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The international convention for the safety of life at sea: highlighting interrelations of measures towards effective risk mitigation

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ABSTRACT

Safety is often described as freedom from unacceptable risk. The International Maritime Organization (IMO) since its establishment has consistently been working towards mitigation of risks at sea by implementing measures through specific legal Instruments. The IMO's principle Instrument with this focus is the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS). By identifying and examining a wide range of risks that must be addressed in order to ensure the safe operations of ships at sea, the chapters of SOLAS provide the necessary mitigation measures. This paper goes on to discuss three specific risks among those being mitigated by SOLAS, which are a) structural integrity and stability related risks; b) fire risk and c) navigational risk. The reason for this choice is quite simple: analysis of past statistics from shipping incidents databases clearly indicates that these risks are recorded with the highest numbers; with statistics testifying that navigational risk is linked to the greatest number of accidents. A conclusion clearly standing out is that the various measures being put forward by SOLAS and the associated supporting Codes work in a complementary manner and together have provided a positive contribution towards the safety of personnel, environment and property.

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International Convention for the safety of Life at Sea Risk (SOLAS); Safety; risk Mitigation Measures; international Maritime Organization (IMO)

Background

In the course of human history, shipping activities have always been vital for supporting trade. It is also a rather self-explanatory fact that at any point of time the building characteristics and equipment of ships are heavily reliant on the vessels' "intended" mission, and most importantly, upon the technology applications available to support these quite complex activities. It is not a coincidence that during the so-called industrial revolution, dependency on shipping increased because of the ships ability to transport high volumes of goods and in a very cost-effective manner, especially when considering the benefit of "economics of scale" (Heaver 2002). However, as sea-going vessels were increasing in size and complexity, it also became obvious that coordinated effort to endure the safety at sea were needed. It is indicative that the absence of an effective Convention to regulate the safety of shipping in this period¹ was probably one of the factors which resulted in the death of more than 1500 out of 2224 passengers and crew on-board the passenger liner RMS Titanic, when it collided with an iceberg on 15 April 1912.

No matter the grief for the numerous lives lost at sea, that maritime disaster had a positive impact: it opened the way for the adoption of International Convention for

the Safety of Life at Sea (SOLAS) (Dalaklis 2017). Following a path of continuous improvement since that point in time, the wider regulatory framework under the auspices of the International Maritime Organisation (IMO) has resulted in a safer, cleaner and more sustainable shipping industry that is capable to effectively deal with the global economy needs. The main purpose of this paper is to discuss the aforesaid evolution in IMO's framework to enhance safety at sea, facilitate its better understanding and especially highlight the interrelating approach deployed for the various Conventions and Codes supporting this. Following this brief introductory section, the berth/evolution of IMO is discussed next. Then, the focus is shifted towards the main Convention dealing with safety at sea, SOLAS. The methodology deployed to serve risk mitigation by SOLAS is presented in section 4. An analysis of measures used to deal with the most "threatening" types of risk is conducted in sections 5–6, along with identification of their interrelations. Finally, conclusions are provided.

Evolution of the IMO

In 1948, an international conference in Geneva adopted a Convention formally establishing IMO (the

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¹In July 1912, the British Government appointed the Merchant Shipping Advisory Committee (following the RMS Titanic incident), whose sub-committee on statistics observed that since 1855 there were only basic regulations governing ships carrying i) emigrants ii) other vessels carrying passengers and iii) seagoing vessels not carrying passengers. Additionally, all these three regulations didn't mandate requirements for lifeboats to carry 100 percentage of ships complement (Donald 1913). One of the main reasons for the deaths on-board the RMS Titanic was the inadequate capacity of the available survival crafts to full complement of passengers and crew.

original name was the Inter-Governmental Maritime Consultative Organization or IMCO, but the name was changed in 1982 to IMO). The IMO Convention entered into force in 1958, and the new Organisation met for the first time the following year. Since its inception, in 1959, the Organization (IMO) has exerted every effort to protect human life at sea. The purposes of the IMO, as summarised by Article 1(a) of its Convention, are: "... to provide machinery for cooperation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade; to encourage and facilitate the general adoption of the highest practicable standards in matters concerning maritime safety, the efficiency of navigation and prevention and control of marine pollution from ships". The Organization is also empowered to deal with administrative and legal matters related to these purposes. IMO's first task was to adopt a new/updated version of the International Convention for the Safety of Life at Sea, the most important of all treaties dealing with maritime safety; this was achieved in 1960 (IMO 2020b). IMO has used the concept of continuous development, keeping abreast to the advancement in technologies to ensure that relevant measures have been incorporated in this Convention to mitigate existing or newly identified risks. Accordingly, significant amendments in 1929, 1948, 1960 and 1974 have developed the Convention into the current International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS 1974). SOLAS 1974 was adopted on 1 November 1974² (IMO 2020b).

International convention for the safety of life at sea, 1974, as amended (SOLAS 1974)

SOLAS 1974: Amendments' procedure

Article VIII of the SOLAS 1974 Convention states that amendments in the Convention can be made via two different avenues (IMO, 2014a). The first one is after (formal) consideration within IMO. Amendments proposed by a Contracting Government must be circulated at least six months before their consideration by the Maritime Safety Committee (MSC), which may refer discussions to one or more IMO Sub-Committees. Amendments are adopted by a two-thirds majority of Contracting Governments present and voting in the MSC. It is also interesting to note that Contracting Governments of SOLAS 1974, whether or not Members of IMO are entitled to participate in the consideration of amendments in the so-called "expanded MSC". The second way is via a dedicated Conference. This Conference (of Contracting Governments) is called when a Contracting

Government requests the holding of a Conference and at least one-third of Contracting Governments agree to hold the Conference. Amendments are adopted by a two-thirds majority of Contracting Governments present and voting.

In the second method of updating/changing SOLAS 1974 (Conference), as well as in the case of the expanded MSC, amendments (other than those to Chapter I) are deemed to have been accepted at the end of a set period of time following communication of the adopted amendments to Contracting Governments, unless a specified number of Contracting Governments object. The length of time from communication of amendments to "deemed acceptance" is set at two years unless another period of time (which must not be less than one year) is determined by the two-thirds of Contracting Governments at the time of adoption. Amendments to Chapter I are considered as accepted after positive acceptance by two-thirds of Contracting Governments; amendments enter into force six months after their "deemed acceptance". The minimum length of time from circulation of proposed amendments through entry into force is therefore 24 months (circulation: six months, adoption to deemed acceptance date: 12 months minimum; deemed acceptance to entry into force: six months).

However, a resolution adopted in 1994 ensures that an accelerated amendment procedure can be used in exceptional circumstances, allowing for the length of time from communication of amendments to "deemed acceptance" to be shortened to just six months in exceptional circumstances and when this is so decided by a Conference. In practice to date, the expanded MSC has adopted most amendments to SOLAS 1974, while Conferences have also been held on several occasions (notably to adopt whole new Chapters to SOLAS 1974, or to adopt amendments proposed in response to a specific incident). Instead of requiring that an amendment shall enter into force after being accepted by, for example, two-thirds of the Parties, the tacit acceptance procedure provides that an amendment shall enter into force on a specified date unless, before that date, objections to the amendment are received from an agreed number of Parties.

Focus of SOLAS 1974

SOLAS 1974 is the principle Instrument by the IMO, which focusses on human life protection during shipping activities (Vassalos et al. 2010). SOLAS 1974 applies to all passenger ships and cargo ships over 500 GT engaged on international voyages (unless provided otherwise in the Convention). The MSC (and its six sub-committees³) of IMO deal with matters on maritime safety and the amendments to SOLAS 1974

²SOLAS 1974 has also been amended twice in 1978, and 1988 vide protocols.

³The MSC sub-committees consist of Sub-Committee on Human Element, Training and Watchkeeping (HTW), Sub-Committee on Implementation of IMO Instruments (III), Sub-Committee on Navigation, Communications and Search and Rescue (NCSR), Sub-Committee on Ship Design and Construction (SDC), Sub-Committee on Ship Systems and Equipment (SSE) & Sub-Committee on Carriage of Cargoes and Containers (CCC).

(Beckman and Sun 2017). The structure of the SOLAS 1974 leads from Chapter one, which includes the specifications of types of vessels on which the Convention applies and follows by providing necessary definitions used with the Instrument. Chapter 1 also contains the details on the requisite inspection and survey regime towards maintenance of statutory certificates on-board vessels. These elements are followed by the chapters elaborating on various risks addressed by SOLAS 1974. The structure and a brief overview of salient features of SOLAS 1974 are summarized in Figure 1.

It may be observed from Figure 1 that SOLAS 1974 does not work in isolation, but it utilises Codes empowered by the Convention. These Codes serve to effectively mitigate specific risks identified in the Convention, while keeping the Convention generic and at the same time more compact.

Risk mitigation in SOLAS 1974

Arnaud, as cited in Ale, Burnap, and Slater (2015), has defined risk as a set of two parameters, namely, the potential of an occurrence in tandem with the outcome of an incident. Furthermore, safety is often described as freedom from unacceptable risk (Hollnagel 2016). Management of risks associated with shipping operations is a very effective way to ensure safety of life at sea; this is the main objective of SOLAS 1974 and very evident in the introduction to its Articles.⁴ Even though many of the amendments to SOLAS 1974 are “additional” measures towards risk mitigation, these amendments have on occasions been a responsive measure, i.e., legislation by disaster due to accidents/incidents (Dalaklis 2020). As per O’Neil (1991) as cited in Mitrouss (2004), IMO started transitioning from being reactive to marine disasters and becoming proactive in the 1990s by starting to

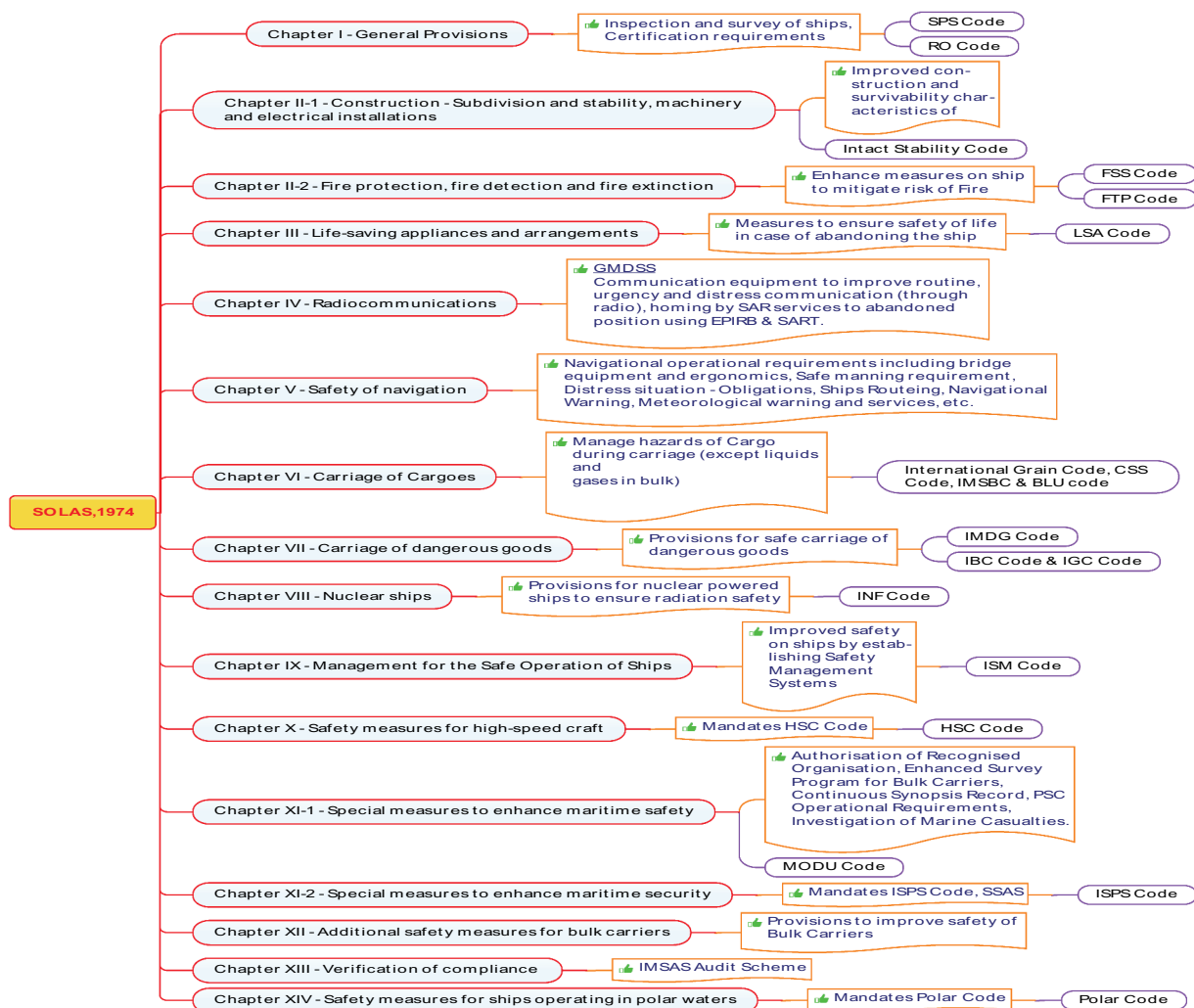


Figure 1. Overview of SOLAS 1974 with the associated Codes (Created by the Authors).

⁴The introduction to the Articles of SOLAS quote as “Being desirous of promoting safety of life at sea by establishing ...”

utilise methodologies to anticipate and prevent accidents. Accordingly, the adoption of Guidelines for Formal Safety Assessment (FSA), was such a proactive move by IMO⁵ ensuring that an analytical and methodical technique in risk management was incorporated into their rule-making process (Figure 2) (IMO 2002).

Risks cannot be wholly mitigated but are managed using FSA methodology by IMO to ensure that the risks are kept to 'As Low As Reasonably Practicable (ALARP)' (Figure 3) (Pedersen 2010).

Types of Risks

The risks being managed in SOLAS 1974 may be categorised into the following (non-exhaustive) list of eleven (11) different (but, interrelated) types (Figure 4).

A certain number of these risks are also addressed in other IMO Instruments such as MARPOL⁶ and STCW,⁷ with the issue of shipboard operations standing out, but with different objectives when compared to SOLAS 1974. Additionally, some of these risks and their management are interlinked within different SOLAS 1974 chapters under the specific provisions.⁸ Furthermore, the risks being managed in SOLAS 1974 can be also be categorised into two stages based on its handling stage, as described in Table 1.

SOLAS 1974, through its legislation, has ensured that risks are managed by "properly sharing" between the four main stakeholders: Ship-owner, Flag State,

Classification Society (Class) and Port State. This sharing ensures that a safety net is created through Survey, Audit, Inspection and Examination to verify that the provisions of SOLAS 1974 are being complied with and therefore ensure that risks are sufficiently and efficiently managed. Further, certificates specified in MSC.1/Circ.1586 are issued by a competent authority after the Survey/Audit/Inspection/Examination to a vessel to formally testify "compliance" with the requirements of the Convention (Dalaklis 2020).

Three very influential risks addressed in SOLAS 1974

Risks do not exist in isolation but are, at times, inter-linked. When an incident occurs due to a particular primary risk acting out, the following sequence of events may result in a secondary risk manifesting itself. For example, a navigational risk which is manifested due to a collision incident may also result in a structural damage. The most influential (three) risks addressed in SOLAS 1974 is best possible to be identified by analysing past statistics of accidents.

As per a relevant report by EMSA (2019), out of 23,073 incidents/casualties which occurred between 2011 and 2018 (Figure 5), the navigational incidents represented 54.4% of the total, consisting of collisions (26.2%), contact (15.3%) and grounding/stranding (12.9%), followed by incidents/casualties due to fire &

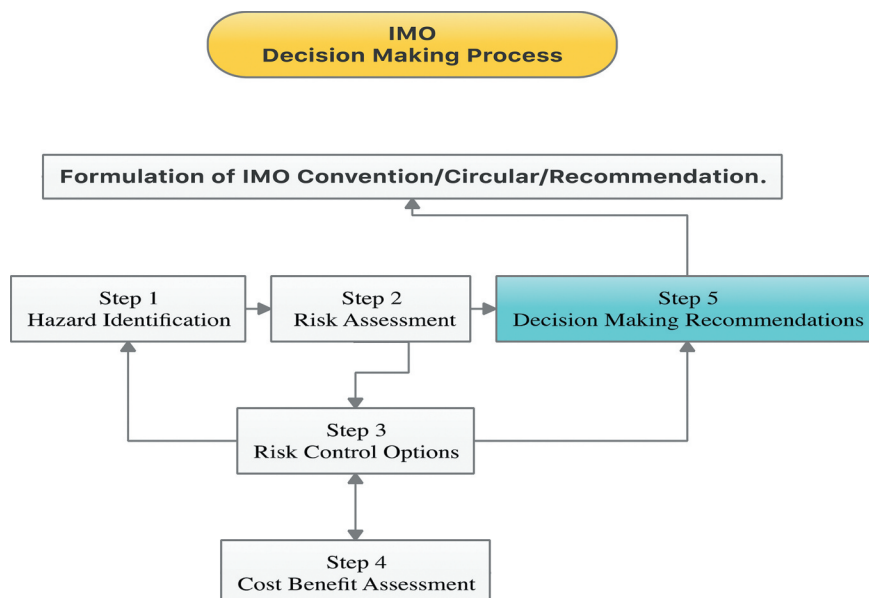


Figure 2. Flow chart of the FSA methodology (created by the authors, by adopting from IMO (2002)).

⁵74th session of MSC on 8 June 2001

⁶International Convention for the Prevention of Pollution from Ships (MARPOL).

⁷International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW).

⁸For example, a Polar class vessel who need to comply with the International Code for Ships Operating in Polar Waters (Polar Code) in order to ensure its safe operation must simultaneously comply with the relevant provisions of the other chapters in SOLAS such as Chapter V.

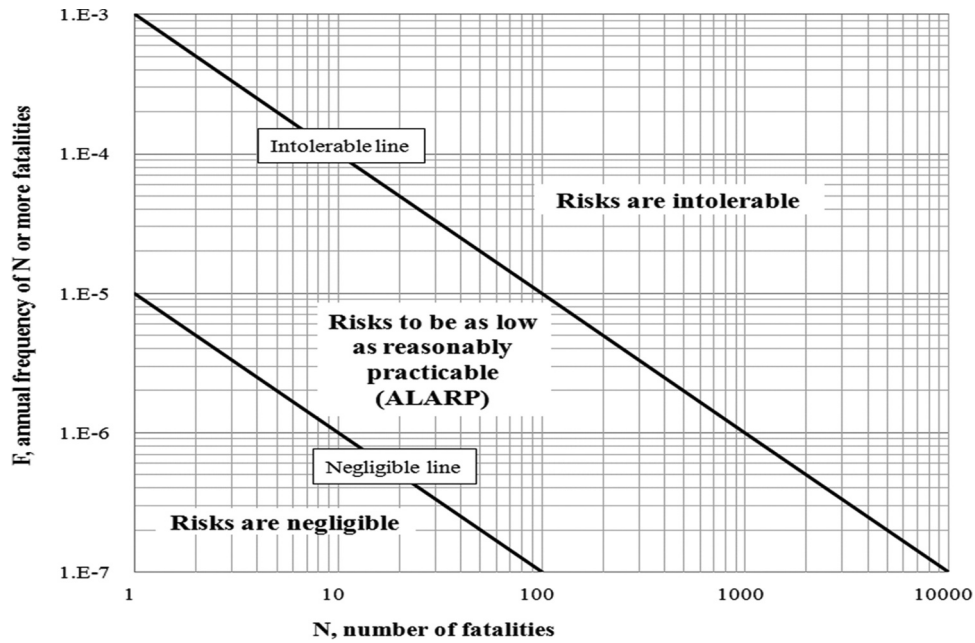


Figure 3. Typical risk acceptance criterion, F–N diagram (Pedersen 2010).

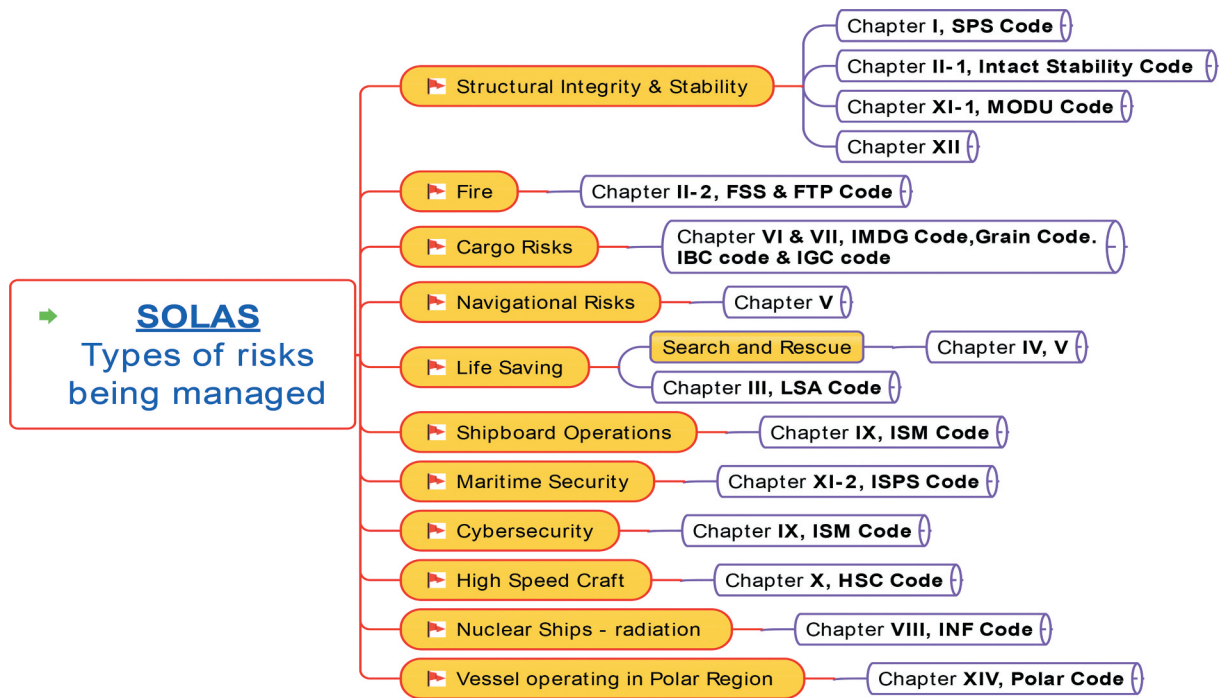


Figure 4. Classification of risks being managed in SOLAS 1974 and associated chapters mitigating the primary risks (Created by the Authors).

stability/structural integrity. This exactly same trend is also observed in other databases with a similar purpose (Kristiansen 2013).

Due to particular emphasis placed by IMO (and SOLAS 1974) on Roll-on/roll-off Passenger (RO-PAX) and passenger⁹ vessels, statistics indicate that passenger vessel losses constitute a minute fraction in comparison of losses of cargo vessels which is at 40% for the

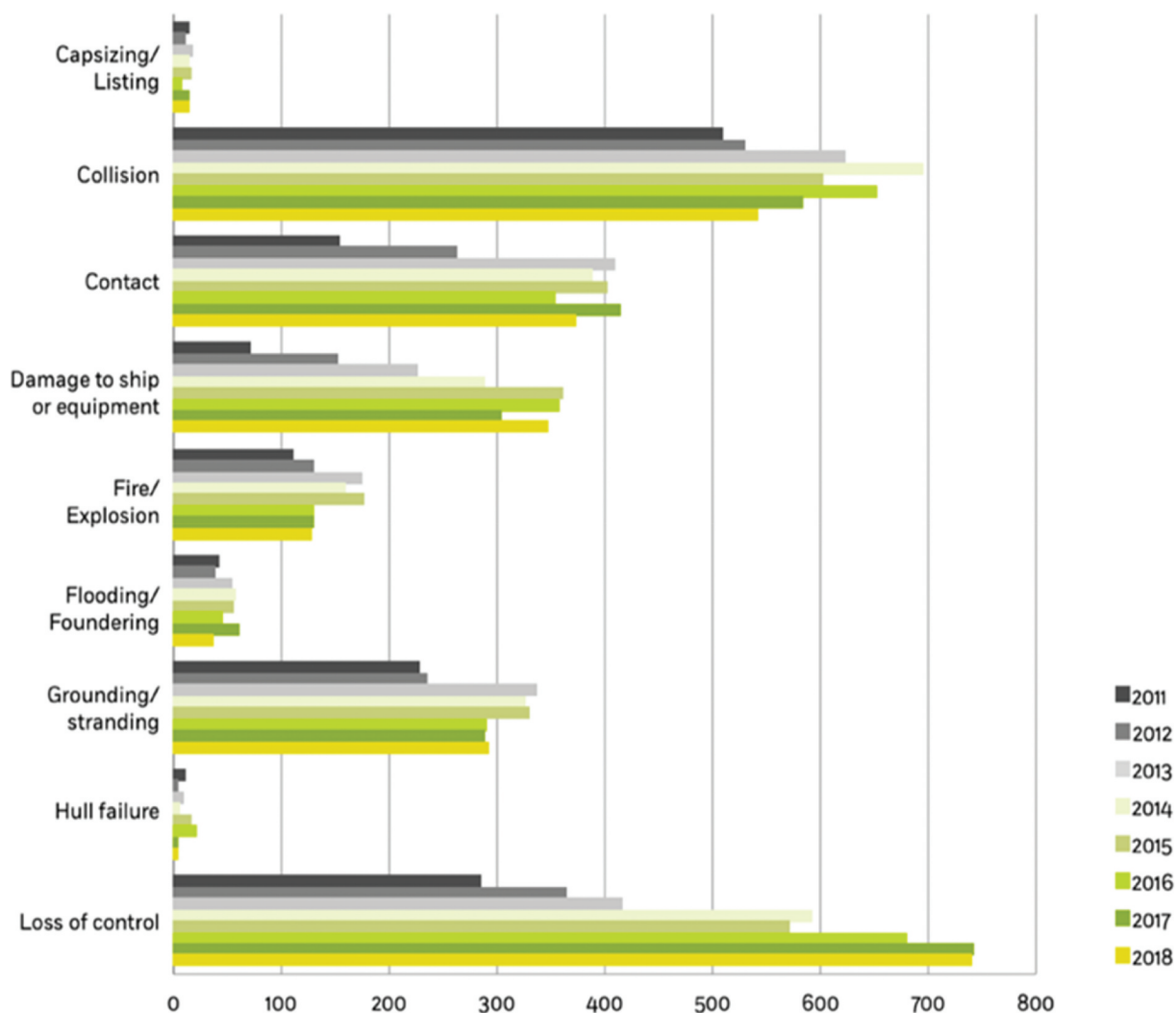
period 2009 to 2018 (Figure 6) (AGCS 2019). This paper is, therefore, focussing on common risks addressed in SOLAS 1974 for all types of vessel irrespective of its mission in the following sub-sections, by providing an overview of structural integrity and stability, as well as fire risk. A detailed analysis of navigational risk is provided in section 6, considering that this is the risk associated with the largest number of accidents.

⁹This is also evident from the implementation date of new amendments in SOLAS, wherein passenger ships always have had an earlier implementation date in relation to all other types seagoing vessels.

Table 1. Categorisation of risk mitigated in SOLAS 1974 based on its handling stage (created by the authors).

Construction stage	Operation Stage
The construction stage is when risks are managed during shipbuilding in the ship design, construction and/or equipment fitment stage by complying with the requirements of SOLAS provisions.	Operation stage is when risks are dealt during the routine operations by the ship crew and/or by necessary shore support by complying with the requirements of SOLAS provisions.
The risks dealing with structural stability and integrity, fire, navigational risks, lifesaving appliances, High speed craft, Nuclear Ships, etc. are generally mainly dealt in the construction stage.	The risks dealing with cargo (grain code, etc), Shipboard operations (ISM Code), maritime security (ISPS Code), cybersecurity (ISM Code) are being dealt mainly in the operational stage.

Note: Many of the risks have elements which need to be addressed in both the construction and operation stage. To cite an example, SOLAS under chapter II-2 Part E “Operational Requirements” deals with the method of mitigating and managing the risks of fire for example by conducting training and drills using the operational method whereas most of the other Parts in chapter II-2 are addressed when ships are in the construction stage.

**Figure 5.** Distribution of types of incidents/casualties for period 2011 to 2018 in EMCIP database (EMSA 2019).

Structural integrity and stability related risk

Figure 7 presents the chapters in SOLAS 1974 addressing “Structural Integrity & Stability” as Primary & Secondary Risk. The importance of this risk is evident from the fact the sea is indeed a very dangerous place and the common saying that a ship itself is the best available “lifeboat” for the crew while conducting the voyage. Ensuring safety at sea is made possible via

the mitigation of all “primary and secondary” risks by SOLAS 1974; this holistic approach is based on identifying all risks interrelations and then ensuring that vessels are being designed with resiliency to encounter the perils of the seas (Barker and Campbell 2000). For example, a fire incident can compromise the vessel’s structural integrity, and SOLAS 1974 Chapter II-2, which deals with fire risk, also has risk management

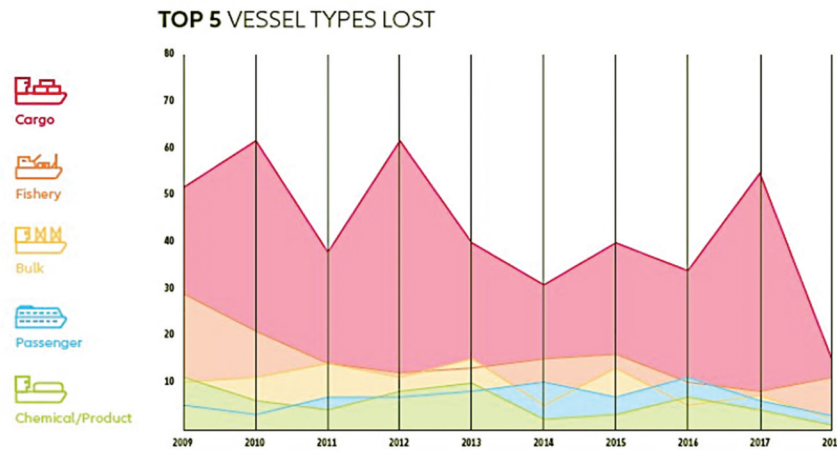


Figure 6. Total losses by type of vessel: 2009–2018, (Lloyd’s List Intelligence Casualty Statistics as cited in AGCS 2019)

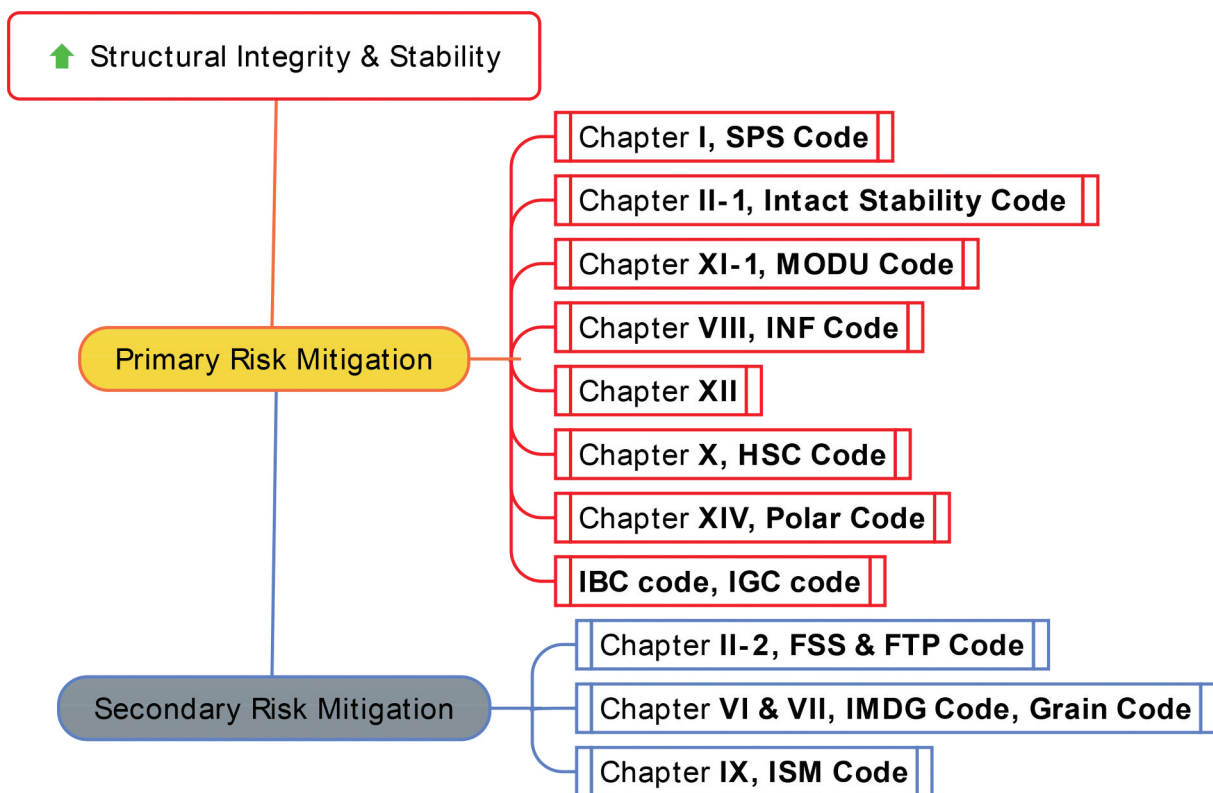


Figure 7. Chapters in SOLAS 1974 and associated codes addressing “structural integrity & stability” as primary & secondary risk codes (created by the authors).

provisions of the secondary risk of structural elements due to fire.¹⁰

SOLAS 1974 Chapter II-1¹¹ Regulation 3–1 requires ships to be designed, built and maintained in compliance with a classification society’s¹² structural, mechanical and electrical specifications. This results in effective micro risk management as the classification society is involved from the stage of ship design up to the end of the ships life when recycled.

Furthermore, under Chapter II-1 Regulation 3–10, the introduction of Goal-based ship construction standards (GBS) for bulk carriers and oil tankers, as incorporated under Res.MSC.290(87) in 2003, was a positive move by IMO. GBS allowed ship designers to overcome the disadvantages of prescriptive regulations which were on bases of past experiences and therefore redundant in some instances due to its failure to take into consideration future design challenges (IMO 2020a).

¹⁰For example, the purpose of SOLAS CHAPTER II-2 Reg 11 “Structural Integrity” is to maintain regulation is to maintain structural integrity of the ship preventing partial or whole collapse of the ship structures due to strength deterioration by heat.

¹¹Chapter II-1 “Construction Structure, Subdivision and Stability, Machinery and Electrical Installations”

¹²The classification society needs to be recognized by the Administration in accordance with the provisions of regulation XI-1/1 and publishes class rules which denote these specifications.

Chapter II-1 which in coordination Chapter XII (bulk Carriers) and codes such as SPS, MODU, INF, IGF, IBC, Polar & Grain contain further measures such as provisions for subdivision, intact stability including special requirements for ships, double bottom requirements and structural requirements, etc., which are applicable for cargo ships and passenger ships (unless specified otherwise). Further, the subdivision and damage stability provisions of SOLAS 1974 under Chapter II-1 part B regulations 4–7 and IMO Resolution A.265 (VIII), as an equivalent to Chapter II-1 part B regulation 7, allow for evaluating the stability of ships in case of damage. These regulations impose requirements on subdivision arrangements and also compartmentalise the vessel by providing for the allowable length of the compartments¹³ to ensure that the ship is safe without submerging the margin line when two consecutive compartments are flooded (Puisa et al. 2013).

Fire risk

The reason why fire risk incidents numbers are high is that ships most commonly operated within an environment where the three elements constituting a fire triangle¹⁴ are present, increasing such exposure to this risk. Casualties from fire incidents are low even though the numbers of incidents are high, and the main reason for this is the rigorous way the SOLAS Convention manages the risk of Fire. For example, the Ch. II-2¹⁵ of SOLAS 1974 (Figure 8) deals with mitigating fire risk by focusing on the location where the fire originates and thereafter containing, controlling and extinguishing it in case of an outbreak (Vassalos et al. 2010).

Regulation 2 of Chapter II-2 specifies five safety objectives with regards to a fire which is prevention, reduction to risk to life, reduction to the risk of damage, contain, control and suppress the fire and provide easy means of escape from spaces on fire.

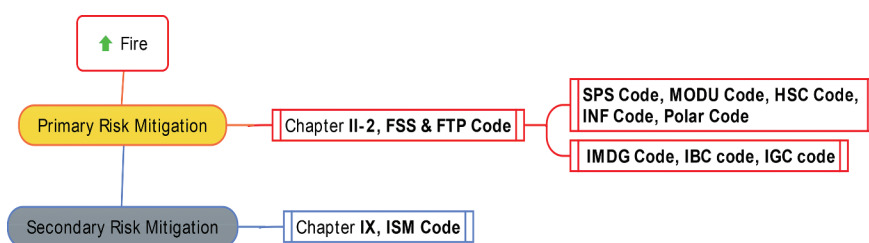


Figure 8. Chapters in SOLAS 1974 and associated codes addressing “fire” as primary & secondary risk codes (created by the authors).

¹³Termed floodable length.

¹⁴The Fire triangle three sides represent heat, fuel, and an oxidizing agent (usually oxygen) required to sustain a fire.

¹⁵Chapter II-2 – Fire protection, fire detection and fire extinction

¹⁶According to IMO’s official website: “Goal-based standards (GBS) are high-level standards and procedures that are to be met through regulations, rules and standards for ships. GBS are comprised of at least one goal, functional requirement(s) associated with that goal, and verification of conformity that rules/regulations meet the functional requirements including goals. In order to meet the goals and functional requirements, classification societies acting as recognized organizations (ROs) and/or national Administrations will develop rules and regulations accordingly. These detailed requirements become a part of a GBS framework when they have been verified, by independent auditors and/or appropriate IMO organs, as conforming to the GBS” ...

The various codes, as listed in Figure 10, also address fire risks for the specific type of ship, especially at the construction stage. This risk mitigation is achieved by constructional requirements, detection and alerting requirements, fitment of equipment for extinguishment, specifying materials which are fire protective/retardant for ships construction, etc.

Safely Return to Port (SRtP) is a very crucial concept introduced by amendments to SOLAS 1974 via MSC Resolution 216(82), aimed at increasing passenger ship safety by making it compulsory for new passenger ships over 120 m in length or with three or more Main Vertical Zones. This amendment provides “safe areas” for passengers and “essential services” to allow it to safely return to port after a fire or flooding incident, provided that the casualty threshold is not reached. The Goal-based standards¹⁶ (GBS) methodology to serve the identification of SRtP according to the provisions of SOLAS 1974 has incorporated innovative methods by bringing in cost-effective designs at the same time optimising passenger ship operations by bringing in more safety standards (Cangelosi et al. 2018).

Navigational risk

As evident from statistics of past marine incident databases, the navigational risk is at the forefront of attention, especially when considering that a very extended number of incidents is linked to this specific risk. This risk is most often associated with consequences such as collision, grounding or contact damage. Incidentally, the collision of RMS Titanic with an iceberg on the ill-fated night was also linked to a navigational risk. Figure 9 presents the chapters in SOLAS 1974 addressing “Navigation” as Primary & Secondary Risk.

Further aspects dealing with navigational risk being addressed by IMO is discussed next.

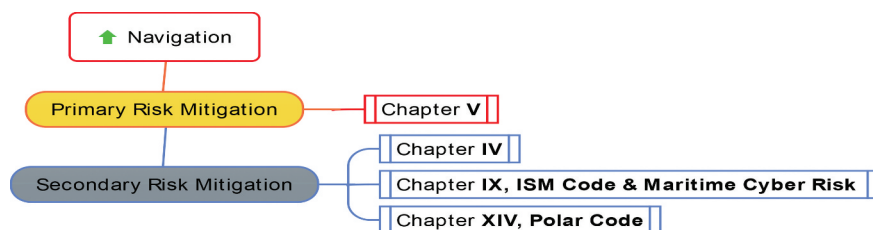


Figure 9. Chapters in SOLAS 1974 and associated Codes addressing “Navigation” as Primary & Secondary Risk Codes (Created by the Authors).

Holistic approach to safety of navigation by IMO

The non-exhaustive measures in regulations of SOLAS 1974 that serve the purpose of mitigating navigational risk through its various Chapters are summarised in Table 2.

These measures clearly indicate that the SOLAS 1974 Convention is a quite forward-thinking legislation in terms of incorporating technological advances as it is evident from its various amendments in the course of time. Effectively adapting to technological changes and new innovations is especially true in terms of SOLAS 1974 Chapter V, as various provisions in the

Convention ensure that the navigational bridge of ships (irrespective of type or size) is fitted with a series of devices and systems that improve the quality of navigation and therefore contribute into the mitigation of risks such as collision, grounding or contact damage.

Furthermore, the 81st session of the MSC agreed on the process of developing a regulatory framework for e-navigation,¹⁷ taking well into account the expected in the future technological advances in shipping. The Correspondence Group on e-navigation of the NCSR sub-committee produced a roadmap called the e-navigation strategy implementation plan (SIP) in 2014. The FSA-derived SIP aims at reaching five specific e-navigation

Table 2. Navigational Risk countermeasures under regulations in SOLAS 1974 Codes (Created by the Authors)

Sl. No.	SOLAS Regulation	Short Title	Factor addressed
1	Chapter IV Reg 5-1	GMDSS	Communication (Routine, Urgent & Distress).
2	Chapter V Reg 4, 5	Navigational, Metrological services and Warnings	Early warning of risks of weather and navigation.
3	Chapter V Reg 7	Search and Rescue	Safety of life in by rescue of persons in distress at sea or coast.
4	Chapter V Reg 9	Hydrographic services	Requirements for charts and publications to be updated to avoid navigation incidents.
5	Chapter V Reg 10 & 11	Ships’ routing and reporting systems	safety of life at sea, safety and efficiency of navigation, and/or protection of the marine environment.
6	Chapter V Reg 12 & 13	Vessel Traffic Services Aids to Navigation	Ship traffic management and collision avoidance.
7	Chapter V Reg 14	Ship Manning	Safe Manning (Human factor).
8	Chapter V Reg 15	Principles related to bridge design, equipment and procedures	Ergonomics of Bridge Design.
9	Chapter V Reg 15	Maintenance of Navigational Equipment	Planned Maintenance System (PMS) also addressed in ISM Code.
10	Chapter V Reg 19	Carriage requirement of navigational equipment	Mandatory Navigational Equipment list.
11	Chapter V Reg 19-1	Long-range identification and tracking of ships	Locating remotely the position of ships.
12	Chapter V Reg 20	Voyage Data Recorders	Similar to an aeroplanes Black Box to access data recorded from various bridge equipment for incident investigation in case of navigational incident.
13	Chapter V Reg 33	Distress situations: obligations and procedures	Master obligation to provide assistance in distress situation.
14	Chapter IX	ISM Code	Ensure safe shipboard operations (i.e. manage Human Element) by following standardised documented procedures to ensure safe operations (including navigational operations and PMS of bridge equipment); Management of maritime cyber risk, Shore responsibility established by creation of DPA and certification (DOC).
15	Chapter XIV	Polar Code	The Polar Code covers the full range of design, construction, equipment, operational, training, search and rescue and environmental protection matters relevant to ships operating in the inhospitable waters surrounding the two poles. The Polar Code entered into force on 1 January 2017.

¹⁷IMO defines “e-navigation as the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment (as defined in the Strategy for the development and implementation of e-navigation (MSC 85/26/Add.1, annex 20).

solutions¹⁸ (IMO 2018). Once formulated and incorporated into SOLAS 1974 amendments, this regulation will go a long way towards further improving navigational safety. E-navigation also needs consideration towards integration with the so-called “net-centric”¹⁹ functionality of technological equipment and systems towards optimisation of processing of high-quality data and information coming from them, which can further improve response to navigational risks (Dalaklis et al. 2020).

Furthermore, the International Safety Management (ISM) Code,²⁰ which was introduced as a result of RORO ferry Herald of Free Enterprise sinking that resulted in the death of 193 persons, ensures safe shipboard operations by following standardised procedures as well as ensuing responsibilities are shared between the ship and shore personnel (Mukherjee 2007). These procedures include but are not limited to Bridge Team management, Planned Maintenance System for equipment/machinery/structure, etc. SOLAS 1974, therefore, addresses the Human Element aspect of the risks through the ISM Code for all the risks (Figure 4) including risks of navigation, fire as well as structural integrity and stability.

Conclusion

The SOLAS Convention, which has its origin a couple of decades before the IMO’s establishment is a constantly evolving legislation; today 165 member States party to the Convention²¹ and there is a coverage of 99.04% of the gross tonnage of the world’s merchant fleet (IMO 2020c). For any IMO Instrument, the critical aspect is legislation by the Member State followed by Implementation and Verification. The success in this regard is evident from statistics as SOLAS 1974 has resulted in a reduction in the number of marine casualties/incidents over the years. IMO specifically through its MSC and member states have ensured that SOLAS 1974 has evolved to become more proactive for example through the GBS methodology, the timely introduction of the Polar Code (Dalaklis 2017), shifting the focus towards cybersecurity, etc. Additionally, the regulatory scoping exercise of IMO Instruments to evaluate preparedness for Maritime Autonomous Surface Ships that was

initiated in 2017 is another positive step in this direction (Ringbom 2019).

However, risks cannot be wholly eliminated/extinguished, but with the help of various mitigation measures can be kept to the ALARP level. With ongoing technological advances, electronically aided collisions could be recorded in the future as another navigation risk. When considering the “ordinary” distractions from numerous equipment on the ship’s bridge, human errors associated with failure to interpret the information accurately, or even lack of training and inability to maintain proper navigational watch, now there is a need to deal with “new distractions”, such as looking/answering a smartphone phone. Such an evolving issue would need to be constantly addressed as most of the navigational incidents are clearly linked to human errors. Even though SOLAS 1974 is associated with very strict safe manning provisions under Chapter V regulation 14, the number of personnel involved with navigational watchkeeping task is most commonly maintained to the absolute minimum; this approach is deployed to keep costs down, but when factoring in issues like fatigue and/or information overload from the bridge equipment can result into devastating effects. Here the issue of effective training, working in unison with the further built-up of certain “soft skills” can provide the solution.

At the same time, the positive impact of introducing FSA has resulted in risks being studied before legislating in relation to new technologies and therefore mitigating these risks by introducing countermeasures in SOLAS 1974. Additionally, the early introduction of concepts such as e-navigation and net-centric functionality of technological equipment and systems can further help in the alleviation of the risks related to navigation. Such positive measures have contributed towards ensuring the safety of life at sea and at the same time facilitate the Organisation²² to “uphold its leadership role as the global regulator of shipping, promote greater recognition of the sector’s importance and enable the advancement of shipping, whilst addressing the challenges of continued developments in technology and world trade; and the need to meet the 2030 Agenda for Sustainable Development”.

¹⁸The basis of the SIP are the following 5 e-navigation solutions:

- S1: improved, harmonized and user-friendly bridge design;
- S2: means for standardized and automated reporting;
- S3: improved reliability, resilience and integrity of bridge equipment and navigation information;
- S4: integration and presentation of available information in graphical displays received via communication equipment; and
- S5: improved communication of VTS Service Portfolio (not limited to VTS stations) (IMO 2018).

¹⁹Definition of “net-centric” operations as per United States (US) Department of Defence as cited in Dalaklis et al. (2020), as “the ability for users to obtain the required information and applications when and where they are needed”.

²⁰SOLAS Chapter IX

²¹The combined merchant fleets of 165 States which constitute approximately 99.04% of the gross tonnage of the world’s merchant fleet.

²²IMO Strategic Plan for the Organization for the six-year period 2018 to 2023 (Resolution A.1110(30))

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