Maritime remote inspection technology in hull survey & inspection: A synopsis of liability issues from a European Union context

Vera Alexandropoulou, Tafsir Johansson, Klimanthia Kontaxaki, Aspasia Pastra and Dimitrios Dalakis

ABSTRACT
Vessel hull inspection is a regulatory obligation. Adherence to procedural requirements forged by classification societies helps avoid numerous adverse consequences. In this era of technological innovation, drones, crawlers and underwater submersibles, aptly known as Remote Inspection Technologies, represent emerging technologies, and are being tested to conduct surveys and inspections that will gradually replace human presence on board ships and in-water. However, counter arguments have also emerged against the usage of these AI-based alternatives. Liability is one crucial drawback that could potentially discourage innovation and market growth, especially at the European Union level. Ship owners require a "safety net" as they are a part and parcel of global commerce. Then again, survey and inspection via technologies require the involvement of multiple actors, which makes it difficult to apportion liability. Solutions are required, especially at the European Union level, so that member states could move forward in a spirit of partnership, and nurture and foster technological innovation through partnership. Against the foregoing, this article delves into the European Union liability landscape and outlines some of the critical challenges and strategic ways forward for consideration.

Introduction

The ongoing improvement and enhanced capabilities of artificial intelligence (AI) applications, along with their integration with robotics, are creating a rather expanded portfolio of Robotic and Autonomous Systems (RAS) that offers cutting-edge solutions to industries engaged in maritime activities and especially shipping. The progressive nature of innovation upholds RAS as a remarkable catalyst that continuously maintains the motion of the "autonomy" agenda. Present efforts seek to autonomize the traditional "manned" concept with a view to introducing autonomous vessel to the global maritime industry. In tandem, by dint of technological evolution and adaptation, the maritime robotic industry is surfacing as one of the fastest growing markets (Jan Rødseth 2017). This growth is marked by the emergence of niche technologies often referred to as Remote Inspection Technology (RIT) that enables "...a Remote inspection Vehicle (RIV) with no pilot on board to provide access for the inspection of structures" (American Bureau of Shipping 2019).

Capable of operating in air or underwater, RITs are viewed as a viable option for surveying a ship and its structures for identifying corrosion, fracture and design-related damages during annual survey, intermediate survey, special survey, bottom survey and damage and repair survey where applicable (IACS Recommendation 76 1994). Other than acting as an alternative to human presence that could encounter risks when entering certain areas of a ship for inspection, RITs complement the global shipping agenda that conducts business in a just-in-time fashion. Generally speaking, annual surveys require around 1–2 days, intermediate surveys take around 3–4 days, and specials surveys take around 1–2 weeks (Johansson, Dalakis, and Pastra 2021). In addition, the ship owners need to factor in post-inspection actions to repair and mitigate corrosion and other defects and deterioration. Operators confirm that reduced survey-time is an implied promise that comes with RIT deployment (Johansson 2021).

The effective integration and further improvement of the capabilities offered by RIT, as a result of advanced and clearly innovative technical applications, has the potential to fundamentally change certain aspects of operations within the maritime sector. Service robots remain the nucleus of RIT and showcase a revolutionary milestone in remote inspection, survey and maintenance. The advantages of utilizing RIT are
manifold, especially when considering the numerous crucial mandatory statutory and classification tasks that are carried out on major carriers of the world fleet that are currently between the age 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 (UNCTAD/RMT/2019/Corr.1, Review of Maritime Transport 2019; European Maritime Safety Agency 2019). From a maritime standpoint, state-of-the-art RIT has the potential to conduct close-up surveys and thickness measurements in a timely manner and contribute to the mitigation of hull fouling or biofouling that could increase vessels’ energy efficiency altogether reducing the level of fuel consumption (McClay et al. 2015).

Numerous factors (as well as an number of sub-factors) are said to affect hull performance. Evidently, hull fouling or biofouling contributes to increased emissions – presently viewed as a phenomenon that is troubling the wider shipping industry (Deligiannis 2017). Mitigation measures typically involve direct human interventions, which are steadily shifting to an RIT mode with “human-in-the-loop,” and potentially towards full-autonomy in the not-so-distant-future. Patently, classification societies, shipowners, manufacturers and service providers assert that RIT indeed has the potential to achieve the above effectively and efficiently by replacing the current rudimentary inspection system that is time-consuming to say the least (Official homepage of Seadrone 2020). There are clear indicators that the paradigm shift has already begun: National flag State authorities, classification societies and ship owners are gradually adapting to RIT applications that will, in turn, have vital regulatory applications in the context of control, enforcement and compliance, as well as assist in meeting requirements under environmental, climate and shipping regulation.

The International Association of Classification Societies (IACS), a non-governmental organization composed of 12 leading individual member societies that class 90 percent of total commercial tonnage has outlined the basic principles, as well as procedural guidelines in relation to operations concerning the usage of RIT in Recommendation 42 and Unified Requirement (UR) Z17 on Procedural Requirements (International Association of Classification Societies Information Paper 2020). Carefully inserted within the texts of international standards promulgated by IACS are specific types of RITs in remote inspection and survey operations. It is important to note that IACS enters the scene of ongoing discussions by virtue of two independent roles: a “public role” which is assumed as an international Maritime Organization (IMO) endorsed recognized organization, and a “private role,” which is assumed when conducting inspections on behalf of the ship owner (International Association of Classification Societies Information Paper 2020).

IACS Recommendation 42 is bearing the title Guidelines for Use of Remote Inspection Techniques for Surveys and succinctly sets the stage for remote inspection techniques via RAS platforms that include: unmanned robot arm, Remote Operated Vehicles (ROV), Climbers and Drones (IACS Recommendation 42 1996). This list under discussion is kept open ended by adding the sentence “(o)ther means acceptable to the society,” which is a prudent move given that innovation will influence the scope for the development of new types and varieties of RITs that might have greater role in the immediate future (IACS Recommendation 42 1996). In retrospect, RIT has garnered attention in international 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 (Johansson 2021).

Quite recently, the European Union (EU) has taken the lead in developing tailor-made standards for products operated by RAS. Examples of this are ripe in the work of European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC) and the European Telecommunications Standards Institute (ETSI) (Johansson 2021). Parallel to these initiatives is the work of the European Union High-Level Expert Group on Artificial Intelligence that envisions the development of a horizontal foundation for AI through the establishment of trust between the producer/manufacturer and end-user (High-Level Expert Group on Artificial Intelligence 2019). However, from a European Union (EU) RIT horizontal policy perspective, there are aspects that remain shrouded with grey areas. “Liability” is one such important area that could impede the seamless integration of RIT within the EU maritime domain. A stark emphasis on safety and liability implications of RAS can be found in the 2020 report that states:

At Union level, product safety and product liability provisions are two complementary mechanisms to pursue the same policy goal of a functioning single market for goods that ensures high levels of safety, i.e. minimise the risk of harm to users and provides for compensation for damages resulting from defective goods (European Commission 2020).

Against the above backdrop, this article provides a synoptic discussion on EU liability aspects relating to RIT. The discussion commences with an overview of international (RIT) procedural requirements, forming the current regulatory framework. This provides the vital building blocks of the framework, with a focus
on gaps bearing “liability” in mind. Discussions then segue into an expository overview of potential liability challenges from an EU setting. Subsequently, the focus is shifted towards certain thorny issues corresponding to liability for hull inspection using RIT that sets the scene for a discussion on ship owner/carryer liability. This is followed by a critical synthesis on how ship owners could limit liability under existing international rules. Finally, alternatives are explored and recommendations provided before drawing concluding remarks.

RIT International Governance Framework: a synoptic overview

In response to the evolving RIT landscape, RIT Procedural Requirements embedded in IACS UR Z17 have undergone the fourteenth revision in March 2019. IACS also submitted a paper to the 7th session of IMO Sub-Committee on Ship Design and Construction (SDC) in February 2020 on the use of RITs during Enhanced Survey Programme Surveys (SDC 7/10 "Use of Remote Inspection Techniques (RITs)"). However, those suggestions were conditional on the surveyor being on board. All in all, as it stands today, IACS UR Z17 includes nine relevant sections with sections 3 and 16 of Annex I covering provisions on ROV for in-water survey and RIT as a tool for close-up survey of ship’s structure and mobile offshore units respectively (IACS UR Z17 1997).

Pursuant to IACS UR Z17 procedural requirements, the extent to which firms or service suppliers can operate ROVs is limited to in-water survey and/or internal hull survey of compartments filled with water (IACS UR Z17, 1997). Self-explanatory from the title of s. 3 of Annex I, ROVs can be deployed as an alternative to diver conducted surveys subject to the approval of the shipowner. On the other hand, provisions pertaining to the usage of RITs in close-up surveys, “where the details of structural components are within the close visual inspection range of the surveyor,” rests in a separate section under Annex I of IACS UR Z17 (IACS UR Z17, 1997). Close-up surveys may be performed in conjunction with thickness measurement, if required, and is traditionally included in the planning document alongside other mandatory specifics (IACS Recommendation 76 1994).

For better comprehension of the procedural requirements and integral elements that come into play, the following tables provide a structured and categorized overview of the integral elements at play during various phases of ROV and RIT deployment as found within the texts of IACS UR Z17. The structure takes from the three-part conceptual framework, i.e., actors, tools and mechanisms, as proposed by Markell and Glicksman (2016) in a 2016 publication with a view to assisting “policymakers seeking to design regulatory structures likely to produce effective governance in dynamic circumstances” (Markell and Glicksman 2016). Table 1 contains the general provisions,

| Table 1. Breakdown of IACS UR Z17 elements integral to survey and inspection general provisions using ROVs and RITs pursuant to IACS UR Z17 sections 3 and 16 of Annex I. |
|---|---|---|
| **IACS UR Z17: General Provisions** | **Section** | **Summary** |
| Actors in Operation | S. 3 | Manufacturers, Service Providers, Agent, Subsidiary. Subcontractor: Section 3 provides definition of the specific entities governed by IACS UR Z17. |
| Application of Mechanisms (in Preliminaries) | S. 4 | Permissible in Statutory Services and Classification Services except non-ESP ships <500 Gross tonnage (GT) and all Fishing vessels. |
| Tools Involved in Preliminaries | 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 5.2.10 | Training of Personnel (s. 5.2.2); Supervision (s. 5.2.3); Personnel Records (s. 5.2.4); Equipment and facilities (s. 5.2.5); Control of Data (s. 5.2.6); Servicing Stations (s. 5.2.7); Documented Work Procedure (s. 5.2.8); Information of Agreements and Arrangements to-be Provided by Supplier if any Parts of Services are Subcontracted (s. 5.2.9); Verification of Service Providers by Supplier (s. 5.2.10). |
| | S. 5.3 | Society to audit the Supplier. |
| | S. 5.4 | Obtaining a certification is conditional on demonstration of performance in relation to the specific service as well as completion of satisfactory reporting. |
| | 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 Supplier 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 8.4 | Cancellation of Approval. |
| Tools Involved During Conduct of Task | S. 5.2.12 | Documented Procedures and Instructions on Recordings by Suppliers. |
| Tools Involved after Completion of Task | S. 5.2.12 | Documented Procedures and instructions to-be available for the Recording of Damages and Defects found during inspection. |

Source: IACS UR Z17, 1997
Table 2. Breakdown of IACS UR Z17 elements integral to survey and inspection procedural requirements for ROVs pursuant to section 3 of Annex I.

| Elements                                      | Section | Summary                                                                 |
|-----------------------------------------------|---------|-------------------------------------------------------------------------|
| Actors Involved in Preliminaries              | S. 3.1  | Training of Personnel (divers, ROV operators and supervisors) by supplier. |
|                                               | S. 3.4.1| Diving supervisor must be qualified in accordance with supplier’s general requirements and shall have a minimum of two years’ experience as a diver carrying out inspection. |
|                                               | S. 3.4.2| ROV supervisor shall have a minimum of two (2) years of experience conducting inspections using ROVs. |
|                                               | S. 3.5.1| The diver conducting shall have had at least one year’s experience as an assistant diver carrying out inspections (including minimum 10 participation in different assignments). |
|                                               | S. 3.5.2| ROV operators shall have at least one year of experience with conducting inspections using ROVs. |
|                                               | S. 3.8  | Supplier to obtain verification from surveyor for each separate job followed by the surveyor’s signature. |
| Actors Involved after Completion of Task      | S. 3.1  | In-water survey in lieu of a docking survey and/or the internal hull survey of compartments filled with water. |
| Application of Mechanisms during Conduct of Tasks| S. 3.7.1| 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.” |
|                                               | S. 3.7.2| Suppliers should document 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 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. |

Source: IACS UR Z17, 1997

Table 3. Breakdown of IACS UR Z17 elements integral to survey and inspection procedural requirements for RITs pursuant to section 16 of Annex I.

| Elements                                      | Tools | Summary                                                                 |
|-----------------------------------------------|-------|-------------------------------------------------------------------------|
| Actors Involved in Preliminaries              | S. 16.3 | The supplier will assume responsibility for the training and qualification of its operators operating RIT. UAV Pilots should be qualified and licensed under applicable national requirements or an equivalent industrial standard acceptable to the society. |
|                                               | S. 16.5 | The supervisor must be certified according to the recognized national requirements or an equivalent industrial standard coupled with a minimum of two years’ experience in the inspection of ship’s and/or MOU’s structure. |
|                                               | S. 16.6 | The operator must be certified according to the recognized national requirements or an equivalent industrial standard coupled with a minimum of one years’ experience in the inspection of ship’s and/or MOU’s structure. |
| Actors Involved after Completion of Task      | S. 16.10 | Supplier to obtain verification from surveyor for each separate job followed by the surveyor’s signature. |
| Mechanisms involved in the Preliminaries      | S. 16.4 | Training Plan for Personnel |
| Mechanisms involved During Conduct of Task    | S. 16.2 | Close-up Survey of ships’ structure and mobile offshore units’ structure by deploying RIT |
| Tools involved in the Preliminaries           | S. 16.4 | A plan (developed by supplier) for training of personnel |
|                                               | S. 16.8 | The supplier shall ensure the following operational procedures and guidelines well documented: - Requirements for preparation of inspection plans when UAV are part of the equipment flight plans shall be included; - 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; - Guidance of the operator to provide complete coverage of the structure to be inspected; - Guidance for the maintenance of the remotely operated platforms, data capture and storage devices and display screens, as applicable; - Requirements for the collection and validation of data; - If data is to be stored, then requirements for location attribution (geo-tagging); - Validation and storage of data; - Requirements for the reporting of inspections, including the recording of damages and defects found during inspection and repair work; and |
|                                               | S. 16.9 | The supplier under an obligation to maintain he following: - Records of training; - Operator statutory and regulatory certificates and licenses; - Equipment register for UAVs, Robots, data collection devices, data analysis devices and any associated equipment necessary to perform inspections; - Equipment maintenance manuals and records/logbook; - Records of calibration; and - UAV/Robot operation logbook. |
| Tools involved in the Preliminaries           | S. 16.7 | High-definition display screen with live high-definition feed from inspection cameras as an integral part of the RIT. |
| 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, 1997

Table 2 is ROV-specific and Table 3 relates to provisions that govern the usage of RITs for remote inspection and survey. The summary of contents in relation to the elements covered under this three-part framework depicts IACS as a pioneer of regulatory standards in the maritime
domain (Johansson 2021). Notwithstanding, however, when conducting a detailed observation of IACS UR Z17 standard requirements (see Tables 1, 2 and 3) against requirements developed by individual Classification Society rules (namely, Lloyds Register, Bureau Veritas, American bureau of Shipping and China Classification Society), there appear to be a number of crucial shortcoming limitations in the IACS-developed international common minimum standards that govern the usage of RIT. Certain sources assert that while the basic instructive building blocks for using ROVs in in-water surveys and RIT for close-up surveys are logically stacked; it seems neither s. 3 nor s. 16 of Annex I adequately covers the important safety details concerning risk management system, safety assurance and third-party liability (Johansson 2021). According to certain views that are being put forward, all the above are important considerations that require adequate coverage within the texts of IACS UR Z17 in so far as RIT deployment and operations are concerned (Johansson 2021). Those considerations also require an investigation into the complex and challenging world of “liability” given that it is an important facet that has existed in varying forms as far as the functioning of the shipping industry is concerned. Therefore, liability challenges associated with RIT usage from an EU context is spearheaded through in the next section.

(R)IT Associated Liability Challenges in a European Union Context

Developments in IT Technologies, in particular RIT, the learning ability and connectivity, cause the emergence of new risks or implications in the control of existing risks whereby new value chains imply the entry of new actors, such as data suppliers, operators or machine trainers. Moreover, Robotics may damage physical assets without intermediate human intervention while the learning ability of digital systems is certainly a developing field of unknown risks whereby the increasing connectivity leads to additional new challenges in terms of both safety and security.

The findings of the European added value assessment (EAVA) “Civil liability regime for artificial intelligence conducted by the European Parliamentary Research Service (EPRS) to accompany the European Parliament’s draft report on a legislative initiative proposal on a civil liability regime for artificial intelligence delineate that the current EU civil liability regime is based on the partially harmonized product liability system accompanied by a fragmented civil liability framework (European Parliament resolution of 20 October with recommendations to the Commission on a civil liability regime for artificial intelligence (2020/2014 (INL)). The comparative legal analysis of the national liability systems of 19 Member States has indicated great divergence between member states (MS) in terms of their current rules and their degree of flexibility to adjust to the new challenges related to IT Technologies. Hence, in the absence of a common EU action, it is very likely that dissimilar divergent practices might emerge among MS, giving rise to obstacles hindering the functioning of the EU internal market.

Liability policies have major economic and social implications when explaining the substantial added value that could potentially be generated as a result of EU common action on AI liability. Apart from direct impacts on the reduction of risks and increase in safety, liability policies have dynamic effects on innovation, investment in research and development and ultimately business competitiveness while maintaining considerable social impact. This is due to the fact that rules on the distribution of risks and mechanisms for compensation of damages determine the acceptance and trust of technologies by consumers.

Turning to the status quo EU product liability regime, it is noted that this regime relies on the EU Product Liability Directive 85/374/EEC 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. It is also highlighted that the European Parliament proposed a “Regulation on liability for the operation of Artificial Intelligence-systems” containing a strict liability for operators, but suggested only (arguably) minor amendments to the existing product liability (software as a product, reversal of burden of proof in certain cases) (European Parliament Resolution of 20 October 2020 with recommendations to the Commission on a civil liability regime for artificial intelligence, 2020) in paragraph 8 as follows:

“The European Parliament urges the Commission to assess whether the Product Liability Directive should be transformed into a regulation, to clarify the definition of ‘products’ by determining whether digital content and digital services fall under its scope and to consider adapting concepts such as ‘damage’, ‘defect’ and ‘producer’; is of the opinion that, for the purpose of legal certainty throughout the Union, following the review of the Directive 85/374/EEC, the concept of ‘producer’ should incorporate manufacturers, developers, programmers, service providers as well as backend operators; calls on the Commission to consider reversing the rules governing the burden of proof for harm caused by emerging digital technologies in clearly defined cases and after a proper assessment [...]” (European Parliament Resolution of 20 October 2020 with recommendations to the Commission on a civil liability regime for artificial intelligence, 2020).
As far as the most conducive liable party is concerned, the shift in risk control has to be taken into account. Provided that “risk control is a result of causation, risk knowledge and the ability to change the causative behavior, thereby choosing the level of activity and the level of care, with regard to IT systems, risk control is increasingly shifted from the user to the producer as a result of automation whereby the end user, apart from the decision to use a system or not, has no further options to influence the risk” (Zech 2021). In this regard, it has been suggested that all human input, i.e., the persons that create, maintain or control the risk associated with the IT-systems shall attract liability while different liability rules will apply as to different risks (Zech 2021). Also, depending on the degree of high risk control a distinction between backend and frontend operators of IT systems has been proposed, thereto attributing a strict, joint and several liability regimes accompanied by a mandatory liability insurance.

**RIT hull inspection liability**

In the contemporary era, technology has improved considerably: to the point where marketed RIT are now considered as viable leading performers of surveys without surveyors physically attending ships. Current practices involve Classification Societies and Shipping Companies testing the application and success factors of ROVs and real-time RIT sensing devices. In this regard, some classification societies consider that these new techniques offer greater efficiency, higher flexibility, and increased reliability in the day-to-day activities of survey and inspection without impairing the result of the outcome of such niche-area surveys. Furthermore, the Covid-19 pandemic has also drawn attention to the need for remote survey approaches (without requiring a surveyor to be on board), as in many cases surveyors cannot physically access ships to conduct surveys. This situation has also underlined the importance of developing common requirements for the implementation of remote survey approach as an acceptable form of intervention in some circumstances for overcoming the challenges of surveys in person. It is very likely that there will be progressive developments and adoption of remote surveys beyond the Covid-19 emergency situation as there are apparent benefits of advanced technology and greater flexibility in conducting surveys by deploying specialist surveyors, and flexibility for dealing with simple issues – while ensuring comparable quality and safety standards – are realized. In response to these trends, IACS established a Project Team in 2020 to develop common requirements for remote survey approach (Ko 2020). The Project Team will consider diverse aspects such as the equivalency between remote and traditional survey with surveyor attendance and impediments in existing IMO instruments and IACS Resolutions to remote survey and any inconsistencies which may exist.

In line with the aforementioned in Section I, the legal challenges that arise with regard to RIT orchestrated hull survey and inspection is that new actors are brought into the forefront such as data suppliers, data technicians, IT experts, machine learning experts or machine trainers, operators as well as, under an extended definition, manufacturers (producers) on whom different liability regimes will apply according to the risk-control measures they exercise. In case the maritime sector witnesses mass deployment of fully autonomous RIT, producer liability will be invoked since the probability of defectiveness is difficult to discharge on the part of the injured party as well as determine the causal link between the defect of the product and the damage while the extent of damages is still yet unknown. The latter is likely to be combined with a third-party liability insurance regime in order for the risks to be fairly distributed. The liability regime as to IT technologies and in particular with respect to RIT in relation to hull inspection remains unappraised both at the international and the EU level.

It should be emphasized that intended surveys and inspections on the hull relate to and aim at ensuring the seaworthiness of the vessel, as enshrined Article 94 of the United Nations Convention on the Law of the Sea of 1982 (UNCLOS 1982). Consequently, Article 94 of UNCLCOS constitutes an overarching obligation and non-delegable duty on the part of the shipowner. In the absence of an RIT liability regime, chances are the aforementioned actors could attract liability when damage or loss has occurred due to unseaworthiness depending on the facts of each particular case and only in the event where the shipowner has exercised due diligence to make the ship seaworthy, thereby excluding his liability, by way of example in the case of latent defects on the hull which could not have been discovered even with the exercise of reasonable care on the part of the shipowner. If this is the case, then the leading authority on cases involving the liability of classification societies in tort for negligence in relation to third parties, i.e., The Nicholas H where the judgment of Lord Steyn exposes the policy issues which advocate against imposing liability on classification societies, might no longer be deemed as relevant henceforth (Marc Rich & Co. A. G. v Bishop Rock Marine Co Ltd 1995). Similarly, then, it should also be considered whether the limitation of liability regime of the Convention on Limitation of Liability for Maritime Claims (LLMC 1976/96), which is available to the shipowner and his agents/servants should be extended to the abovementioned actors in their capacity as independent contractors. To this effect, in the following Sections, an analysis of the non-
The liability of the shipowner/carrier

In maritime law, seaworthiness of a vessel is the overriding duty on the part of shipowner/carrier. Where there is no express provision in the charter-party as to seaworthiness, there is an implied obligation of seaworthiness at common law. In *Hong Kong Fir Shipping v Kawasaki Kisen Kaisha* it was held that the obligation of seaworthiness embraces every part of the hull and machinery, stores and equipment and the crew itself (Hong Kong Fir Shipping Co Ltd v Kawasaki Kisen Kaisha Ltd 1961). Hence, the requirement for the shipowner to provide a seaworthy vessel comprises a twofold obligation, namely that the vessel must be suitably manned and equipped to meet the ordinary perils likely to be encountered while performing the services required of it, while at the same time it must be cargo worthy in the sense that it is in a fit state to receive the specified cargo. As far as the first aspect of the seaworthiness concept is concerned, the implied undertaking at common law covers not only the physical condition of the vessel and its equipment, but also extends to the competence of the crew and the adequacy of stores and documentation (Wilson 2010).

At common law, the obligation of providing a seaworthy vessel is "absolute" — signifying that in the event of breach, the shipowner will be liable irrespective of fault. This was particularly elucidated by Lord Blackburn in *Steel v State Line Steamship Co* stating that "there is a duty on the part of the person who furnishes or supplies the ship ... that the ship shall be fit for its purpose ... not merely that they should do their best to make the ship fit but that the ship should really be fit" (Steel v State Line Steamship Co. 1877). Moreover, the Court in *McFadden* held that the question whether a ship is seaworthy or not, is a question of fact which must be determined by the standard of an ordinary careful and prudent owner (*McFadden v Blue Star Line 1905*). Where the Hague-Visby Rules, incorporated into English law by The Carriage of Goods by Sea Act 1971, apply whether by the express incorporation in a charterparty via a paramount clause or in respect of a Bill of Lading governed by the respective Rules, the common law absolute undertaking of the shipowner is by virtue of Article III rule 1(a) of the Hague-Visby Rules replaced by the undertaking of the obligation on the part of the shipowner/carrier to exercise due diligence to make the ship seaworthy before and at the beginning of the voyage (Hague-Visby Rules). The test appears to be objective in that "the vessel must have that degree of fitness that an ordinary careful and prudent owner would require his vessel to have at the commencement of her voyage having regard to all the possible circumstances of it" (*McFadden v Blue Star Line 1905*).

In the case of a voyage charter, the obligation to provide a seaworthy vessel attaches at the time of sailing on the charter voyage (Wilson 2010). On the other hand, in respect of time charter the obligation attaches only at the time of delivery of the vessel under the charterparty (Eder, B. et. al. 2015). The initial seaworthiness undertaking is normally supplemented by some form of maintenance clause under which the shipowner is required to "keep the vessel in a thoroughly efficient state in hull, machinery and equipment for and during the service" (NYFE Form 2015). The obligation of the shipowner/carrier to exercise due diligence to "make the ship seaworthy before and at the beginning of the voyage" as per Article III rule 1(a) is viewed as a personal, overriding duty that cannot be delegated and any attempt by the carrier further to reduce or exclude responsibility under the rules to provide a seaworthy ship is invalidated (Art III rule 8) (The Hague-Visby Rules 1968). Accordingly, the shipowner/carrier will be liable not only for own negligence but also for the negligence of any party, including an independent contractor, to whom the performance of his obligation to make the vessel seaworthy was delegated (The Hague-Visby Rules 1968). This was principally established in *The Muncaster Castle*, where the House of Lords was called to decide whether the shipowners were liable for failure to exercise due diligence to make the vessel seaworthy, whereby unseaworthiness was due to the negligence of the fitter employed by competent ship repairers engaged by the shipowners (*Riverstone Meat Co Pty Ltd v Lancashire Shipping Co Ltd 1961*). On appeal by the cargo owners, the Court held that the carriers were liable unless due diligence in the work has been shown by every person to whom any part of the necessary work had been entrusted, no matter whether he was the carrier’s servant, agent or independent contractor.

The Hague-Visby Rules in Art IV (2) defers to a list of specific instances and perils in which the shipowner’s/carrier’s liability for damage or loss to goods will be excluded, even where such loss or damage is caused by the act, neglect, or default of the master, mariner, pilot, or the servants of the carrier in the navigation or in the management of the ship. Finally, a general exculpatory provision provides for any other cause arising without the actual fault or privity of the shipowner/carrier, or without the fault or neglect of the agents or servants of the
latter. In order for the shipowner/carer to avoid liability, it must be shown that such loss or damage is covered by an exception. If the shipowner/carer fails to establish the proximate cause of the loss, then he will be unable to rely on the exception (Hamilton v Pandorf 1887; The Popi M 1985). With regard to a defective, i.e., either ineffective or disastrous hull inspection by RIT, the most relevant exceptions potentially invoked in The Hague-Visby Rules under Art IV 2 are the following: “[n]either the carrier nor the ship shall be responsible for loss or damage arising or resulting from (p) Latent defects not discoverable by due diligence or, the exception (b) of Fire, unless caused by the actual fault or privity of the carrier” (The Hague-Visby Rules – The Hague Rules as Amended by the Brussels Protocol 1968).

Additionally, the shipowner/carer may avail himself of the general exclusion clause of Art IV 2(q) any other cause arising without the actual fault or privity of the carrier, or without the fault or neglect of the agents or servants of the carrier, but the burden of proof shall be on the person claiming the benefit of this exception to show that neither the actual fault or privity of the carrier nor the fault or neglect of the agents or servants of the carrier contributed to the loss or damage (The Hague-Visby Rules – The Hague Rules as Amended by the Brussels Protocol 1968).

However, the exceptions “only exclude the absolute liability of a carrier, and do not discharge him from the consequences of the want of reasonable skill, diligence and care” (Notara v Henderson 1872). The exceptions do not operate if such occurrence could have been avoided by the exercise of reasonable care. Accordingly, a shipowner or carrier cannot avail himself of an exception where the cargo owner is able to establish that the immediate cause of the damage was not the excepted peril but the unseaworthiness of the vessel. Whenever loss or damage has resulted from unseaworthiness the burden of proving the exercise of due diligence shall be on the carrier or other person claiming the exemptions of Art IV (Art IV (1) (The Hague-Visby Rules – The Hague Rules as Amended by the Brussels Protocol 1968). Similarly the benefit of limiting shipowner’s/carer’s liability under Art IV (5) of the said Convention applies in any action against the carrier or the agent/servant of the carrier (but not being independent contractor of the carrier) in respect of loss or damage to goods covered by a contract of carriage whether the action be founded in contract or in tort is not available if it is proved that the damage resulted from an act or omission of the carrier (agent/servant) done with intent to cause damage, or recklessly and with knowledge that damage would probably result (see Article IV (e), Art IV bis 1 & 2) (The Hague-Visby Rules – The Hague Rules as Amended by the Brussels Protocol 1968).

Limitation of liability under the LLMC 1976/96

One of the unique features of maritime law is the shipowner’s right to limit liability by bringing an increased range of claims within the ambit of a limitation fund, for loss or damage resulting from negligent navigation or management of vessel under the provisions of the 1976 International Convention on Limitation of Liability for Maritime Claims (LLMC 1976/96). The limitation rule is just one example of protectionism in the form of state support for the shipping industry by providing the shipowner with a calculable risk before embarking on a marine venture. If the maximum liability of the shipowner can be assessed in advance, then it should be easier and more cost-effective to obtain insurance cover – a factor also important to the injured party if he can thus be certain of recovery in the event of loss.

The 1976 LLMC Convention sets specified limits of liability for certain types of claims against shipowners (including salvors and insurers), whereby the term “shipowner” shall mean the owner, charterer, manager and operator of a seagoing ship in accordance with the rules of this Convention for claims set out in Art 2 containing:

(a) claims in respect of loss of life or personal injury or loss of or damage to property (including damage to harbor works, basins and waterways and aids to navigation), occurring on board or in direct connection with the operation of the ship (or with salvage operations), and consequential loss resulting therefrom;
(b) Claims in respect of loss resulting from delay in the carriage by sea of cargo, passengers or their luggage;
(c) Claims in respect of other loss resulting from infringement of rights other than contractual rights, occurring in direct connection with the operation of the ship;
(d) Claims in respect of the raising, removal, destruction or the rendering harmless of a ship which is sunk, wrecked, stranded or abandoned, including anything that is or has been on board such ship;
(e) Claims in respect of the removal, destruction or the rendering harmless of the cargo of the ship;
(f) Claims of a person other than the person liable in respect of measures taken in order to avert or minimize loss for which the person liable may
limit his liability in accordance with this Convention, and further loss caused by such measures (LLMC 1976/96).

The claims set out in the foregoing paragraph shall be subject to limitation of liability even if brought by way of recourse or for indemnity under a contract or otherwise (Art 2 (2)) (LLMC 1976/96 1976).

The Convention allows for shipowners to limit their liability except if “it is proved that the loss resulted from his personal act or omission, committed with the intent to cause such loss, or recklessly and with knowledge that such loss would probably result” (LLMC 1976/96 1976). Furthermore, under Article 3(e) Claims by servants of the shipowner whose duties are connected with the ship, including claims of their heirs, dependents or other persons entitled to make such claims, if under the law governing the contract of service between the shipowner and such servants, the shipowner is not entitled to limit his liability in respect of such claims, or if he is by such law only permitted to limit his liability to an amount greater than that provided for in Article 6 (LLMC 1976/96 1976). Additionally, if any claims set out in Article 2 are made against any person for whose act, neglect or default the shipowner is responsible, such person shall be entitled to avail himself of the limitation of liability provided for in the Convention as well (Article 1 (4), LLMC 1976/96 1976). However, Article 4 stipulates that a person shall not be entitled to limit his liability if it is proved that the loss resulted from his personal act or omission, committed with the intent to cause such loss, or recklessly and with knowledge that such loss would probably result (LLMC 1976/96 1976).

Exploring suitable alternatives: fault-based liability, strict liability or vicarious liability?

There is no gainsaying that the terms “due diligence” and “reasonable care” are subject to objective interpretation. RITs are at present semi-autonomous guided by the notion of “human-in-the-loop.” The associated international rules (See Tables 1, 2 and 3) comprise a structured business model in which a plethora of actors come into play. Here, determining fault-based liability can be challenging due to the involvement of multiple actors that are dependent on technology manufactured by a third party not involved in the business model and main operations. The core of this principle revolves around the establishment of causal nexus. In other words, application of the above principle depends on the determination of “sufficiently close causal connection” with reference to “cause-and-effect-relationship-factual link coupled with an inquiry “into whether this factual link was proximate rather than remote” (Owen 2007). Ozturk (2021) views the concept of foreseeability as the bedrock of “proximate” cause, and cites Karrow (2016) to argue that foreseeability on the part of actors-in-the-loop operating technology, especially fully autonomous, is likely to be highly uncertain per se (Karrow 2016; Ozturk 2021).

Literature dedicated to liability challenges in relation to RAS also explores strict liability that branches out into two categories, namely “strict product liability” and “liability for ultra-hazardous activities” (Ozturk 2021). Relevant to this discussion is the former category governed by the EU Product Liability Directive 85/374/EEC that, in the opinion of the authors, releases the ship owner from liability by holding the producer or manufacturer responsible for damages caused by products that are inherently defective in nature (EU Product Liability Directive 85/374/EEC 1985). Although the Directive does not explicitly cite “software” as a product per se, electricity is nevertheless coined as a product pursuant to Article 2 (EU Product Liability Directive 85/374/EEC 1985). Moreover, commentators view software as tangible products although the information embedded within the software medium is intangible (Alheit 2001; Ozturk 2021).

Taking into account this view, authors assert that RIT indeed falls under the category of “product” in the context of Directive 85/374/EEC. Consequently, the manufacturer or producer will be held liable for damages caused by defective RIT invoked via Article 6 that states: “[...] it does not provide the safety which a person is entitled to expect, taking all circumstances into account, including (a) the presentation of the product; (b) the use to which it could reasonably be expected that the product would be put; (c) the time when the product was put into circulation” (EU Product Liability Directive 85/374/EEC 1985). The defense is, of course, readily available to the defendant under the exculpation clause, Article 7: “[...] 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 [...] 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 [...]” (EU Product Liability Directive 85/374/EEC 1985).

Relevant to the discussion on ship owner liability is “vicarious liability” – a liability that is “premised on fault, albeit with a reversed burden of proof (Entlastungsbeweis) (Gilliker 2021; German Ministry of Justice). A sound example of this principle is provided by McMahon and Binchy (2013): “[t]he law may hold the employer liable for the wrongs of an employee, the principal liable for the wrongs of an agent, or the firm liable for the wrongs of its partner, in spite of the fact that the employer, the principal, or the firm may not have been at fault in any way. When the law imposes
liability in these circumstances we speak of the employer, principal, or firm being “vicariously liable” (Binchy and McMahon 2013). When observing the RIT procedural landscape, it seems that the task of approval of service provider lies with the concerned Classification Society authorized by relevant flag administration (ICAS UR Z17, 1997). In the process of executing responsibility (see Table 1), the Classification Society is under an obligation to first and foremost, verify the performance of the third party (the service supplier) and subsequently, approve, verify and certify as seen fit for the purpose of conduct of classification and statutory surveys (ICAS UR Z17, 1997). What is also noteworthy is that the attending surveyor representing the Classification Society must verify each and individual tasks completed by the supplier. Based on this chain of command, the authors submit that when applying the principle of “vicarious liability” considering the roles mentioned above, the burden of proof in a liability case for damage will rest on the Classification Society.

An array of novel liability applications has emerged in tandem with RAS, as discussed above. Considering that RITs are characterized as objects under fault-based and strict liability and apply with certain restrictions, the application of vicarious liability, on the other hand, appears to operate with less restriction, in a manner of speaking, and therefore, better suited to determine liability in a befitting manner. In sharp contrast with the above proposition is the proposal tabled by Bertolini (2016) that favors the risk-management approach (Bertolini 2016). As opposed to fault-based liability that features time-consuming complex litigation for determining defendant’s liability, a risk-management-based approach, according to Bertolini (2016) proceeds to hold the producer/manufacturer as absolutely liable whereby the defendant is able to acquire insurance, in a strategic manner to cover damages caused and provide for prompt compensation without being subjected to court proceedings (Bertolini 2016).

**Recommendations**

Based on the discussions and all the issues identified in the preceding sections, the following recommendations are being put forward:

- **RIT Standards**: It is important to consider the notion/feasibility of establishing an EU RIT Agency that could contribute to developing RIT standards by taking into account EU wants and needs – until a state-of-the-art regulatory code is developed at the international level. Developing effective and detailed regulatory standards could serve as a stepping stone in developing the much-needed liability regime for RITs;

- **Stakeholder Consultation**: The EU RIT stakeholders in consultation with IMO and IACS should carve out pertinent items that could be placed within an overarching tailor-made RIT regulatory Code of Conduct framework. While critical aspects, e.g., definitions including a refinement of IMO’s definition of close-up survey as found in Harmonized System of Survey and Certifications (HSSC), data governance and data protection, trust and ethics, should receive the much-needed consideration; filling out the current void in relation to liability is in order (Johansson 2021);

- **Opting for a Clear Pathway**: Develop a methodology that could guide the projection of the direction “liability” could take from RIT deployment, and simultaneously ensure that Tort law and Product Liability Regulations do not overlap as a result of human-RIT interactions. The methodology should be robust enough to provide guidance not only in the semi-autonomy/ “human-in-the-loop” phase, but also once RIT autonomy reaches its peak;

- **Determining Types of RIT Liability & Developing a Safety Net**: As part of future research activities, exploring in detail all categories of liability with respect to actions by ship owners, producers/manufacturers and any other entities involved should follow swiftly. This would also entail highlighting aspects that could exempt the entity involved in RIT operations from liability. Whether or not an RIT/smart insurance system should be initiated – is a matter to be determined jointly by producer/manufacturer, service suppliers and insurance companies. The notion that that an RIT/smart insurance system safety-net could serve as an important incentive which would allow innovation to grow without being stalled by incidental issues is also expressed here.

**Conclusion**

It is a self-explanatory fact that RITs hold a wealth of advantages. Beyond the general services, RITs play a critical role in bolstering support to the notion of “digital maritime” in this era of increased connectivity, with the new paradigm of 5 G that is currently being rolled out. The opening of opportunities is on the other hand hampered by threats in the form of liability that could inhibit the widespread usage of RIT services. This will, not only slow the market growth of technology, but also leave ship owners and surveyors with no other option but to revert back to hull survey and inspection
through physical presence that is deemed as risky and onerous (Johansson, Dalaklis, and Pastra 2021). Liability will certainly have an important bearing on emerging technology applications and their effective use, since the fear of moving into “uncharted waters” could have a devastating effect. As the future rolls towards full autonomy, those liability aspects need to be identified and effectively addressed at the outset, not only for ensuring that all actors involved can play their part with utmost duty of care observing due diligence, but also for confirming that producers/manufacturers have the proper incentives to present new technologies for expediting the survey and inspection process.

An implied criteria of the EU Digital Single Market rests upon a holistic environment through which technology can grow and prosper. This environment comprises the landscape within which stakeholders of technology could maneuver at ease and carry out designated roles and responsibilities. Regulating that environment entails mitigating possible grey areas for discharging the full potential of the innovation at hand (Bertolini 2016). The maritime sector, in that aspect, is no different from the land-based sector in which efforts are persistent in removing barriers that could hinder the market growth of autonomous vehicles. Liability, in that sector, is already an issue that is being dealt proactively by practitioners, academics and experts (Bertolini 2016). EU Maritime stakeholders engaged with RIT operations need to proceed with the same level of diligence and integrity, and help push the “liability” agenda forward before individual EU member states developing their own rules. It is certainly worthwhile to explore the development of an EU RIT Code of Conduct in which liability rests alongside other provisions so as ensure a harmonized management system that is precautionary in essence.

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ORCID
Tafir Johansson http://orcid.org/0000-0003-4877-0429
Aspasia Pastra http://orcid.org/0000-0002-8587-9100
Dimitrios Dalaklis http://orcid.org/0000-0001-5260-7910

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