challenge in the context of Latin America and the Caribbean. The speaker concluded by underscoring the paramount importance of stakeholder engagement as the foundational element for various innovative and technological solutions and emphasized the fundamental role of legislation for advancements in technology and innovation. It was observed that outdated or lagging legislation hinders progress in these domains.

Satellite services rely on digitally driven technologies. How does it ensure network resilience and to what extent bridging of the digital divide is addressed for the global South?

The speaker highlighted that the satellite technology is at the forefront in delivering digital services, particularly in remote or underserved regions lacking traditional infrastructure. It was emphasized that satellite services are diverse, with various systems available for communication and navigation and it pertinent to use the latest technology to enhance resilience and address risks, such as cyber threats. The impact on security was carved out by expanding on the importance of monitoring cyber threats in the satellite communications industry, emphasizing its sensitivity due to satellite positioning in the sky. A potential cyber threat to a satellite could lead to significant consequences, as the deployment of another satellite within a short timeframe is not feasible. The necessity of redundancy through additional satellites was highlighted, citing the example of Inmarsat satellites in maritime services. The regulatory efforts and policies implemented by international organizations, particularly the International Mobile Satellite Organization, were mentioned as crucial components in ensuring satellite network resilience. Interoperability between systems was also discussed as a methodology to enhance overall resilience.

The moderator posed a final ‘rapid fire’ question to the panel on the issue of overcoming barriers while accepting the challenges of financing new technologies and corresponding regulatory framework as well as skilled human resources in the Global South.

The panel responded by stating that knowledge exchange within the Global South, while perhaps not primarily focused on technological capacity, was still considered innovative and suggested that learning from one another within the Global South can be a valuable contribution in addressing certain challenges or concerns.

7.6.3 Audience Interaction

Question:

A member of the audience stirred the panel by inquiring about the basis of the difference between the Global North and Global South. They questioned whether this distinction is rooted in geographical terms and sought clarification on whether the terms refer to developed and developing countries, expressing concern about the potential misleading nature of associating the south with lack of development, especially considering the presence of developed countries in the Southern Hemisphere.

Response:

The question received multiple responses from the panel and from the forum each adding different perspective. The panel began by explaining that, within diplomatic circles, the terms "Global North" and "Global South" were historically associated with the distinctions between the developed and developing nations. The concept of the "West" was also employed in diplomatic discourse, primarily referring to Europe and America, but later encompassing Japan, Australia, and New Zealand. This classification was initially linked to geographical positions, with developed nations aligned with Europe in the north. However, as times evolved, the terms have become more nuanced, and it is challenging to make generalizations. The essence remains in categorizing countries as developed or developing, with considerations for advancements in technology, such as those seen in China and India.

Another input from the panel, with a straightforward example, contended that it becomes evident that the distinction between the consumer and the producer aligns with the global north being the producer and the global south being the consumer, especially in the realm of technology. This pattern extended to resources, where countries in the global south predominantly sold their natural resources and acquired man-made products and services. This perspective provided a clearer understanding, emphasizing the economic dynamics rather than geographical location.

A member of the audience with the due permission of the moderator, argued that negotiations over the BBNJ (Biodiversity Beyond National Jurisdiction) processes have extensively covered the topic of capacity building. The new agreements specifically address capacity building for parties involved, with a notable focus on developing states parties. The categories encompassed least developed countries, landlocked developing countries, geographically disadvantaged states, small island developing states, coastal African states, archipelagic states, and developing middle-income countries, representing a diverse spectrum. The audience member recommended abstaining from using the terms Global North and Global South, recognizing their simplification of a much more intricate concept.

7.6.4 Key Take-aways & Recommendations

• The digital divide is not only between the global north and south, but also within the global south, with varying levels of digitalization processes among countries.

• Emphasis was placed on the importance of the single window system in the maritime sector, with the suggestion to learn from each other's experiences.

• Governments in the global south were urged to recognize the significance of digitalization, especially in the maritime industry, and integrate it into their strategies and policies.

• Opportunities for collaboration and cooperation exist both within the global south (South-South cooperation) and with the Global North.

• The traditional dichotomy of Global North versus Global South is considered outdated, and the focus should be on recognizing opportunities within the global south.

• Governments need to initiate their own policies, starting with a focus on technology, capacity building, and infrastructure development.

• Public awareness and stakeholder understanding are highlighted as crucial factors in embracing new technologies, as demonstrated by the reference to hydrogen technology.

• The call for disseminating information globally, especially to governments and academics in the global south, is underscored.

In the dynamic landscape of maritime digitalization, it is evident that technology has become an integral part of daily operations, fostering efficiency and safety. The evolving nature of the industry requires a nuanced understanding of challenges and opportunities, particularly in bridging the digital divide between the Global North and South.

The panelists emphasized the importance of addressing challenges in implementing digital processes in developing countries. While technology availability and budget constraints are commonly perceived as obstacles, the key hindrance lies in issues of cooperation. Streamlined regulations that promote collaboration among different agencies and organizations are crucial for successful digitalization.

The Americas, albeit lagging behind Europe in digital transformation, showcase champions in port digitalization. The success story of Barbados, a small Member State, illustrates the significance of inclusive planning, stakeholder engagement, and integration of cyber resilience in digital initiatives. This south-south collaboration model serves as an inspiration for other countries in the region.

The use of robotics in the shipping industry presents immense potential, but a stark digital divide exists between the Global North and South. Bridging this gap requires collaborative efforts to address challenges such as limited internet connectivity, inadequate infrastructure, and financial constraints. The panelists highlighted the importance of inclusive strategies to ensure the benefits of robotics are accessible to all.

When evaluating the current mode of technology transfer, the panel acknowledged successful projects but emphasized the need for continuous efforts, especially in the implementation phase. While collaboration with developed nations is beneficial, there's a call for developing countries to invest in their research and technology innovation, fostering self-reliance.

In navigating maritime digital isolation, understanding cultural nuances, adapting to local infrastructure, and developing flexible systems are crucial. Manufacturers should prioritize practicality and usability, taking input from end-users. The panel stressed the need for comprehensive regulatory frameworks to accommodate autonomous systems in shipping, with governments playing a pivotal role.

Measuring technological know-how in the Global South on a scale proves challenging due to varying capabilities. The panelists advocate for a tailored criterion based on each nation's skills and resources to assess progress accurately. The lack of awareness in the Global South calls for collaborative initiatives like the African Harbour Master Committee, serving as a bridge for information sharing and support.

The rapid advancement of drones in the shipping industry raises concerns about regulatory bodies' ability to keep pace, particularly in developing countries. Issues of liability, technology, and limited resources need attention, requiring a tacit acceptance procedure and comprehensive statutes to address evolving challenges.

The challenges faced by ports in Latin America and the Caribbean include financial and technical constraints, emphasizing the importance of human resources and stakeholder buy-in. Legislation plays a fundamental role, and outdated laws hinder progress in technology and innovation.

Satellite services, crucial for the Global South's digital connectivity, require resilience against cyber threats. Regulatory efforts, policies, and interoperability between systems are essential to ensure network resilience and address the digital divide.

Overcoming barriers in financing new technologies and building skilled human resources in the Global South calls for knowledge exchange within the region. Learning from each other's experiences can contribute innovatively to address challenges and concerns in the pursuit of maritime digitalization.

7.7 Panel Five: Innovation & Regulation: How Best to Break Silos?

7.7.1 Moderator's remarks

After expressing their great honor in facilitating the panel discussion, highlighting the presence of esteemed specialists contributing insights from diverse areas of practice, the moderator emphasized the relevance of the panel's topic, which resonated throughout the day's keynote addresses and discussions. Drawing from personal experience as both a practitioner and AI researcher, the moderator underscored the critical role of regulation in fostering innovation. Furthermore, they emphasized the significance of multidisciplinary approach and collaboration, particularly in the context of technologies like robotics and artificial intelligence, extending beyond the maritime industry to the broader robotics sector.

Before commencing the discussion, the moderator laid out some housekeeping rules, addressing the panelists. Emphasizing the theme of breaking silos, the moderator encouraged dynamic interactions among the speakers. While structured questions would guide the discussion, speakers were invited to interrupt, comment, or contribute additional insights spontaneously to foster a more dynamic and engaging conversation. Despite the panel's theme being "Innovation and Regulation," the moderator decided to initiate the conversation by first delving into the topic of regulation before transitioning to the discussion on innovation.

7.7.2 Discussions

The moderator opened the panel for discussions by asking a panelist, “Do you believe that the current regulatory environment in shaping has assisted innovation? And if you can bring us any examples in relation to that?”

The panelist commenced by focusing on the role of regulation and when regulatory intervention becomes necessary, highlighting that regulators typically step in when problems arise. They added that in the context of the shipping industry, historical instances such as oil spillages prompted regulatory action, leading to the implementation of technical solutions like double hulls. More recently, issues surrounding emissions had emerged, prompting regulators to adopt a goal-based approach, allowing market forces to determine the most suitable solutions rather than imposing specific mandates. The shift towards tailored, flexible solutions rather than a one-size-fits-all approach in regulations was recommended.

Acknowledging the pros and cons of different systems, the emphasis was on regulations that provided greater freedom, potentially fostering more innovation. However, the challenges are usually pertaining to the time it took to identify a dominant design when users were given the flexibility to explore various tools. Despite industry concerns framing this as a threat, the speaker viewed it as an overall positive development for the industry.

The moderator followed up by asking whether such regulations consider the entire value chain or if it was focused on some stakeholders instead of others?

While acknowledging that not all value chains can be equally satisfied and that there were benefits to be gained across various value chains, the panelist continued by stating that that the satisfaction of value chains depended on how it was divided

Moving on to the next panelist, the moderator asked “Which stakeholders should regulation of service robotics in the maritime industry look for?”

The second panelist enumerated that the final decision on allocating preferences and protection in regulation often involved political considerations. The diverse range of stakeholders in the sector, including researchers, engineers, investors, commercial operators, clients, users, governments, workers, and local communities was recognized. The panelist suggested that a crucial initial step in dealing with regulation is conducting a Regulatory Impact Analysis, akin to the EU Better Regulation Agenda, to assess how regulations will impact existing conditions and anticipate potential outcomes in the existing environment. The panelist further elaborated that the second step in introducing regulations in this field involves deriving principles from existing legal frameworks and outlined fundamental principles found in charters, treaties, and declarations, which established a clear hierarchy of values. Safety was highlighted as a crucial and fundamental objective that regulations should prioritize, echoing views expressed in previous panels. Continuing their perspective, the panelist emphasized additional guiding principles in the regulatory process. They delved into the importance of principles like proportionality and the precautionary principle. Proportionality, in particular, was highlighted as a crucial concept, stressing that rules should not impose unjustified burdens on excluded stakeholders. They outlined key aspects of proportionality, such as ensuring any rule applied should generate unjustified burden on excluded stakeholders, are necessary to achieve specific objectives and that these restrictions would be the least burdensome option available and that this involved considering cost-effective regulatory solutions in the decision-making process.

Concluding their insights, the panelist drew the forum’s attention to the importance of conducting a comprehensive cost-benefit analysis in the regulatory process. They underscored the significance of ensuring that the burdens imposed by regulations do not outweigh the benefits they generate. The assessment, they highlighted, should encompass various dimensions beyond economic considerations. Drawing a connection to the Greek concept of “metritis or proper measure, they emphasized the need for regulations to strike a balance, avoiding excesses in both restrictions and freedoms. This balanced approach was seen as essential to prevent any deviation from the intended regulatory objectives.

How can the development and implementation of standardization can contribute to more efficient regulation of robotics?

In discussing the role of standards in the robotics domain, the panelist explained several potential benefits for creating a more cohesive landscape with the help of clear guidelines for designing technological solutions. Drawing parallels to fields like pharmaceuticals and nuclear technology, they emphasized that such guidelines instill confidence among manufacturers, fostering the development of innovative technologies. Additionally, in the panelist’s opinion, the establishment of standards facilitates interoperability among various systems, as mentioned in the fourth panel of the forum, ultimately enhancing safety and reliability when these systems collaborated. The panelist suggested considering the harmonization of international regulations to streamline compliance and certification processes, stressing upon the importance of certification for ensuring reliability. They laid emphasis on the need for data sharing, echoing sentiments from the first panel, highlighting that data was crucial for informed decision-making. The interconnection between different models and the understanding of regulatory constraints were underscored as vital for engineers to develop solutions that align with regulations, avoiding the development of solutions rendered unusable due to regulatory issues, as discussed in a previous example.

The panelist stressed the importance of promoting ethical and social standards in the development of robotics, noting that this approach contributes to the creation of responsible solutions. They highlighted the significance of understanding and predictability in technology acceptance, drawing parallels with the industrial field's journey towards embracing robotic solutions. While acknowledging that regulations may sometimes be viewed as barriers to innovation, the panelist acknowledged that regulatory constraints can lead to innovative outcomes by directing the focus towards the purpose of innovation. They emphasized the need for innovation to be purpose-driven and aligned with ethical and social considerations while pushing for interdisciplinary communication among various fields, such as engineering, law, and economics.

Lastly, they provided an example related to hydrogen innovation in maritime shipping, where the discussion about data became pivotal. The panelist underscored the significance of conducting comprehensive comparative studies on the environmental impacts of hydrogen production methods. In particular, they provided the example of considering the entire life cycle, as the production phase might have emissions even if the end-use of hydrogen is emission-free. This underscored the crucial role of data in making informed decisions about the environmental sustainability of innovative solutions.

Assuming, wide market acceptance of these technologies, is there a first impact assessment available, in particular on the cost of operations, resilience and financial sustainability of maritime business and ship-operators?

The third panelist began the response from the perspective to that of investors, highlighting the critical importance of selecting the right business model to ensure cost-effectiveness, resilience, and financial sustainability. They outlined two potential business models:

• Service Provision Model: In this model, a company operates the technology and provides services to clients. This approach is akin to a typical service-oriented business model.

• Leasing Model: Alternatively, the technology provider or developer leases the assets to a specialized technology company, which then utilizes the technology for various purposes such as conducting surveys. This model follows a business-to-business (B2B) approach and presents different legal considerations compared to the service provision model.

The speaker dwelt upon another potential business model where the technology, such as robots, were made available for use by consumers. This model operated on a business-to-consumer (B2C) basis, allowing end-users like ship operators to access and utilize the technology. The speaker drew parallels with urban mobility innovations, where cars or scooters can be leased or bought for specific periods, emphasizing the shift towards new business models in the evolving economy and the need to rethink approaches to robotics and similar innovations.

The speaker further emphasized the critical importance of cybersecurity in ensuring the resilience and sustainability of businesses by elaborating the indispensability of data and its handling, underscoring questions regarding data creation, purpose, access, and distribution among stakeholders. Despite the significance of these aspects, the speaker noted the absence of a legal framework or solution to address them, posing a challenge to investor and financier interest in their vision or technology. Additionally, they acknowledged the relevance of physical asset attributes, whether movable or otherwise, in the overall resilience and sustainability of the business. The panelist provided the contours of crucial prerequisites for potential investors and financiers interested in further developing these technologies. They discussed the necessity of workable, bankable, and marketable solutions, highlighting that these are not merely desirable attributes but essential. The speaker underscored the importance of managing intellectual property rights without conflicts, obtaining licenses or permissions for global operations, and avoiding restrictions that could limit technology deployment to specific regions. These considerations were identified as key factors influencing investor decisions and fostering the growth of emerging technologies.

The significance of specifying the operational context for robotics and related assets, considering factors such as whether they operate within a specific jurisdiction, in ports, or during sea transit was a key point discussed by the panelist. Addressing the applicable legal framework and regulatory limitations was highlighted as vital. In addition, the panelist stressed the need for well-defined aftermarket and salvage strategies, emphasizing the importance of exit plans for investors and stakeholders involved in these technologies. These considerations were presented as integral aspects of sustainable investment and development in the robotics sector. The panelist proposed the adoption of risk-sharing models to ensure sustainable development that meet both regulatory requirements and investors' expectations. They highlighted the emerging trend in the investment landscape, where considerations extend beyond mere yields to encompass social benefits and stakeholder interests. Referring to concepts like the Blue Economy and ESG (Environmental, Social, and Governance), the speaker underscored the need for a balanced approach that allocates benefits to all stakeholders involved. They concluded by suggesting that risk-sharing models or similar adaptations could provide a viable solution to address these challenges in technology development and investment.

The panel witnessed interventions from other members wherein they stated that the challenges related to jurisdiction and regulatory frameworks for operating assets acquired from academic institutions in Europe. They highlighted the absence of a legal framework for such operations, particularly in cases involving academic institutions, private organizations, or public entities. The panelist addressed the need to tackle these challenges, pointing out that a risk-based approach and a balanced consideration of rights, along with research-related caveats, appear to be emerging trends in the European context and referenced the draft AI act as a potential guide in navigating these issues.

Focusing on an aspect that was evident in all the interventions and in the previous panels, related to collaboration, conflicting interests, manifold aspects and complex value chains within the shipping industry, and of the importance of balancing those rights and interests making them coexist, the moderator reflected how the coexistence of different interests can impact regulation, not only in its implementation, but also its conception. Following which a question was posed to the panel regarding cooperation amongst that stakeholder in the different disciplines, throughout the creation of regulation in the maritime industry vis-à-vis innovation.

The panel affirmed that alignment of interests is a key factor in breaking down silos, particularly when everyone agrees on common goals and outcomes, emphasizing the influence of financial considerations, stating that when profits and losses align, silos become less significant, fostering collaboration and action. The panel further acknowledged examples of successful collaboration driven by shared interests in digital technologies. However, they pointed out instances, such as the limitations on drone inspections in Australia and New Zealand, where alignment of interests may be lacking, hindering the establishment of a dominant design that might garner universal acceptance. The ongoing importance to human element in decision-making, especially in the absence of a widely accepted solution was critically noted.

Ultimately, it was highlighted that the focus on technology, the final decision-making authority still rests with human beings. The criticality of the man-machine relationship was underscored that by stating, presently, humans are responsible for most critical decisions. While acknowledging the advancements in artificial intelligence and automation, the panel pointed out that machines can only provide answers pre-programmed into the system, lacking the capability to generate responses for unforeseen situations and that the human element remains crucial in navigating complex and novel scenarios.

Moving on from the conception of regulations and the different aspects and purposes towards the practical side of implementation, the moderator sought insights from one the panel members who was from the biotechnology industry. Questions regarding challenges in inter-departmental communication and cooperation were asked to the panelist in the context of risk-prone industries.

The panelist highlighted the pharmaceutical industry as an exemplary model for collaboration between engineers and regulatory experts and provided a personal perspective, working in cell therapy for lymphoma, a cutting-edge technology with ongoing efforts to overcome technological challenges. To proactively address regulatory considerations, the speaker described their team's approach by giving examples of having team members dedicated to staying abreast of regulatory frameworks, meeting regularly to ensure compliance with existing regulations, and engaging with regulatory authorities when necessary. This approach, in their perspective aligned innovation with current regulations and, in the absence of applicable regulations, actively involve relevant stakeholders, potentially including policymakers, to address regulatory gaps. The panelist then acknowledged the crucial aspect of data security and drew a parallel between the medical and maritime sectors. They stressed on the importance of data protection, particularly in the medical field where anonymity is paramount. Expressed confidence that similar data protection measures can be implemented in the maritime sector and quoted Europe's advancements in safeguarding patient data.

Technological innovation is linked to high risk-high yield investments; do maritime and ocean robotics innovation meet the expectations of investors, in terms of yield, turnover, and exit-options?

The panelist revisited the key factors that investors seek, emphasizing compliance, security, transparency, returns, turnover, and exit plans. Drawing from personal experience, they added that investors also prioritize liability of advisors and agents, forming a comprehensive set of considerations. The panelist posed a crucial question regarding the nature of robotics investments: whether they should be viewed as asset-based or technology-based investments? Expressing personal uncertainty about the classification, they underscored the importance of this distinction as it directly influences investor interest and potential funding sources.

In addition to the above, the panelist raised sharp questions about the financial resilience of robotics operators and the dynamics between technology providers and users. They highlighted the need to address key aspects, such as software updates, the relationship beyond the sale, and the connectivity of robotics parts to other assets like chips. The speaker emphasized that answering these questions is crucial for defining expected yields and investor interest. Furthermore, the panelist delved into the complexities of equity placement, noting that investors have diverse agendas and strategies. They stressed the importance of specifying factors like the Technology Readiness Level (TRL) stage and the presence of a scale-up plan. Drawing distinctions between asset-based and technology-based investments, the speaker mentioned the expected returns, noting that double-digit returns are anticipated for asset-based investments, while triple-digit returns are expected for technology placement. They referenced examples, such as Google's algorithm, which yielded over 800% returns to the original capital, illustrating the distinct risk approach of investors in the technology ecosystem.

The panelist concluded by emphasizing the need to clarify business models, technological versus asset-based investments, and to establish a track record with family offices and various sources of capital. They expressed caution regarding strategies where state funds or defense funds offer incentives to investors, as such approaches might dilute the expected yields and returns within the capitalist market. The speaker highlighted the importance of careful consideration and transparency in shaping sustainable financial strategies for the robotics industry.

The question of whether investors in innovative shipping be willing to accept lower revenues in order to comply with (non-financial) sustainability requirements was posed to the expert panel.

In a reflective tone, one of the panelists acknowledged the potential optimism in their views and acknowledged a potential narrowness in their perspective. They asserted that, in their opinion, the short answer to whether sustainability is achievable is yes. The panelist contended that a broader reflection on sustainability should commence with a key clarification, emphasizing that sustainability is unfortunately expensive. They posed questions about who should bear the costs and how investors are reacting to the shift towards sustainable production and consumption.

Regarding the theme of breaking silos, the panelist highlighted the significant divide between lawyers and academia, particularly in sociological studies. They argued that this silo needs to be dismantled. The panelist observed that environmental concerns are increasingly influencing public opinion, leading to a growing number of investors willing to accept lower returns to align with environmental objectives. They also noted a trend of final users being willing to spend more on sustainable products and services, reflecting a form of green critical consumerism. The underlying assumption here was that environmental sustainability is considered a value, and people are willing to pay for it.

The panelist added that the notion that environmental costs should be internalized in decision-making, both in the private and public sectors, is not a novel concept. In the realm of models and assessments, considerable effort has been invested in identifying ways to economically evaluate environmental costs. Noteworthy examples included the System of Environmental and Economic Accounting developed in the 1990s. The panelist cited the European Union, Regulation 691 of 2011 which addressed European economic and environmental accounts, contributing to the economic evaluation of environmental costs. Similar mechanisms emerged in the United States, particularly under the Biden administration, aiming to provide comprehensive information for public decision-making, with a focus on accounting for the economic impact of environmental factors was acknowledged.

Another panelist argued that, from their perspective and experience, investors were unlikely to compromise on yields and returns for the sake of sustainability. They emphasized the divergence between public and private investments, highlighting that public fund focused on social returns, while private investments prioritized financial returns. The speaker underscored the significance of returns in private investment, stating that when sustainability funds failed to meet high benchmarks and did not yield results, investors tended to lower subsequent sustainability benchmarks.

Continuing the argument, they defended that in conventional business practices, the majority of private investors and funds, whether regulated or not, prioritize optimizing and maximizing returns. Sustainability is often seen as an additional compliance checkbox rather than a primary focus. This trend extends to various industries, including shipping and emerging technologies.

They pointed out instances, especially in Germany and the northern part of Europe, where funds struggle to find suitable investments due to a lack of maturity in the provided technology. Consistency with investor expectations is crucial, as unfulfilled returns can lead to significant challenges. They reminded the audience that most institutional investors, such as mutual funds and pension funds, tend to avoid highly risky ventures and even when they engage in riskier investments, adequate returns are essential to cover costs and ensure their sustainability.

There was a third intervention to the discussion where the panelist seconded with previous points and provided two straightforward examples highlighting the complexities surrounding sustainability. The first example delved into the realm of electrification and electric cars. While often marketed as sustainable, the panelist raised doubts, citing studies that specifically outlined the conditions under which electric cars can genuinely be considered sustainable.

The second example brought attention to the EU ETS (Emissions Trading System) regulation in shipping, effective as of January 1st. The panelist pointed out the uncertainty surrounding the end result of these regulations, emphasizing that the ultimate impact on the sustainability of the shipping industry remains highly debatable. They also highlighted the likelihood that the final consumer would bear the brunt of any taxes resulting from these regulations. In summarizing the arguments, the panelist highlighted a crucial point regarding the EU ETS and noted that its primary focus is on financing the liquidity of the European markets. They urged caution in interpreting the instruments, emphasizing that Europe's objective is to enhance liquidity and whether the resulting reserves and returns benefit the people is a highly debatable point, echoing discussions from the preceding panel.

As a final question, the moderator requested a one- or two-word response from each panel member to the question of what can be considered absolutely essential to ensure effective regulation?

The following responses were received from the members of the panel,

Prudency;

Common Sense;

Data;

Precaution and Proportionality.

7.7.3 Key Take-aways & Recommendations

Based on the extensive discussion points outlined in the panel, several detailed recommendations can be derived to enhance the regulatory environment and foster innovation in the maritime industry.

Firstly, there is a strong consensus on the importance of tailored and flexible regulations rather than a one-size-fits-all approach. Acknowledging the pros and cons of different regulatory systems, the emphasis should be on regulations that provide greater freedom, potentially fostering more innovation. However, it's crucial to address the challenges related to the time it takes to identify dominant designs when users are given flexibility. Despite industry concerns framing this as a threat, a balanced perspective views it as an overall positive development.

Moreover, the development and implementation of standardization are seen as crucial contributors to more efficient regulation of robotics. Drawing parallels to industries like pharmaceuticals and nuclear technology, clear guidelines for designing technological solutions can instill confidence among manufacturers and foster the development of innovative technologies. The harmonization of international regulations, certification processes, and data sharing are recommended to streamline compliance and ensure reliability. Emphasizing the importance of ethical and social standards in robotics development, the focus should be on purpose-driven innovation aligned with ethical considerations.

Moving to the practical side of implementation, collaboration among stakeholders in different disciplines is essential. The alignment of interests is identified as a key factor in breaking down silos, emphasizing the influence of financial considerations. Successful collaboration examples in digital technologies should be studied, while recognizing instances where alignment of interests may be lacking, hindering the establishment of a dominant design. The human element in decision-making remains critical, emphasizing that, despite advancements in AI and automation, humans are currently responsible for most critical decisions.

In terms of challenges in inter-departmental communication and cooperation, lessons can be drawn from the pharmaceutical industry's exemplary model. Regular communication, compliance checks, and engagement with regulatory authorities are recommended to align innovation with current regulations. The importance of data security, especially in risk-prone industries, is underscored, with parallels drawn between the medical and maritime sectors.

Addressing the concerns of investors in maritime and ocean robotics innovation, clarity on business models and the nature of investments (asset-based or technology-based) is crucial. Factors such as software updates, relationships beyond the sale, and connectivity of robotics parts to other assets must be addressed for defining expected yields and investor interest. Clear communication and transparency are emphasized in shaping sustainable financial strategies for the robotics industry.

Finally, in the context of sustainability, acknowledging the expense of sustainability, there is a need to clarify who should bear the costs. Environmental concerns influencing public opinion and growing willingness to pay more for sustainable products reflect a shift towards green critical consumerism. Efforts to economically evaluate environmental costs, as seen in various models and regulations, should be continued. However, recognizing the divergence between public and private investments, it's essential to align sustainability goals with realistic investor expectations and returns.

In conclusion, a balanced, collaborative, and purpose-driven approach to regulation, innovation, and sustainability is recommended, taking into account the diverse perspectives and challenges discussed in the panel.

7.8 Panel Six: Recommendations for Digital Reform: Ways Forward Capacity Building & Technology Transfer

7.8.1 Moderator's remarks

The moderator expressed gratitude for the opportunity to oversee a panel of distinguished professionals deeply embedded in the maritime industry. The impending discussion aimed to delve into the subsequent actions. The moderator highlighted the intention to synthesize the collective understanding of stakeholders before delving into recommendations and future strategies. Acknowledging the accelerating pace of technological advancements and the increasing integration of shipping within the global supply chain, it was noted that maritime stakeholders find themselves compelled to adjust and reconsider their current strategies, operational frameworks, and approaches to utilizing generated data. The overarching goal was to ensure the establishment of efficient, sustainable operations that fortify their competitiveness in both short and long-term scenarios. Emphasizing the vital role of engaging with all stakeholders, the moderator along with the panel aimed to explore collaborative pathways to navigate the evolving dynamics in the maritime sector.

7.8.2 Discussions

What is the level of acceptance of stakeholders such as regulators, port state control and what is the reaction of classification societies to the challenges of digitalization in terms of acceptance, security, preparation, etc.?

The panelist initiated their response by addressing the varying levels of acceptance observed among owners and operators in the maritime industry. They noted a spectrum ranging from no acceptance to full acceptance. The lack of acceptance, as explained, often stemmed from competing priorities within the industry, such as the mandatory focus on zero emissions and MRV (Monitoring, Reporting, and Verification). The panelist highlighted that incorporating new methods of operation, such as remote work and robotics, may not be the foremost concern for some in the industry.

Furthermore, the panelist delved into the segment of stakeholders showing reluctance, emphasizing concerns about data utilization. Some operators, particularly in the tanker sector, expressed worries about potential repercussions if vessel deficiencies were disclosed, fearing challenges in securing future charters. Contrasting this, the panelist elaborated on the instances of full acceptance, where owners actively sought comprehensive digital classification. These stakeholders demonstrated a keen interest in leveraging all available onboard data and making it accessible for enhanced operational capabilities.

The panelist continued to address another crucial group of stakeholders – the regulators. Within this category, the spectrum of acceptance ranged from non-acceptance to full acceptance. The panelist recounted an audit experience where a regulatory body questioned the rationale behind remote services, asserting that there was no explicit permission for such practices. In response, the panelist defended the approach, highlighting it as a tool to fulfill the required scope and draw conclusions effectively. However, it was noted that the explanation might not have been entirely convincing as the regulatory body appeared to have preconceived opinions.

The panelist also referenced a recent development from the Australian Maritime Safety Agency (AMSA), which had issued a letter stating a refusal to accept any remote services for detained vessels. This highlighted the ongoing dynamic nature of regulatory acceptance, with some flag states endorsing certain practices while others express reservations. The situation appeared to be subject to fluctuation and ongoing discussions within the regulatory landscape.

Finally, on the matter of classification, the panelist addressed the role of classification and the concerns within the surveyors' community. The panelist expressed that there was a prevalent fear among colleagues regarding potential job loss, perceived monotony in the job, and increased stress levels. It was noted with concern that the diverse range of perspectives within the industry, ranging from non-acceptance to full acceptance, contingent upon the individual's role and viewpoint.

What are some barriers key barriers that you find are delaying the digitalization in shipping?

The second panelist shared a practical insight based on personal experience, emphasizing that digitalization goes beyond software and revolves around placing data at the core of all activities. The key, as per the panelist, existed in a shift in mindset and recounted a specific incident from a few years ago involving the installation of an advanced system on a VLCC (Very Large Crude Carrier) for enhanced navigation using computer vision and AI. Despite the system's capabilities to assist seafarers in congested areas, the crew's reaction was one of apprehension. They expressed that despite the AI system's impressive capabilities, including continuous alertness on board, the crew expressed concerns about its potential to replace human tasks and interactions, highlighting the need for addressing fears and perceptions in the process of introducing digital solutions in the maritime industry.

The panelist further explained that upon grasping the concept, they recognized the system as a tool with the potential to assist them. The nuances of digitalization became evident, revealing a complexity beyond a simple dichotomy. As they gradually integrated the system into their operations, positive changes were observed, creating a more relaxed atmosphere on the bridge. The speaker emphasized the multifaceted nature of these barriers, which extend beyond conventional expectations and can be challenging to navigate. They underscored the significance of considering the human element, acknowledging the inherent complexity of individuals. The key takeaway conveyed was the prioritization of people over software in the realm of digitalization.

Has the digital reform affected the ship financing and in which way? How do the financiers perceive digital reform?

The panelis explained that, concerning the perception of individual financiers, it's easy to assume that the role of a shipping financier has been swiftly replaced by a black box or similar technology. However, this is not entirely accurate. Digitalization has indeed brought significant changes to finance, including shipping finance. Before joining the panel, the speaker conducted a SWOT analysis to understand the strengths, weaknesses, opportunities, and threats of digitalization. While it presents new opportunities, entering this new era comes with challenges and risks. One notable change is the potential loss of sensitivity in the financing process, making some roles more critical and responsible than others. Thus, the landscape of finance is evolving, impacting various stakeholders differently and reflected on the role of regulators and their understanding of the specific cyclical nature of the market.

Recalling the experience in 1998, where the panelist represented a French bank, they highlighted the shock regulators faced at that time. As a young banker, the speaker had to explain the intricacies of financing judgments, credit processes, and the nuances of different European markets. The point was made that regulators, especially those within the European Parliament, might lack a comprehensive understanding of the dynamics in the cyclical shipping market. The speaker expressed concern that current regulators may not fully comprehend the implications of their decisions and statements regarding shipping credit and the financing approaches of banks. This lack of understanding is seen as a contributing factor to the decline of major European shipping financiers. The speaker emphasized that this scenario could be an unintended consequence of transitioning to a more advanced digital environment.

The panelist continued to elaborate on the acceleration and transparency achieved in the credit process through digitalization. They emphasized the benefits of a transparent system where numbers and credit marks are clearly visible, ensuring accurate compliance at every stage of the financing process. The initial stages of the relationship were highlighted for their accelerated compliance, facilitated by fast and in-depth analysis of available data. The abundance of data was acknowledged, with recognition that platforms and data analysts play a crucial role in processing and interpreting this vast amount of information.

Furthermore, the panelist pointed out the strength of digitalization in utilizing combined knowledge for various credit and investment aspects, encompassing technical, financial, and managerial elements. They emphasized the significance of market comparisons, drawing parallels with the appeal of sports statistics in newspapers.

The panelist proceeded to discuss the identified weaknesses in the digitalization of the financing process. They highlighted the elimination of sensitivity, emphasizing that the seasoned financier's intuition and judgment no longer play a significant role in the credit process. Previously considered a valuable asset up to 2005-2010, the panelist expressed concern that the current emphasis is solely on figures and results. A major drawback mentioned was the elimination of the special character inherent in cyclical industries like maritime transport and real estate. The panelist noted that the model-driven approach does not account for the unique experiences and strategies employed by individuals, especially ship-owners who navigated through past crises. The withdrawal of personal judgment and the expulsion of ultimate owners' integrity were also flagged as notable downsides.

The panelist underlined the importance of understanding how ship-owners tackled crises in the past, such as the challenges faced in the 50s, 60s, and 80s. They questioned whether these historical insights still hold value in the current model-centric approach. The panelist further emphasized the significance of observing how charters behaved during critical events like the Lehman Brothers collapse, stressing the need to consider human reactions and experiences beyond numerical data.

The panelist further discussed key weaknesses in the digitalization process, emphasizing the challenges of incorporating certain elements into the models. Notably, the regulatory position has evolved into an enhanced mode, signifying a shift in the role of regulators within this transformed landscape. Another identified weakness is the shortage of specialized personnel, with the panelist highlighting that it's not solely an age-related concern but a matter of education. They stressed the importance of educational backgrounds, pointing out that even graduates from esteemed maritime universities may require further training to adapt to the changing environment.

The panelist underscored the pressing need for training in this evolving landscape, acknowledging the uncertainty about existing capabilities in the face of digitalization. This recognition of the changing dynamics and the necessity for continuous training adds to the list of challenges in embracing the new digital environment. The panelist emphasized the potential opportunities arising from the digitalization process, highlighting the creation of new financing platforms catering to both lending and investment. Noteworthy is the influx of new entrants, with a special mention of individuals, predominantly from India, contributing to the development of innovative platforms. The panelist illustrated the current prevalence of digital financing platforms, especially in real estate markets, and exemplified the integration of smaller domestic banks into the international market through advanced digital processes. Drawing attention to a specific case, the panelist mentioned the success of a Greek bank, Viva Bank, operating as a notable FinTech entity with a unique license covering the entire European region. The example showcased the effectiveness of incorporating local regulations into the digital model, emphasizing the potential applicability of FinTech concepts to cyclical loans and financing.

In conclusion, the panelist emphasized the necessity of adapting to the evolving digital environment, acknowledging the challenges and the obligation to embrace the changes. The panelist highlighted the emergence of new specialized services and job opportunities in the evolving landscape. Recognizing the inevitability of following this trajectory, the panelist encouraged both seasoned professionals and the younger generation to actively participate in and navigate the transformative path of digitalization

Which business fields will be affected and how the business models of these fields will be modified to accommodate the introduction of robotics in shipping? What are the difficulties being faced from the various shareholders for the introduction of robotics in shipping?

In response, the panelist emphasized the imminent presence of robotics in the maritime industry. Acknowledging the upcoming transformation, they noted that the adoption of this new model might take a few more years to proliferate. The panelist contended that the slow pace of change is attributed to smaller companies like theirs, such as SMS, facing challenges in capital availability and return on investment. This lag necessitates a waiting period for funded projects and mature investors to facilitate a faster transition. Envisioning significant alterations in business models across sectors, the panelist highlighted the impact on SMEs, classification processes, CPL, and shipping commerce.

The panelist emphasized the staggering volume of steel structure inspections required for medium-sized vessels, approximately 600,000 square meters every two and a half years. They emphasized the arduous and costly process of scaffolding for vessels older than 15 years, posing risks to human workers. Looking ahead, the panelist predicted the elimination of scaffolding departments in shipyards for inspections and repairs, with robotics gradually taking over these tasks. The ultimate vision is for vessels to be constructed with the assistance of robots or similar advanced technologies.

In a futuristic projection, the panelist envisioned a transformative role for robots in the maritime industry. They highlighted that ships would be designed with robots, creating an intermediary step involving classification rules for access means. Anticipating changes in rules to incorporate robotic access, the panelists suggested that vessel owners could receive discounts from classification societies, fostering benefits in both cost savings and market efficiency. The panelist shared a practical example of an intermediary survey on a vessel over 7.5 years old, conducted in just six hours using three surveyors, six UTM operators, and three robots. This contrasted with the potential six days required for a traditional survey, showcasing the efficiency and time-saving potential of robotic inspections.

Clarifying the initial use of robotics in shipping, the panelist emphasized that it wouldn't be exclusively remote inspection but rather a facilitation of inspections. This approach would lead to more standardized, faster, and cost-effective inspections, minimizing risks. The panelist stressed that, in the beginning, inspections would still involve the presence of surveyors and service providers on board. However, as technology matured over the next decade, the panelist foresaw a transition to remote inspections, possibly involving augmented reality, where surveyors could analyze vessel conditions from a remote location using advanced visual and 3D reconstruction technologies. These futuristic visions were backed by ongoing research projects and field trials, showcasing the industry's gradual evolution towards a more automated and technologically advanced future.

In conclusion, the panelist brought out the challenge in the availability of capital. The successful introduction of advanced technologies into the maritime industry depends on when ship-owners recognize the need for such changes. The panelist suggested that ship-owners might take the initiative to align these advancements with their specific requirements. Alternatively, classification societies, insurance providers, or charterers could also drive these changes. However, the panelist cautioned that any imposition of burdens on the primary actors in the industry could introduce additional complexities and challenges across various aspects of the maritime sector.

Summarizing the discussions so far, the moderator directed the panel towards deliberating the ways forward, recommendation and the next steps to be taken.

The panel highlighted the importance of using common sense and building trust in achieving physical equivalence from a classification society standpoint. To accomplish this, the panelist emphasized engaging staff in test trials and proof of concepts in collaboration with ship-owners. The involvement of flag states and adherence to existing regulations, including potential future guidelines, were deemed crucial. Despite challenges such as the postponement of certain rules, efforts to enhance data security were emphasized.

Furthermore, the panel stressed the significance of owner participation, noting that many ship-owners are already increasing vessel connectivity. The ongoing challenge is to extend quality connectivity throughout vessels, addressing issues like onboard connectivity and leveraging available technology through test trials. The panel acknowledged both positive and negative outcomes in their experiences, with some owners expressing that certain technologies might be premature, emphasizing the need to re-evaluate and conduct trials when more advanced solutions emerge.

The moderator requested the panel for some examples on what the industry needs to do to ease the digitalization process and the lowest hanging fruits of digital reform.

The speaker offered three practical examples, considering three different stakeholders: vendors, educators, and shipping companies.

• Vendors: The advice for vendors is to shift their focus from highlighting features to emphasizing benefits. The speaker suggested that vendors should stress the value their products bring rather than overwhelming potential users with technical details. Additionally, the speaker recommended that some vendors should enhance flexibility in integrating their systems with other platforms.

• Educators: The speaker urged educators to reconsider the educational material provided to seafarers. Expressing concern about the current material being perceived as dull, the speaker emphasized the need for more engaging and enjoyable educational content. Drawing from personal university experience, the speaker highlighted the importance of making learning fun for effective comprehension, particularly in the context of continuous training for seafarers.

• Shipping Companies: The speaker shared an anecdote involving a collaboration with a shipping company and an IT solution provider. In the story, the IT director initially intended to attend the meeting but eventually brought in a larger team, including safety personnel and other directors. The lesson learned from the experience was the challenge of convincing users, especially when they are resistant to change. The speaker emphasized the need for shipping companies to navigate the dynamics within their teams and address user concerns when implementing digital solutions.

Another member of the panel made an intervention by focusing on three key technological advancements—augmented reality (AR), artificial intelligence (AI), and robotics—in shipping for the next two decades. The focus, according to the speaker, lies not only on the technology itself but on the industry's maturity. Acknowledging the conservative nature of the shipping sector and the complexity of ships as assets, the speaker highlighted the necessity for technology to mature significantly before widespread adoption. The call was to disseminate the current state of new technology within the shipping industry, paving the way for its fruitful integration.

The remarks by the final speaker of the member captured the importance of education to address threats in the maritime sector, particularly emphasizing the need to educate regulators. The responsibility of global institutions, such as the World Maritime University, was stressed in tandem with the speaker's organization's efforts, exemplified by opening an office in Shanghai. The move aimed to share insights on financing best practices and showcased a new trend in China where bankers, as an example, had to take personal responsibility for loans which can be addressed better through digitalization. The overall message conveyed the inevitability of digitalization and the tremendous opportunities it presents in the evolving global market.

7.8.3 Key Take-aways

• Digitalization brings combined knowledge, acceleration, transparency, and compliance to the maritime industry.

• Integration of smaller banks with larger ones and the creation of new jobs are opportunities offered by digital platforms.

• The maritime industry can adapt to global challenges through digitalization but must balance benefits against safety, security, environmental protection, and trade facilitation.

• Human factors, including the impact on personnel both onboard and ashore, should be considered in digitalization strategies.

• Communication and educational efforts are essential for creating value in the maritime sector.

• Embracing digital markets is inevitable, and resisting digitalization is ineffective.

The level of acceptance among stakeholders in the maritime industry towards digitalization varies widely, with owners and operators exhibiting a spectrum from no acceptance to full acceptance. This diversity is influenced by competing priorities, such as the industry's mandatory focus on zero emissions and Monitoring, Reporting, and Verification (MRV). Some stakeholders, particularly in the tanker sector, express reluctance due to concerns about data utilization, fearing potential repercussions for disclosing vessel deficiencies and impacting future charters. On the other hand, there are instances of full acceptance, where owners actively seek comprehensive digital classification, demonstrating a keen interest in leveraging onboard data for enhanced operational capabilities.

Regulators also showcase a spectrum of acceptance, ranging from non-acceptance to full acceptance. An audit experience highlighted a regulatory body questioning the rationale behind remote services, indicating preconceived opinions about such practices. Additionally, the Australian Maritime Safety Agency's refusal to accept any remote services for detained vessels underscores the dynamic nature of regulatory acceptance, with some flag states endorsing certain practices while others express reservations. Classification societies, too, face challenges, with surveyors expressing concerns about potential job loss, perceived monotony, and increased stress levels, reflecting a diverse range of perspectives within the industry.

Barriers to digitalization in shipping are multifaceted. The first panelist emphasized the need for a mindset shift, beyond just implementing software, and recounted an incident where seafarers initially resisted an advanced system due to fears of job replacement. Overcoming these fears and perceptions is crucial in introducing digital solutions. The second panelist highlighted the evolving landscape of finance due to digitalization, with strengths and weaknesses identified through a SWOT analysis. They pointed out potential loss of sensitivity in the financing process, impacting various stakeholders differently, and stressed the need for regulators to comprehend the cyclical nature of the market to avoid unintended consequences.

In the realm of ship financing, the panelist revealed that the role of shipping financiers has not been entirely replaced by technology, and digitalization has brought both opportunities and challenges. The potential loss of sensitivity in the financing process is a notable change, making certain roles more critical. The panelist expressed concern that regulators may lack a comprehensive understanding of the cyclical shipping market, contributing to the decline of major European shipping financiers. Digitalization has brought about acceleration and transparency in the credit process but has also eliminated the special character inherent in cyclical industries. The need for training and adapting to the changing environment was emphasized, along with the emergence of new financing platforms and job opportunities.

The introduction of robotics in shipping is imminent, with the panelist envisioning significant alterations in business models across sectors. While acknowledging the slow pace of change due to capital availability challenges for smaller companies, the potential elimination of scaffolding departments in shipyards for inspections and repairs through robotics was highlighted. The panelist foresaw vessels being designed with robots, potentially leading to discounts for vessel owners from classification societies. Despite ongoing research projects and field trials, challenges in capital availability pose a barrier to the widespread adoption of robotics.

Summarizing the discussions, the panel stressed the importance of using common sense, building trust, and engaging in test trials and proof of concepts to achieve physical equivalence from a classification society standpoint. The involvement of flag states and adherence to existing and potential future regulations were deemed crucial, along with efforts to enhance data security. Owner participation in increasing vessel connectivity, addressing onboard connectivity issues, and leveraging available technology through test trials were emphasized. The need for a balance between positive and negative outcomes and re-evaluating technologies when more advanced solutions emerge was also noted.

In terms of recommendations and next steps, the panel highlighted the importance of common sense and building trust to achieve physical equivalence. Engaging staff in test trials and proof of concepts in collaboration with ship-owners, involving flag states, and adhering to regulations were emphasized. The significance of owner participation in increasing vessel connectivity and addressing connectivity issues through test trials was noted. The panel suggested that vendors should focus on emphasizing the benefits of their products rather than technical details, educators should provide more engaging educational content for seafarers, and shipping companies should navigate team dynamics when implementing digital solutions.

Finally, the panelists discussed the need for technological advancements, including augmented reality (AR), artificial intelligence (AI), and robotics, in the maritime industry over the next two decades. The speaker emphasized the necessity for technology to mature significantly before widespread adoption, considering the conservative nature of the shipping sector and the complexity of ships as assets. The importance of disseminating information about new technology within the shipping industry was highlighted to pave the way for fruitful integration. The significance of education, especially for regulators, was stressed, acknowledging the inevitability of digitalization and the tremendous opportunities it presents in the evolving global market.

7.9 Concluding Remarks

7.9.1 Key Take-aways and Recommendations

As the event concluded, the President expressed gratitude and admiration for the insightful discussions that unfolded throughout the six sessions on overcoming regulatory barriers for service robotics in the ocean industry. The collective wisdom, passion, and dedication of the panelists were highlighted, emphasizing the remarkable nature of the discourse. The panelists' expertise and thoughtful analysis illuminated the challenges and opportunities surrounding service robotics in maritime activities. The President extended heartfelt gratitude to all panelists for their invaluable contributions, recognizing the diverse viewpoints and comprehensive discussions that laid the foundation for actionable steps to address barriers. Each discussion was acknowledged for its depth and breadth, showcasing a profound sense of interconnectivity among the major issues presented.

Furthermore, the president expressed gratitude to the highly engaged audience, acknowledging their role as the driving force behind the insightful discussions. It was highlighted that the audience likely carried valuable takeaways from the discussions to their respective journeys home. The president emphasized the pivotal reality of standing at the cusp of a technological revolution, with the coming decade and the next few years poised for unparalleled advancements in technology, particularly in service robotics and artificial intelligence. The responsibility to shepherd this innovation with prudence and safety by design was recognized as a shared endeavor among everyone present at the event.

A heartfelt appreciation was extended to the team at the Sasakawa Global Ocean Institute and Assistant Professor Tafsir Johansson for their contributions.

The president expressed gratitude, acknowledging that WVU owed a big note of thanks to the Senior Advisory Group for their unwavering support throughout the project. The president conveyed appreciation for the guidance, feedback, and considerable time dedicated by the Senior Advisory Group to the initiative. The president extended thanks to everyone, including the audience both present in the room and online, emphasizing the significant role played by the DANAOS Research Centre in making the project a reality.

Reflecting on the visit to Piraeus, the president noted the rewarding experience on both professional and personal levels. The president expressed gratitude for the opportunity to reconnect with close friends, particularly mentioning HELMEPA, and former WMU students, including a delegation of Hellenic WMU alumni. New connections and friendships within the shipping community were also highlighted. The president expressed appreciation for the warm reception and mentioned the pleasure of seeing Norman Martinez, the head of the sister institution under IMO, the International Maritime Law Institute.

Finally, the president extended an open invitation to anyone in the Scandinavian region to visit the World Maritime University, emphasizing that they would be very welcome. The president concluded with final thanks, expressing the hope that paths would cross again in the future.

7.9.2 Professor Ronán Long

Professor Long expressed gratitude, acknowledging the president and local hosts for their wonderful support. The director extended thanks to both the in-person and virtual audience, emphasizing the significance of the forum being held in the Hellenic Republic, a place with classical traditions that holds a special meaning. The director shared personal enthusiasm for being in Athens, describing it as one of their favorite cities globally, and mentioned taking extra time to appreciate it.

The director reflected on the initial discussions about where to hold the forum, considering options like London with the International Maritime Organization or Brussels due to the European Commission's substantial contribution. Ultimately, the decision was made to bring the forum to the industry partners, a choice that proved meaningful in the rich context of the discussions during the event. The director noted that the forum had illuminated various issues, leaving them with more questions than answers by the end of the day. This sentiment was likened to what the director often tells students in Malmo.

Professor Long emphasized that, for sailors, the essence lies in the journey rather than the destination, understanding the significance of the voyage and the experiences it brings. Reflecting on the discussions, Professor Long highlighted a key takeaway from the last session regarding the crucial role of the shipping industry in the global trading system. Despite the pandemic, some people worldwide may not fully comprehend this importance, but disruptions during the pandemic shed light on the vital role of shipping in the world's functioning.

The Director further expressed satisfaction in learning about the industry's commitment to greener shipping, emphasizing the positive impact it can have on the future. Additionally, Professor Long acknowledged and emphasized the importance of the DANAOS, recognizing their presence and contribution throughout the event. The director acknowledged the Nippon Foundation for their support in the university and expressed appreciation for the pivotal role of Chairman Sasakawa in sponsoring Research and Innovation for global shipping, emphasizing that their support made the event possible.

The director also highlighted the importance of funding from the university, which directly benefits students, postdocs, and PhD students, thanks to the Nippon Foundation. Addressing the global audience, the director underscored the significance of diversity and inclusion, noting the participation from Central and Latin America, Southeast Asia, and Japan, the home of their donor organization. The director emphasized the truly global nature of the industry and the program. Additionally, the director revealed plans for a new program at the university focusing on robotics and AI in the coming months. This initiative aims to build on the partnership with the 21 partners involved in Bug Rights, acknowledging the contributions of technologists, Cedric, Thomas, and industry partners. The director expressed optimism about advancing this work, possibly through an EU-funded initiative, with the partners in the room forming the core of the consortium.

Lastly, Professor Long expressed gratitude to the program manager, Elnaz, at the Institute, acknowledging her professionalism and efficient management of a small team. Drawing on extensive experience in various sectors, Professor Long commended Elnaz as one of the most outstanding individuals worked with throughout their career. Professor Long highlighted Elnaz's exceptional ability to handle the professional and business aspects of the work program while infusing a sense of enjoyment. Special thanks were extended to Elnaz's team and, foremost, to the President of the university as he embarked on his new tenure. Professor Long concluded by expressing hope to see everyone in Malmo, especially acknowledging Cedric, Laura, Thomas, and the other members of the consortium.

7.9.3 Tafsir Matin Johansson, Assistant Professor, WMU-Sasakawa Global Ocean Institute, World Maritime University (WMU)

In a heartfelt vote of thanks, Dr. Johansson expressed deep gratitude to various individuals who contributed to the BUGWRIGHT2 event, including the audience, the moderator, panel speakers, and Professor Ronan Long. Reflecting on the journey that started four and a half years ago, Dr. Johansson acknowledged the influence of BUGWRIGHT2 and its impact on personal growth and development. A special mention was made to Cedric, the event's initiator, and the Thomas trio, who provided valuable insights into classification societies and diverse perspectives.

Dr. Johansson highlighted the electrifying brain power unleashed during the event and expressed appreciation for the brilliant minds encountered, including Vera and numerous Greek friends. Addressing the significance of the moment, Dr. Johansson emphasized that BUGWRIGHT2 marked the end of an era and thanked everyone for their support, collaboration, and contributions to the event's success.

A special acknowledgment was reserved for a colleague, Assistant Professor Dr. Aspasia Pastra, whom Dr. Johansson commended for commitment to excellence, their work on the research side, and her tolerance, expressing sincere thanks for her invaluable contributions. Dr. Johansson then invited Dr. Pastra to join them on stage to share a few words.

7.9.4 Aspasia Pastra, Assistant Professor, WMU-Sasakawa Global Ocean Institute, WMU

In a heartfelt expression of gratitude, Dr. Pastra conveyed deep appreciation for the transformative and joyful experience over the past seven years at work. The acknowledgment was extended to a team of seven individuals led by Max, who is set to guide them into the new era of decarbonization. Special recognition was given to the director, Ronan Long, whose boundless energy became a source of inspiration. Dr. Pastra marveled at Dr. Johansson’s unwavering availability, addressing problems and questions promptly, even maintaining a 24/7 responsiveness, adding a light-hearted touch to the gratitude expressed.

7.9.5 Key Take-aways & Recommendations

As the event concluded, the President expressed sincere gratitude and admiration for the insightful discussions that unfolded throughout the six sessions on overcoming regulatory barriers for service robotics in the ocean industry. The President underscored the collective wisdom, passion, and dedication of the panelists, emphasizing the remarkable nature of the discourse. The expertise and thoughtful analysis provided by the panelists illuminated the challenges and opportunities surrounding service robotics in maritime activities, laying the foundation for actionable steps to address barriers.

The President extended heartfelt appreciation to all panelists, recognizing the diverse viewpoints and comprehensive discussions that showcased a profound sense of interconnectivity among the major issues presented. Each discussion was acknowledged for its depth and breadth, reinforcing the importance of the discourse in shaping the future of service robotics in the ocean industry.

Furthermore, the President expressed gratitude to the highly engaged audience, acknowledging their role as the driving force behind the insightful discussions. The President highlighted the pivotal reality of standing at the cusp of a technological revolution and recognized the shared responsibility of shepherding this innovation with prudence and safety by design among everyone present at the event.

A special mention of gratitude was extended to the team at the Sasakawa Global Ocean Institute and Assistant Professor Tafsir Johansson for their invaluable contributions to the success of the event. The President also acknowledged that WVU owed a big note of thanks to the Senior Advisory Group for their unwavering support throughout the project, expressing appreciation for the guidance, feedback, and considerable time dedicated by the Senior Advisory Group to the initiative.

Reflecting on the visit to Piraeus, the President noted the rewarding experience on both professional and personal levels. Gratitude was expressed for the opportunity to reconnect with close friends, particularly mentioning HELMEPA, and former WMU students, including a delegation of Hellenic WMU alumni. New connections and friendships within the shipping community were highlighted, and the pleasure of seeing Norman Martinez, the head of the sister institution under IMO, the International Maritime Law Institute, was mentioned.

The President concluded by extending an open invitation to anyone in the Scandinavian region to visit the World Maritime University, emphasizing that they would be very welcome. The President expressed the hope that paths would cross again in the future, fostering continued collaboration and progress in the field.

In response, Professor Long expressed gratitude, acknowledging the President and local hosts for their wonderful support. The director extended thanks to both the in-person and virtual audience, emphasizing the significance of the forum being held in the Hellenic Republic, a place with classical traditions that holds a special meaning.

Reflecting on the initial discussions about where to hold the forum, the director highlighted the meaningful decision to bring the forum to the industry partners, a choice that proved significant in the rich context of the discussions during the event. The director noted that the forum had illuminated various issues, leaving them with more questions than answers by the end of the day, echoing the sentiment often shared with students in Malmo.

Professor Long emphasized that, for sailors, the essence lies in the journey rather than the destination, understanding the significance of the voyage and the experiences it brings. Reflecting on the discussions, Professor Long highlighted a key takeaway from the last session regarding the crucial role of the shipping industry in the global trading system.

The Director expressed satisfaction in learning about the industry's commitment to greener shipping, emphasizing the positive impact it can have on the future. Additionally, Professor Long acknowledged and emphasized the importance of the DANAOS, recognizing their presence and contribution throughout the event.

The director acknowledged the Nippon Foundation for their support in the university and expressed appreciation for the pivotal role of Chairman Sasakawa in sponsoring Research and Innovation for global shipping, emphasizing that their support made the event possible.

ANNEX I: Companion Publications for the Development of Guidelines

Principal Resources

Alexandropoulou, V., Johansson, T., Kontaxaki, K., Pastra, A. and Dalaklis, D. (2021). Maritime remote inspection technology in hull survey & inspection: A synopsis of liability issues from a European Union context. *Journal of International Maritime Safety, Environmental Affairs, and Shipping*, 5(4), pp.184–195. DOI: https://doi.org/10.1080/25725084.2021.2006463

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ANNEX II: Take-aways from Meetings Attended at the International Maritime Organization

A. Lessons Learnt from the attendance at the Maritime Safety Committee (MSC 107) of IMO: The case of Maritime autonomous surface ships (MASS)

The Maritime Safety Committee of IMO met from 31 May till 9 June 2023 at IMO Headquarters, and, amongst others, the discussions about Maritime autonomous surface ships (MASS) attracted the attention of the participants and policymakers.

The emergence of autonomous ships has highlighted the necessity for a dedicated regulatory framework. The framework should address the nuances of autonomous ships, particularly their interaction and co-existence with traditional manned ships, in a landscape where existing regulations predominantly presume human manning and intervention. In response to this need, the International Maritime Organization (IMO) has reached a consensus to formulate a non-mandatory, goal-oriented code for Maritime Autonomous Surface Ships (MASS) by 2025. The discussion in MSC 107 concluded:

- the code would apply to SOLAS cargo ships and high-speed craft and should follow a risk-analysis-based approach following the structure of MSC.1/Circ.1455;
- the definitions of the "modes of operation," which are crucial for delineating the various conditions under which a ship's functions operate collectively to ensure safe navigation and fulfill its intended purpose;
- a human master will be accountable for the Maritime Autonomous Surface Ship (MASS), irrespective of its operating modes. Additionally, the term "Remote Operations Centre" (ROC) has been designated to refer to the location where the remote master and remote operators are situated;
- the existing requirements of COLREG would be still applicable regardless of how a ship is operated.

Regarding further work on the draft MASS Code, some of the elements that IMO should consider in the following years are listed below. These elements are also considered crucial for the mass deployment of RIT and the development of a regulatory blueprint.

1. Risk assessment Methodology

MSC 107/5/4 and MSC 107/INF.8 proposed a MASS risk-assessment methodology, the so-called risk-based assessment tool, as part of functional safety and are intended for inclusion in the MASS Code.

Due to the lack of explicit regulations, it is important to guarantee safety by following functional criteria established through objective-oriented methods, as outlined in the proposed MASS Code. To support this initiative, the European Commission, in collaboration with the European Maritime Safety Agency (EMSA), has initiated a project to create a Risk-Based Assessment Tool (RBAT) specifically for MASS.

The RBAT methodology aims to enable risk assessment and evaluation of safety equivalence in introducing technologies with automated/autonomous functionalities as a future part of vessel operations. RBAT proposes an alternative to the classical definition of risk evaluation by using a combination of the worst-case outcome from an undesired event and the effectiveness of the mitigation actions to prevent losses. To do so, the method is divided in five main parts:

I. Define use of automation: describes the overall mission and operation as well as assigning the responsibility for either performing or supervising functions to software or human agents;

II. Hazard analysis: this stage includes a) identification of unsafe conditions associated with control actions, b) identification of causal factors that may initiate the unsafe conditions, c) description of the worst-case outcomes from unsafe conditions, d) ranking of the worst-case outcomes severity, e) description of the relevant operational restrictions and limitation;

III. Mitigation analysis: examines if Fault Detection, Isolation and Recovery (FDIR) is planned to be part of control functions' design and identify which mitigation layers are in place;

IV. Risk evaluation: compares the risk level for each assessed scenario against a set of risk acceptance criteria to determine the need for risk control;

V. Risk control: ensures that unacceptable (High) and tolerable (Medium) risks are made as low as reasonably practicable (ALARP) using risk control measure

2. Cybersecurity

MSC 107/INF.11 provided information on cybersecurity in the maritime domain, considering the future systems and requirements for network security equipment to support MASS operation.

The details of network security equipment development proposed by Korea are as follows:

I. provision of authentication and encryption between ship and external communication;

II. detection and blocking of attacks based on deep packet inspection (DPI) analysis of external incoming traffic;

III. data flow control for external incoming traffic;

IV. AI-based anomaly detection through monitoring of internal networks;

V. interworking of an integrated security management system for attack detection and collection-analysis of anomalies detection results;

VI. provision of security for the user's bring your own device (BYOD) device (such as malware detection); and

VII. prevention of forgery and modulation of data on external communication with the ship and internal communication of the ship.

VIII. The following elements are considered necessary for developing network security equipment when operating MASS ships:

a) Security requirements for controlling data, functions, and operational access of the target system for confidentiality;

b) System functional requirements that must be performed by a target system or that must be performed by a user using the target system;

c) Performance requirements such as processing speed and time, throughput, dynamic and static capacity, and availability of the target system;

d) System interface requirements connecting the target system to the outside, including links with other software, hardware and communication interfaces, and protocols used for information exchange with other;

e) Equipment composition requirements and components HW/ SW/ NW required for the configuration of the target system; and

f) Test requirements checking whether the built system is operating properly relative to the planned target.

2. Development of a Regulatory Framework

MSC 107/INF.12 provided a summary of the MASS regulatory framework implemented in France in alignment with the Interim guidelines for MASS trials (MSC.1/Circ.1604). As a first step, a temporary and experimental set of regulations was developed in France in May 2020 to account for such new technologies and avoid restraining their development. As a second step, a new law on autonomous vessels enacted in October 2021.

The French Maritime affairs created a regulatory distinction between Maritime Autonomous Surface Ships (MASS) and smaller unmanned maritime devices or "maritime drones". Thus, an autonomous ship "is a ship operated remotely or by its own operating systems, whether or not there are seafarers on board". Maritime drones, referred as "Mini MASS" are defined as "a floating surface or underwater vehicle operated remotely or by its own operating systems, without personnel, passengers or cargo on board, and whose technical characteristics, in particular size, power and speed limits, are defined by regulation, without its gross tonnage being greater than or equal to 100". Although the new legislation does not yet define the mentioned technical characteristics, upcoming regulations will clarify the limits within which an autonomous vehicle is regarded as maritime drone or MASS-based, in particular, on overall length, maximum speed and kinetic energy. This distinction is particularly justified by the significant difference in risks presented by the navigation of these two types of vehicles concerning the expected safety and security requirements for people and goods, as well as environmental preservation. Hence, operation of smaller autonomous devices complying with the operation and technical thresholds ordained will fall under a simplified regime, while a specific MASS authorization regime, based on a case-by-case study, will apply to all vessels exceeding these requirements.

Although the operation of maritime drones is enclosed in a more flexible framework than MASS, in the form of a simplified procedure, it requires the fulfillment of various formalities briefly introduced hereafter. To address liability concerns, it is compulsory for maritime drones to be registered and display their identification number, ensuring clear determination of ownership and operational use. Consequently, a dedicated registry for maritime drones, distinct from the ship's registry, has been established, under which these drones operate under the French flag. Additionally, to minimize the risk of insolvency in the event of accidents, it is mandatory for all drones to have insurance coverage before operation.

The safety, security, and environmental sustainability of maritime drone operations have been secured through a variety of measures. Firstly, the new legislation has incorporated, within the national context, the guidelines of the COLREG Convention applicable to maritime drones. This includes various liability frameworks concerning compensation for navigation incidents, abandonment of ships, shipwrecks, rescue operations, and emissions from ship-sourced pollution. In addition, the regulation states that maritime drones must be equipped with a device allowing sea users and police authorities to locate them at all times. Finally, upcoming regulation will provide details on the general maintenance and operating rules to follow, along with the basic mandatory equipment required both on board maritime drones and inside the remote-control centre. Compliance of maritime drones with these requirements is then assessed during a single procedure of application for registration and the authorization to navigate is granted through the issuance of a certificate of registry.

4. Overview of new industry specification for MASS vocabulary

According to MSC 107/5/3 a new technical specification ISO/TS 23860 was published by ISO/TC 8 in June 2022. This specification contains a preliminary and voluntary industry standard MASS vocabulary. Some of the definitions underlined in the document are the following:

O Automatic: This is defined as processes or equipment that, under specified conditions, can function without human control.

O Autonomous: This is defined as processes or equipment in a ship system which, under certain conditions, are designed and verified to be controlled by automation, without human assistance.

O Control: This is defined as a purposeful action on or in a process to meet specified objectives. Control does not preclude that the action is only to monitor the process, e.g. to raise an alarm or to request intervention. Control can be exercised by a human or by automation.

O Process: A set of interrelated or interacting activities that transforms inputs into outputs (from ISO 9000). Processes on board a ship can correspond to function as defined in the International Convention on Standards of Training, Certification and Watchkeeping (STCW): "Function means a group of tasks, duties and responsibilities, as specified in STCW, necessary for ship operation, safety of life at sea or protection of the marine environment."

B. Lessons Learnt from the attendance at the Maritime Environmental Protection Committee (MEPC 80)

The Marine Environment Protection Committee of IMO met from Monday, 3 July to Friday, 7 July 2023 at IMO Headquarters, and, amongst others, the discussions about the reduction of GHG emissions from ships attracted the attention of the participants and policymakers. Some of the MEPC discussions that are also important for the mass deployment of RIT are listed below.

1. GHG Strategy

Actions taken by the Committee on issues related to the reduction of GHG emissions from ships, in particular the landmark decision of adopting the 2023 IMO Strategy on the Reduction of GHG Emissions from Ships, outlining the Organization's continued commitment to reducing GHG emissions from international shipping. The Strategy aims to reach net-zero GHG emissions from international shipping close to 2050.

2. Regulatory Mapping and Regulatory Certainty

MEPC 80/INF.17 presented the regulatory mapping of alternative marine fuels. The mapping exercise pinpointed several areas where additional regulatory efforts might be necessary, not only by the IMO but possibly by other standardization and certification bodies. Key areas identified for further development include enhancing safety guidelines for the onboard utilization of alternative fuels, the formulation of engine standards and the evaluation of potential consequences and hazards associated with alternative marine fuels and green technologies.

The role of shipbuilding in maritime decarbonization and the importance of regulatory certainty for shipbuilders was also underlined in the document MEPC 80/7/5. The document provides an overview of the work undertaken by the OECD Council Working Party on Shipbuilding on the decarbonization of shipping and shipbuilding, which in particular focuses on the role of the shipbuilding sector for broader maritime decarbonization efforts. The discussions highlighted the significance of a consistent, foreseeable, and dependable policy framework for shipowners and shipbuilders that supports the development and implementation of energy-saving and green technologies.

3. Underwater noise - revised guidelines adopted

The MEPC approved revised Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life. The guidelines incorporate revised technical expertise, referencing international measurement standards, recommendations, and rules from classification societies. Additionally, they offer example templates to aid shipowners in creating a management plan for underwater radiated noise.

4. Biofouling management - revised Biofouling Guidelines adopted

Following an extensive review, the MEPC has approved the updated Guidelines for the control and management of ships' biofouling, aimed at reducing the spread of invasive aquatic species (Biofouling Guidelines). The 2023 Guidelines expand on and update the previous version with a view to strengthening it and increasing its uptake. IMO urged developing countries to implement the Biofouling Guidelines and test relevant technologies.

ANNEX III: FORTHCOMING PUBLICATION

The following publication has been submitted for publication in the forthcoming special edition of the International Journal of Marine and Coastal Law (2024) and is currently under review.

Maritime Remote-inspection Performance Transition:

Umbrella Regulation v. Self-Regulation

Tafsir Matin Johansson; Aspasia Pastra and Maximo Q. Mejia Jr.

Vessel inspections conducted manually or via remote inspection techniques (RIT) are prescriptive statutory obligations. Verification of a vessel and its structures integrates continual inspection and certification processes, at regular intervals, throughout its life cycle.[1] Inspections assume paramount significance in upholding environmental standards, through the scrutiny of vessel structures, with a particular focus on hulls, tanks, niche areas, and the like. This scrutiny is imperative to maintenance decisions in instances where the encroachment of biofouling has led to substantial or minor deterioration manifested through, e.g., cracking, buckling, and/or corrosion. RIT-interventions offer added value by completing traditional inspection procedures in an expeditious manner.

For ship owners, certification serves as the ticket to international commercial voyages where compliance with safety standards must be ensured through inspections and surveys. Certification thus serves as proof that a vessel and its structures are in compliance with international regulations.[2] For example, the

* This contribution derives from the findings of project BUGWRIGHT2: Autonomous Robotic Inspection and Maintenance on Ship Hulls and Storage Tanks (Task 1.4) --- funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 871260.

[1] All types of certificates pursuant to international conventions are issued for a 5-year period subject to yearly endorsements.

[1] All types of certificates pursuant to international conventions are issued for a 5-year period subject to yearly endorsements.

[2] *See*, for example, International Convention for the Safety of Life at Sea, 1974, Nov. 1, 1974, 32 U.S.T. 47, 1184 U.N.T.S. 2 (as amended) (hereinafter SOLAS 74/88); International Convention on Load Lines, 1966, Apr. 5, 1966, 18 U.S.T. 1857, 640 U.N.T.S. 133 (as amended) (hereinafter CLL 66/88); International Convention for the Prevention of Pollution from Ships, 1973, Nov. 2, 1973, 34 U.S.T. 3407, 1340 U.N.T.S. 61 (as amended) (MARPOL).

International Ship Construction Certificate and accompanying documents, all requirements of SOLAS Chapter II-1, substantiate that the vessel is safe and seaworthy.

Taking stock of judicial decisions, a number of scholars have scrutinized the scope and nature of what constitutes seaworthiness.[3] While the United Nations Convention on the Law of the Sea (UNCLOS) does not define "seaworthiness," article 94 prescribes that, "Every State shall take such measures for ships flying its flag as are necessary to ensure safety at sea with regard, inter alia, to the construction, equipment and seaworthiness of ships."[4] Articles 219 and 226 offer two other instances where the word "seaworthiness" surfaces, but neither provide a clear interpretation or insight into what the term embodies. Therefore, more research needs to be done to help decipher the non-exhaustive list found in article 94.[5] Nonetheless, "construction" and "equipment" as an essential part of vessel structural integrity remain fundamental to seaworthiness. Therefore, it is safe to assert that what was an implied condition in the 18th century is now an express criterion under UNCLOS.[6]

To set the parameters for the legal status of RIT within an international legally binding treaty, reliance must be made on Part XIII of UNCLOS.[7] The correlation is

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3 Diplock LJ in *The Hong Kong Fir* [1962] 2 Q.B. 26, at 71; Lord Blackburn, in *Steel v. State Line Steamship Co.* [1877] 3 App. Cas., at 86; Judge Channel in *McFadden v. Blue Star Line* (1905) 1 K.B. 697, at 706.
4 *See* United Nations Convention on the Law of the Sea pt. VII, Dec. 10, 1982, 1833 U.N.T.S. 397 (UNCLOS), art. 94(3).
5 Id., Part XII, articles 219 and 226.
6 *See Kopitoff v. Wilson* (1876) 1 QBD 377, 380; *Steel v. State Line Steamship Co* (1877) 3 App Cas 72, 77, 84, 88; Gilroy, *Sons & Co v. W R Price & Co* [1893] AC 56, 63 *Havelock v. Geddes* (1809) 10 East 554.
7 T Davenport, "Submarine Communications Cables and Science: A New Frontier in Ocean Governance?" in H N Scheiber, J Kraska and M Kwon (eds), *Science, Technology and New Challenges to Ocean Law* (Brill Nijhoff, Leiden, 2015), at p. 226; *See* T Johansson, R Long & D Dalaklis, 'The Role

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settled and established via the term marine scientific research (MSR), which similar to "seaworthiness," remains undefined within the texts of UNCLOS. Nevertheless, after extensive research, scholars have strategically placed MSR under the category of "ocean observation and corresponding work".[8] This family of classification has added greatly to this vital field of scholarship.[9] Strikingly, all technologies used for MSR purposes, e.g., ROV, remotely piloted aircraft, profiling floats, unmanned underwater vehicles, have one key feature in common; they all are subject to the "consent regime" of coastal *vis-à-vis* researching States and competent International Organizations (IO), which applies in internal waters, territorial sea, and archipelagic waters.[10] Contrastingly, although possessing similar traits, the legal status of technologies deployed for surveys and inspection are free from debate for several reasons: (a) classification societies are authorized by flag states or duly authorized organizations representing flag states, (b) the task achieved by RIT forms a part of existing statutory or classification tasks and therefore is not purely operational oceanography, and (c) integrating RIT into manual surveys and inspections is already regulated with common minimum standards developed by classification societies (American Bureau of Shipping, China Classification Society, Bureau Veritas and Det Norske Veritas).[11]

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of WMU-Sasakawa Global Ocean Institute in the Era of Big Data' (2019) 14 Journal of Ocean Technology 22–29, at p. 22

[8] F H Th. Wegelein, *Marine Scientific Research: The Operation and Status of Research Vessels and Other Platforms in International Law* (Brill Nijhoss, Leiden, 2005).

[9] For example, *See* J Kraska et al., 'Bio-logging of Marine Migratory Species in the Law of the Sea' (2015) 51 Marine Policy 394-400, at pp. 394, 399; *See* also K Bork et al., 'The Legal Regulation of Floats and Gliders: In Quest of a New Regime?' (2008) 39 Ocean Development & International Law 298-328, at pp. 298, 307, 311.

[10] C Salpin, "The Law of the Sea: A before and an after Nagoya?" in E Morgera, M Buck, & E Tsioumani (eds), *The 2010 Nagoya Protocol on Access and Benefit-sharing Perspective* (Brill Nijhoff, Leiden, 2013) 149-183.

[11] See T Johansson, "International Standards for Hull Inspection and Maintenance of Robotics and Autonomous Systems" in J Kraska and Y Park (eds) *Emerging Technologies and the Law of the Sea* (Cambridge University Press, Cambridge, 2022) 184-213, at s 3.1.

The role of IOs in prescriptive and enforcement jurisdictions through "applicable rules and standards" has its roots in UNCLOS.[12] While general obligations are succinctly embedded in relevant parts, UNCLOS through "rule of reference" requests Member States (MS) to implement Generally Accepted International Rules and Standards (GAIRS).[13] In evaluating the role of GAIRS, scholars note the word "compatible" found in articles 311(2) and 311(3) that "... seek to ensure coherence and consistency within the UNCLOS' system of rules".[14] Undoubtedly, rules of reference proffers cohesion and adaptability, especially with IMO code, conventions and guidelines.

Adopted by Resolutions MSC.349(92) and MEPC.237(65), IMO's RO Code is noteworthy for two reasons.[15] First and foremost, the provisions of the Code assist in the comprehension of the invaluable roles played by other international bodies that are authorized by flag states.[16] "Authorization" has been defined in the Code as "... the delegation of authority to an RO to perform statutory certification and services on behalf of a flag State ...".[17] However, as is observed from the texts found in "general requirements for recognized organizations" --- the focus then shifts from certification services to rule-development tasks defined and prescribed explicitly

[12] See, *supra* note 4. Reference to "generally accepted international regulations, procedures and practices" for ensuring "seaworthiness" is found in art. 94(5). Generic reference is found in art. 226(1)(c).
[13] *See* Report of the United Nations Secretary General (1997) Impact of the entry into force of the 1982 United Nations Convention on the Law of the Sea on related, existing, and proposed instruments and programmes, UN Doc. A/52/491, Section J, paras 8–9; 275(1)–(2); 276(1); 278; 297(1)(c); 319(2)(a); 275(1)–(2); 276(1); 278; 297(1)(c); 319(2)(a).
[14] R Barnes, "The Continuing Validity of UNCLOS" in J Barrett and R Barnes(eds), *The United Nations Convention on the Law of the Sea: A Living Instrument* (British Institute of International and Comparative Law, London, 2016) 459-489.
[15] International Maritime Organization (2013) Code for Recognized Organizations (RO Code), Resolution MSC. 349(92).
[16] Namely, the International Organization for Standardization (hereinafter, ISO); and IACS.
[17] International Maritime Organization (2013) Code for Recognized Organizations (RO Code), Resolution MSC. 349(92), Part 2, s. 1.2.

through the Code.[18] Secondly and specifically, the Code, in a structured fashion through several sections, stresses the importance of the rules and requirements developed by organizations including classification societies.[19]

It is also noteworthy that UNCLOS does not provide any reference to pandemics or situations of *force majeure* when prescribing flag state duties in relation to evaluating vessels' structural integrity under article 94. Reference to *force majeure* (crisis response), can be found in two specific articles that are navigation-specific; Article18, which applies to the meaning of passage in the territorial sea, and Article 39 with regards to duties of ships during transit.[20] Thus, in global emergencies, the focus of the industry shifts to existing provisions or special guidance notes issued in real time by concerned IOs.[21]

Axiomatically, the increasing complexity of the technology necessary for international shipping is *standard-reliant*.[22] While standards provide many advantages; their primary objective is to provide a secure foundation of *support*, *means* and *basis* for critical ongoing developments by "benchmarking". Benchmarking is key to establishing a measurable baseline to assess progress in

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[18] Id., at 11.
[19] Id., ss. 2.2 and 6.6.1.
[20] *Supra* note 4.
[21] D Letts, "Can the Law of the Sea remain Afloat during COVID-19" available at: https://law.anu.edu.au/research/essay/covid-19-and-international-law/can-law-sea-remain-afloat-during-covid-19; accessed 1 January 2023. *See* also J Okerman and B von Tigerstrom, "Any Port in a Pandemic: International Law and Restrictions on Maritime Traffic during the COVID-19 Pandemic" available at: https://www.cambridge.org/core/journals/canadian-yearbook-of-international-law-annuaire-canadien-de-droit-international/article/abs/any-port-in-a-pandemic-international-law-and-restrictions-on-maritime-traffic-during-the-covid19-pandemic/7253C7F0E7928D4FEE13458F00253B57; accessed 1 January 2023, Cambridge University Press, Cambridge Core.
[22] P Hatto, *Standards and Standardization* Handbook (European Commission, Directorate-General for Research; Directorate G - Industrial Technologies Unit G1 - Horizontal Aspects and Coordination, 2010).

relation to future developments.[23] In the maritime world "standards" are comprised of an entangled web of voluntary standards and regulatory standards,[24] which can create ambiguity and thwart stakeholders' capability to develop, maintain and amend, as appropriate, rules and requirements to keep pace with innovation-governance. Today, stakeholders within the maritime technology industry are dependent on organizations that have the mandate to implement four distinct categories of standards: informal, national, regional, and international.[25] To promote the promulgation of uniform international standards, the International Organization for Standardization (ISO), founded in 1947, has had significant impact with "publications, extending to over 17,000 standards, and current work in over 200 Technical Committees [sic]" to date.[26]

In the current context, ISO Technical Committee 8 is given the mandate to focus on *Ships and Marine Technology*. The scope of the work undertaken by ISO TC/8 primarily revolves around standards that are exclusively technical in nature. Initially, standards published by the "marine environmental protection" (hereinafter ISO TC 8/SC 2) and "marine technology" (hereinafter ISO TC 8/SC 13) subcommittees were thought to contain the regulatory standards that govern marine and ocean technology. However, a careful examination of the 30 standards published by ISO TC 8/SC 2, and the 11 standards published by ISO TC 8/SC 13 reveal that the theme and content are, unfortunately, confined to the techno-regulatory-affair side of things.[27]

[23] P Hatto, *Standards and Standardization: A Practical Guide for Researchers* (European Commission, Directorate-General for Research and Innovation; Directorate G-Industrial Technologies, 2010), at p. 6.
[24] P H Lindøe & M S Baram, *The Role of Standards in Hard and Soft Approaches to Safety* Regulation (Routledge, 2019).
[25] *Supra* note 23, at 7.
[26] *Supra* note 23, at 7. The other two organizations are: International Electrotechnical Commission (hereinafter IEC) and International Telecommunication Union (hereinafter ITU).
[27] Those are the exact number of standards published by subcommittees as of 1 June 2022.

Also relevant in the current context is the IMO's *Harmonized System of Survey and Certification* (HSSC).[28] Through HSSC, IMO has addressed procedural matters by harmonizing similar survey and certification processes set as mandatory criteria under several different conventions.

Moving forward, HSSC, has indeed, resolved statutory survey matters that were, for a considerable period of time, considered by industry as repetitive, overlapping and redundant.[29] Evidently, an important feature of the HSSC is its seamless integration of standards that unify surveys pursuant to conventions that are integral to enhancing compliance with rules associated with safety as well as protection and preservation of the marine environment. While regular review reveals that the goal of uniformity is to a great extent achieved, the objective of IMO's HSSC does not entail furnishing the fundamentals of survey procedures. For those matters, annexes to the survey guidelines under the HSSC provide in a systematic manner direct references to the work of classification society standards.[30] As noted earlier, RO Code thus bolsters advertence to classification society standards, which in turn guides analysis-transition towards the core procedures – regulations governing surveys of vessel structures.

[28] Survey Guidelines under the Harmonized System of Survey and Certification, 2021, Resolution A.1156(32), adopted on 15 December 2021, supersedes Survey Guidelines under the Harmonized System of Survey and Certification, 2019, A.1140(31), which was amended and updated in 2019 to reflect amendments to International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004, Feb. 13, 2004, (IMO, BWM/CONF/36) (hereinafter BWM Convention), MARPOL and 1974 SOLAS.

[29] *N.B.* the conduct of statutory survey leads to the issuance of a statutory certificate, which is distinguished from class surveys that lead to the endorsement of a class certification although classification surveyors from classification societies are observed as carrying out those statutory surveys. The types of ship surveys found in the HSSC include initial survey, periodical survey, Renewal, intermediate survey, annual survey, inspection of the outside of the ship's bottom, and additional survey (under BWM Convention regulation E-1.1.5) (Resolution A. 1140(31), 2020).

[30] *Supra* note 28, at 15, 22, 38, 52, 55, 66, 67, 68, 86, 115, 116, 164, 137, 147, 159, 164, 168, 178, 187, and 200.

Remote performance transition defines progress towards off-site remote *port state* surveys using visual and audio technologies[31] for classification and statutory *flag state* inspections as an alternative to on-site human conducted surveys. While RIT-based inspections have developed methodically since the early 1990s, the move towards remote surveys became exponential with the onset of the COVID-19 pandemic. Remote surveys have significantly helped the maritime industry press ahead in achieving "safe shipboard interface between ship and shore-based personnel".[32] That being said, regulatory barriers remain as remote statutory surveys were not contemplated in the texts of either the ISM Code or the ISPS Code. IMO member states acknowledge that RIT may boost the usage of technologies for remote surveys and verifications by creating a level-playing-field for all maritime stakeholders. Hence, overcoming regulatory challenges associated with RIT is considered by the authors as the first step in facilitating remote performance transition, not only during global emergencies, but also when a normal steady state prevails. Keeping law and policy abreast and in pace with science and technology has always been a challenge throughout history, and the advances in RIT are no exception.

[31] K H Chu, M G Papaioannou, Y Chen, X Gong, and I H Ibrahim, "Techno-regulatory challenges for Remote Inspection Techniques (RIT): The Role of Classification Societies" in T Johansson et al. (eds), *Smart Ports & Robotic Systems: Navigating the Waves of Techno-regulation & Governance* (Palgrave Macmillan, London, Forthcoming April 2023); *See* D Knukkel, "Remote Inspection Schemes: Past, Present & Future" in T Johansson et al. (eds), *Smart Ports & Robotic Systems: Navigating the Waves of Techno-regulation & Governance* (Palgrave Macmillan, London, Forthcoming April 2023); *See* also A Kartsimadakis, "Remote Inspections Scheme on Tanker Vessels during Covid-19 Pandemic" in T Johansson et al. (eds), *Smart Ports & Robotic Systems: Navigating the Waves of Techno-regulation & Governance* (Palgrave Macmillan, London, Forthcoming April 2023).

[32] International Maritime organization, "Circular Letter No.4204/Add.16" of 6 May 2020 available at: https://safety4sea.com/wp-content/uploads/2020/02/IMO-Circular-Letter-No.4204-Add.16-Coronavirus-Covid-19-2020_05.pdf; accessed 1 January 2023.

Quantitative findings from thirty-three structured interviews conducted during the Covid-19 pandemic (2021) have helped underscore the pre-requisites, including the identification and removal processes of some particular difficult issues for transition. All respondents confirmed that the goals for transitional *reform* should centre on consideration of *stakeholder opinion* that uniformly demands the *harmonization* of individual classification society requirements while nonetheless adhering to *common* minimum standards.[33] Respondents stressed that there are more than fifty classification societies highlighting the need for synchronization of individual class requirements since vessels are designed, constructed and maintained based on the requirements derived from *common minimum standards*. Once RIT-requirements are streamlined, then it would be meaningful to supplement guidance on remote surveys, specifically for statutory surveys and audits for statutory verification (in line with IMO Conventions). Moreover, respondents noted that a majority of the classification societies that are members of the International Association of Classification Societies (IACS) are based in the European Union (EU). For that reason, harmonization through reform could help conceive *good regulations* on which *good remote performance* can be predicated (following completion of transition from manual to digital inspection and survey).[34] In short, harmonization of standards, such as harmonized definitions, provisions that safeguard against liability, support overall safety of the human-in-the-loop, protect against threats from cybersecurity, support deployment after evaluation through proof-of-concept,

[33] With classification society representatives, service suppliers as well as flag and port state officials from China, Singapore, the Netherlands, Norway, Canada and the United States of America (US). Interviews formed a part of the quantitative research for BUGWRIGHT2 Project Report Deliverable 1.4.2 titled "National Comparative Analysis".

[34] This statement is based on document issued by the European Commission, Proposal for a Regulation of the European Parliament and of the Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts, Brussels, 21.4.2021, COM (2021) 206 final, 2021/0106(COD).

govern the various degrees of autonomy, *inter alia*, are underpinning principles for a successful performance transition. Ascertaining the nuanced stipulations that surpass the provisions and standards available in UNCLOS requires international discourse and deliberation.

There are two schools of thought. One supports adherence to the overarching regulatory paradigm, which affords a holistic and uniform framework within which all stakeholders, encompassing industry, government, and civil society, would operate. This framework follows the "command-and-control" style (of regulation), which is presided over and enforced by the state. Conversely, the second school of thought subscribes to the principle of self-regulation, orchestrated by industry associations to address concerns and issues within specific sectors. Self-regulation tackles emerging issues not as yet sufficiently covered in public regulations by manifesting the industry and business community's commitment to reform through self-imposed standards governing behavioral conduct.[35]

The pivotal inquiry remains: which approach should be embraced? Fifteen stakeholders (between March to September, 2023) from the triple helix were solicited to offer their perspectives on this.

The approach, according to certain respondents, is to allow IOs or regional or national authorities to develop an overarching umbrella regulation covering fundamental principles, objectives and standards that take the form of *policy*

[35] T A Hemphill (1992) "Self-regulating industry behavior: Antitrust limitations and trade association codes of conduct", *Journal of Business Ethics*, 11(12), pp.915–920; *See* also T R Wotruba, T R (1997) "Industry Self-Regulation: A Review and Extension to a Global Setting", *Journal of Public Policy & Marketing*, 16(1), pp.38–54.

guidelines. This regulatory framework would subsequently seek enactment and enforcement through national maritime administrations that monitor classification and statutory tasks, and take the lead on approval of RIT-based survey operations. Respondents also highlighted the need to consider associated drawbacks, particularly within the realm of regional mandates. For instance, rather than focusing on niche areas, such as autonomous vehicles, autonomous vessels or RIT, the EU is directing its efforts toward the enactment of comprehensive regulation on Artificial Intelligence. The aim here is to foster an AI-human "trustworthy" ecosystem.[36] The above answer invokes another question: will such regulation indeed cultivate the indispensable equitable milieu for stakeholders actively invested in maritime remote inspection methodologies?

Concerns were voiced by a few respondents regarding mandates of IOs. Confined by protocol, mandate or strategic directions, IOs (IMO and ISO) could only provide an overarching framework for a specific sector or industry.[37] Matters falling outside the purview of IOs would, in turn, require the attention of national policymakers. Notably, to date, there exist no national policies that provide legal recourse against complaints related to, for example, liability for damages from RIT-deployment.[38]

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[36] Commission, 'Building Trust in Human-Centric Artificial Intelligence' (Communication) COM(2019) 168 final.

[37] *See* J Goldstein, J., M Kahler, R O Keohane, and A-M Slaughter (eds), (2001) *Legalization and World Politics*, Cambridge, Mass.: MIT Press; AND D G Hawkins, D A Lake, D L Nielson, and M J Tierney (eds), (2006) *Delegation and Agency in International Organizations*, Cambridge: Cambridge University Press; *See* also J G March, and H A Simon (1958/1993) *Organizations*, Cambridge, Mass.: Blackwell; AND F Biermann, and B Siebenhüner (2009) *Managers of Global Change: The Influence of International Environmental Bureaucracies*, Cambridge Mass: MIT Press.

[38] Ultimately, RIT integration into traditional human-driven calls for a safety-net to guard against third-party liability. At present, IACS UR Z17 does not provide any caveats that prompts necessary pre-emptive steps from service providers, flag administrators or classification society members. The authors emphasize that quality assurance schemes for protection against liability are not generic either in scope or nature, and that the current legal regime only requires service suppliers ensure that these elements are in place. As previously discussed, inspection and certification fall under the conditional assessment program that is a requirement of charterers and cargo owners. Through such assessment programs shipowners can demonstrate "operational reliability" to their clients. New forms

Other drawbacks, according to respondents, include compliance challenges, industry resistance, enforcement difficulties as well as unintended consequences that may emerge as a result of over-generalization.

Divergent viewpoints were expressed by some respondents that advocated for non-state regulation or self-regulation. Self-regulation, according to respondents, would not impede innovation, given its track record of bolstering public trust and countering adverse public perceptions.[39] The nuclear and chemical sectors have thrived as industries due to self-regulation. Notwithstanding, self-regulation is not free from limitations. Critics disassociate from self-regulation due to matters concerned with internal conflict of interest, issues with respect to accountability, and most importantly, problems that arise from industry regulatory capture.

Self-regulation, according to the respondents, typically takes shape through industry consortiums that set the minimum safety and quality standards along with Codes of Conduct. While this approach affords a degree of adaptability and cost efficiency, there are those that see the practice as conveniently exonerating the government from fulfilling its regulatory mandate.[40] Additional critiques have posited that self-

of RIT liability emanating from dropped object or collision risks, or even unseaworthiness of a vessel due to deterioration or corrosion from biofouling, may seem far-fetched since current routine options, such as reverting back to manual inspections and checks through periodical surveys remain readily available. Even so RIT does have the potential to create some new and unforeseen risks due to the introduction of multiple new actors during an RIT survey. For example, input-material supplied by the asset owner to the service supplier prior to hull inspection (i.e., images, drawings and designs) could infringe on the copyright or other rights belonging to a third party. Hull survey data could be used for marketing by the service supplier without the prior approval of the asset owner.

[39] A K Gupta and L J Lad, "Industry Self-Regulation: An Economic, Organizational, and Political Analysis," *The Academy of Management Review* 8, no. 3 (1983): 417.

[40] J Braithwaite (1993) "Responsive Regulation in Australia" In *Regulation and Australia's Future*" (eds. P Grabosky & J Braithwaite), Canberra: Australian Institute of Criminology.

regulation, as a standalone mechanism of social oversight, may be inherently flawed due to its lack of inherent credibility, rigorous standards, and punitive measures.[41]

A prospective course of action lies in the adoption of a hybrid solution, indicating a fusion of both public and private regulatory paradigms. This suggests a synthesis of public and private regulations, and the need to identify harmonious amalgamation of governmental oversight and industry-driven regulatory strategies. This synergy is evident in mixed systems that combine government and self-regulation into a construct of "co-regulation."[42] This, in turn, precipitates an exploration of the concept of "multi-level governance," which involves the complex interactions that take place among national governments and non-state actors involved in policymaking spanning local, national, and supranational strata.[43] While being a non-governmental organization, IACS assumes a significant role within the IMO. IACS fulfills this role by offering technical support, guidance, and formulating consistent interpretations of the international statutory regulations crafted by the IMO's member states. In this dual capacity (as a non-governmental organization and an active participant in the work of an IO), IACS is arguably best positioned to take the lead and even initiate discussions on RIT "co-regulation".

RIT or ICT-fused inspections and surveys are not an aberration, but an amelioration towards a likely future of fully autonomous robotic and autonomous systems (RAS).

[41] N Gunningham and J Rees (1997) "Industry Self-Regulation: An Institutional Perspective". *Law Policy*, University of Denver [Wiley Online] 19(4), pp.363–414; *See* also K Webb and A Morisson (1996) "The Legal Aspects of Voluntary Codes", Draft paper presented to the Voluntary Codes Symposium, Office of Consumer Affairs, Industry Canada and Regulatory Affairs, Treasury Board, Ottawa, 12-13 September
[42] A K Gupta and L J Lad (1983) "Industry Self-Regulation: An Economic, Organizational, and Political Analysis", *The Academy of Management Review*, 8(3), p.416.
[43] I McManus and J Eijmberts (2017) "Multi-level Governance of Nanotechnology in Europe: Policy Variation in Germany, the UK, and the Netherlands", *European Review* 25(2), 273-294.

As manufacturers cut through design bottlenecks, there will be other challenges in developing synergy between regulation and technology, technology and commerce, as well as commerce and mass deployment.[44] Regulatory developments through meaningful participation, transdisciplinary dialogue, discussion and consultation, and implementation could very well be the best way forward. It must be emphasized to manufacturers, bio-engineers, information technologists, and cybernetic developers, that developing regulations do not imply that potential breakthrough technologies are being restricted. On the contrary, those technologies and technological developments are being administratively projected so that innovation and development stays on track.

As of this writing the world is not yet entirely free from the deleterious grasp of the Covid-19 pandemic. At the height of the pandemic, the world called attention to social-distancing, travel bans, and quarantines. RIT and remote surveys served as a timely solution to those engaged in vessel inspection and maintenance. A return to a normal operating environment might have pushed inspections and surveys back to the traditional manual-mode, but RAS tools have already been tested rigorously through a baptism of fire and proven their worth. The maritime industry and applicable government and organizational regulators will adapt to technological transformation, as it has consistently done in the past. For that transformation to be successful, all grey areas that could potentially stifle innovation must dissipate through consensus-based multi-level governance.[45]

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[44] *See Supra* note 31.
[45] Id.

Specific harmonized regulations for RIT, if developed the right way at the right forum, could help provide guidance and avoid a plethora of challenging issues for a system marked by multiple echelons and diverse stakeholders. Enforcement of procedural rules through co-regulation will all have a crucial bearing on the types of technology that will emerge in the not-so-distant-future. Transition from UAVs to hybrid unmanned aerial underwater vehicles (UAUV) capable of navigating and operating in both air and underwater environments is underway, and will soon be deployed in the offshore industry.[46] This will further raise RAS-governance questions as both aviation and admiralty stakeholders will need to unravel complex layers, making co-governance inevitable in the long run.

[46] Id.