TOWARDS A NEW SOLAS CONVENTION: A TRANSFORMATION OF THE SHIP SAFETY REGULATORY FRAMEWORK

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SUMMARY

This document considers the necessary elements for fundamentally transforming SOLAS to adapt safety to innovation, technology sophistication and operational efficiency of shipping by means of a long-term comprehensive review of the existing regulatory framework. This should be undertaken with a view to ensuring that the Convention fulfils its mission and meets the future challenges, taking into account the ever-increasing pace of change and technological advancements made since 1974. This paper considers that a Goal-Based-Safety Level approach will provide the key to success and discusses the possibility to take a holistic approach to build a far reaching Convention that will help the stakeholders who deal with these regulations to be more effective.

NOMENCLATURE

SOLAS International Convention for the Safety of Life at Sea is an international maritime safety treaty. It ensures that ships flagged by signatory States comply with minimum safety standards in construction, equipment and operation.

FSA Formal Safety Assessment is a structured and systematic methodology, aimed at enhancing maritime safety, including protection of life, health, the marine environment and property, by using risk analysis and cost-benefit assessment.

GBS Goal Based Standards 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.

SLA Safety Level Approach is the structured application of risk-based methodologies for the IMO rule-making process.

ALARP As Low As Reasonably Practicable; refers to a level of risk that is neither negligibly low nor intolerable high. ALARP is actually the attribute of a risk, for which further investment of resources for risk reduction is not justifiable. The principle of ALARP is employed for the risk assessment procedure. Risks should be As Low As Reasonably Practicable. It means that accidental events whose risks fall within this region have to be reduced unless there is a disproportionate cost to the benefits obtained.

ISM Code International ships management Code is an IMO instrument which provides an international standard for the safe management and operation of ships and for pollution prevention expressed in broad terms so that it can have a widespread application. In this instrument different levels of management, will require varying levels of knowledge and awareness for the compliance of the requirements.

ISO International Organization for Standardization.

GBSLA Goal Based Safety Level approach, currently named GBS-SLA at IMO is the combination of Goal Based Standard philosophy and Safety Level Approach developing a framework to develop rules and requirements based on High level goals and Functional requirements.

GBSLA Goal Based Safety Level approach regulation is a regulation or requirement derived from the systematic application of the Goal Based Safety Level approach.

1. INTRODUCTION

SOLAS is basically a prescriptive instrument adopted following the aftermath of the Titanic and subsequently amended as a consequence of other incidents. Its current form has been in place for more than 40 years and establishes the minimum safety requirements on board the ships and companies for different safety and security matters. It has contributed to establish a common playing field for flags and ship owners through its implementation by Maritime Administrations and Recognized Organizations. SOLAS is amended as necessary and the regulations tell you "what to do", therefore compliance is achieved once the applicable chapters are met, but not in a holistic manner.

SOLAS has become more difficult to use, interpret and amend through the years. As an example *"Safe Return to Port"*[1] , applicable on or over 120 m in length, connects multiple aspects such as structural fire protection, stability, machinery availability and emergency management. This concept requires designing and operating intertwined systems, subsystems, procedures and human element in the ship. Regulations are still being adopted or amended to accommodate and interpret its requirements after the entry into force in 2010. Another example is the limitation within regulations with

[1] SOLAS II-2/regulation 21

regards to the use of materials other than steel[2] for ship construction and equipment.

Some stakeholders argue that there´s a necessity to change its structure in order to gain in clarity and be prepared for the technical challenges ahead, in particular, with regards to ship design and construction.

Flexibility is provided by the regulations on alternative design and arrangements [1], but the use of more safety assessment and risk assessment techniques [2] in framing rule based regulations is being used with increased frequency. In this approach the future of the Convention may lie.

In response to the needs of the society there is also a need that the IMO strategic directions to follow ensure that the trends, developments and challenges of the maritime sector are addressed and that the long term and short term outcomes (number of lives saved with one particular regulation or instrument by the effective use of the instrument developed by the organisation) to be met are measurable with Performance Indicators. Looking at this issue just from safety of ships there is a need to obtain data or develop suitable models so that the safety measures applicable to ships and personnel developed at IMO are more substantiated.

2. ANALYSIS OF THE CURRENT SITUATION

2.1 THE CONVENTION

Since 1974 SOLAS has evolved quite significantly adding new chapters and additional Codes. Regulations refer to technical, operational or both technical and operational matters: ship´s construction, fire-protection and fire-fighting, life-saving, communications, navigation, safety management (through the ISM Code) and security.

Many of the chapters and amendments were adopted based on the principle of giving response to a marine incident after it has occurred and to prevent a similar accident from reoccurring. Sometimes they were based upon the results of the investigation committees or panel reviews and others based on providing an automated response for the evaluation of risk and the means to lower the acceptable risks by the stakeholders using technical judgement; however the solutions agreed may not be close to address the root causes of incidents.

2.2 LIMITATIONS IN THE CURRENT REGIME.

In general ship designers need to comply with the regime "as-is", with a large number of regulations to comply, in order that ships are certified. In this regard traditionally issues that have an impact in maritime safety, i.e. related to fire protection, lifesaving, marine engineering, naval architecture and other maritime disciplines are, in most circumstances, considered in isolation of each other and, after deliberations, prescriptive regulations are prepared on an add-on basis to address each specific area of safety. This tends to limit the flexibility of the designs and the use of innovative technologies.

From the legal point of view, the drafting process has increased in difficulty due to the different ramifications and the different approaches for each of the Chapters. Amending and implementing has also become a complicated task and regulations tend to contain paragraphs accepting equivalent arrangements.

In addition, it is not a simple exercise to assess with justified figures whether a regulation or a combination of regulations have been cost effective since its application after the entry into force, or whether after the implementation these regulations fulfil the safety mission.

In order to tackle this, the following solutions were taken:

- SOLAS parts were extracted into Codes, but SOLAS has continued increasing in size.
- The use of International standards such as ISO, that contributed to lower the prescriptive requirements of the SOLAS Convention, more particularly in the associated Codes, but the standards are prescriptive in nature and might not always be able to address the regulatory requirements.
- SOLAS was not a framework that provided enough flexibility in the design of certain preventative or contingency measures in the ship and there has been reluctance by flags to accept equivalent arrangements as per SOLAS regulation I/5. Consequently, the concept of Alternative Design and Arrangements was introduced [3][4][5].This has been extensively used in the cruise industry.
- While the most fundamental Convention on Marine Safety is based on a prescriptive set of regulations Maritime Administrations had to develop alternatives to frame their own regulations, either by state or national governments, as SOLAS doesn´t provide the ground to apply the best possible technologies. Navies [6] are also using risk based approaches [7] to safety different to prescriptive regulations.

2.3. THE HOLISTIC APPROACH

The solutions indicated above didn´t help to make SOLAS an instrument that considers the ship as an interrelated set of systems where the human element has a primary role. It is difficult to assess the complete integration of the safety concept in one ship and to evaluate safety as a whole, due to its many regulations to apply referring to different safety aspects.

[2] SOLAS Chapter II-2/regulation 3.

It can also be argued that the stakeholders, including those who implement or enforce the regulations, may have a holistic approach to safety, but in any case, due to legal and administrative processes, the minimum requirements of SOLAS have to be met. A "partial holistic" approach is met somehow by a good implementation of the ISM Code, which can very easily assume risk assessment tools, but it is again restricted by the prescriptive approach of the regulations.

It can then be inferred that the current SOLAS is not of holistic nature in its intent to save lives and the property at sea.

3. TOOLS FOR A CHANGE IN THE CONVENTION

3.1 QUANTIFICATION AND DATA MINING

There is enough technology to deal with metadata. Knowledge is focussing more and more on data and its analysis. In order to gather a good data set these need to be mined, their reliability ascertained (with probability distributions) and assessed.

With regards to ship safety data are available from many different sources and ship owners possess an important piece of it but either for strategic, legal or confidentiality reasons, these are not readily shared.

In order to develop suitable rules and regulations or in order to measure whether the rules are effective data and data sharing are needed. In theory these data come from accidents, near misses, possible correlations in rule compliance statistics and port state control inspections, but they are not easy to be obtained due to the reasons indicated above even if IMO member states have committed themselves to provide them.

In view of the lack of data, there may be a need to feed this into analytical models, simulations and expert judgement to complete the data set, and this is probably a must do to assess maritime safety. The formal safety assessment (FSA) tool encompasses the use of databases to draw conclusions and elaborate risks models.

3.2 FORMAL SAFETY ASSESSMENT

At MSC 66, IMO agreed to a new proactive approach to develop regulations before disasters occur. This approach is known as formal safety assessment (FSA) [8], as outlined in Figure 1. This tool evaluates new regulations and helps to compare proposed changes with existing standards, enabling a balance to be drawn between the various technical and operational issues, including the human element, and between safety and costs. FSA defines recommendations, known as risk control options, which should be presented to the decision-makers in an auditable and traceable manner. These recommendations are based upon:

- the comparison and ranking of all hazards and their underlying causes;
- the comparison and ranking of risk control options as a function of associated costs and benefits; and
- the identification of those risk control options which keep risks as low as reasonably practicable.

Since MSC 66, the FSA approach has been extensively used with a relative success for the main ship types, with models mainly focused on scenarios with fault and event trees, relating causes to consequences, as it has helped IMO Members States to consider the necessity of new or amended regulations.

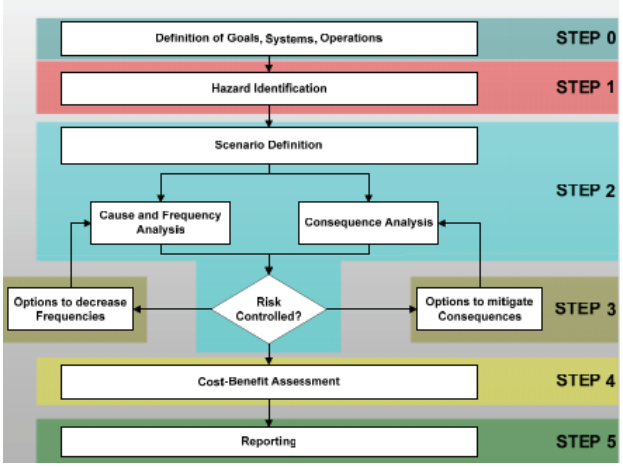

Figure 1. FSA step approach [9]

However, this risk-based approach for SOLAS has some challenges, such as:

- the quality and quantity of the data collected in order to support monitoring and development of safety regulations;
- the integration of risk-based methodologies and the latest analysis techniques into the safety regulatory framework to provide a sound scientific and practicable basis for the development of future safety regulations; and
- the know-how required to use these tools versus the traditional approach to propose new rules or amend new rules with justifications that are not required to contain detailed documented rationales, basis for assumptions, description of uncertainties or sensitivity analysis.

3.3 GOAL BASED STANDARDS

Following the development and adoption of the prescriptive Goal Based Standards (GBS) for the construction of oil tankers and bulk carriers in 2007, so that the rules of Recognized Organizations conform certain goals and functional requirements, it was considered that the framework could also be used in a more generic manner in the development of rules and regulations.

GBS is a "top-bottom" concept that offers a tiered approach, "rules to develop rules", working with the following principles [10]:

- Tier I- Goal, which is a high level objective to be met that should address an issue of concern;
- Tier II- Functional Requirements, which provide the criteria to be complied in order to meet the goals and are developed after the goals and considering the relevant hazards;
- Tier III- Verification of Conformity, which provides a transparent instrument necessary for monitoring and verifying that the associated rules and regulation for ships conform the goals and functional requirements.
- Tier IV- Rules and regulations for ships, which are the detailed requirements (developed by IMO, a national administration, a Recognized Organization or a classification society) and applied by them that need to meet the goals and functional requirements
- Tier V- Industry practices and standards, developed as a consequence that may be referenced in the rules and regulations.

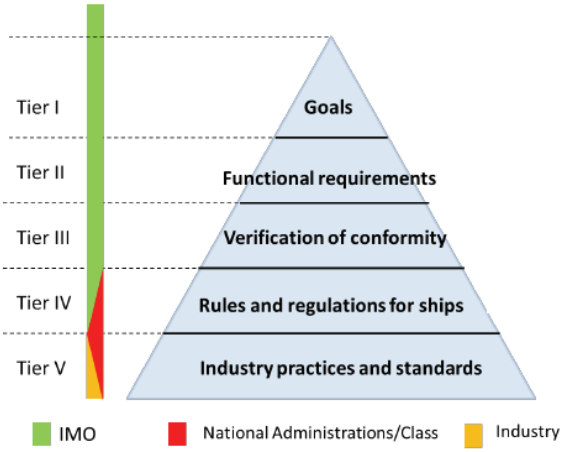

Figure 2: Goal Based Standard tiered structure (Data source: IMO)

See Figure 2 for further clarification of the structure.

Originally the idea to establish functional requirements was used in the latest revision of Chapter SOLAS II-2 on Construction - Fire Protection, Fire Detection and Fire Extinction. Later, the idea to use some parts of this structure, through a Goal Based approach, in particular the use of the concepts of Tier I and II exclusively, has been applied in the development of IMO instruments such as the IGF Code and the Polar Code:

- with the aim to provide more clarity and, in addition;
- to be able to provide a possible flexibility in order to comply with these functional requirements by means of risk management tools; but
- without a pre-established agreed criteria in their definition; and
- following a "bottom-up" approach that makes the functional requirement self-limiting.

Notwithstanding the above, the GBS structure is logic and may be used to restructure the SOLAS Convention, through the achievement of high level goals and functional requirements, instead of achievement of very specific and prescriptive requirements.

3.4 SAFETY LEVEL APPROACH

The concept of safety level approach (SLA) is the structured application of risk based methodologies to reach an explicit safety level or to verify compliance of rules. The aim is to have quantitative and rational safety levels to be able to be used and provide a way to measure safety in the ship concept and the human element in the IMO rule making process. This safety level can be adjusted when needed and the way to adjust it could *inter alia* be based on the cost criterion to implement measures; i.e. a higher safety level would allow more costly measures.

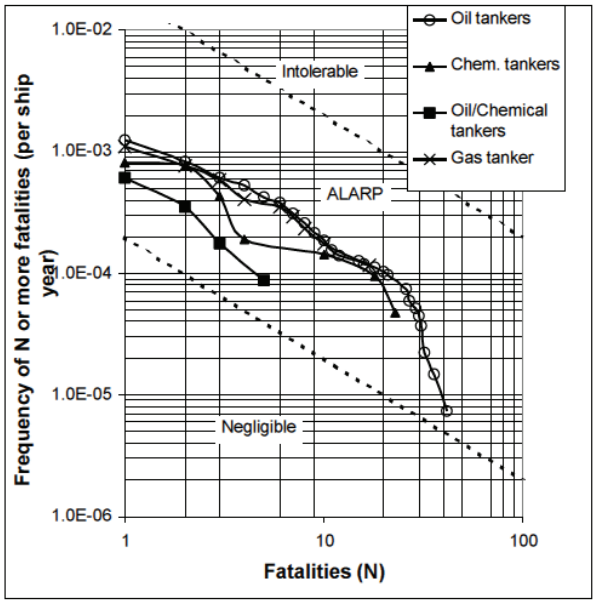

Figure 3: FN curves for bulk and ore carriers, and container vessels, shown together with risk acceptance criteria established by the above outlined method. Data from 1978-1998. (Data source: LMIS)

This approach needs the development of quantitative or qualitative safety levels and processes to be used for achieving a practicable safety level, or an implicit safety level such as that in the ALARP principle [11] with F-N curves (societal risk), as per Figure 3. By doing this IMO could revise and adjust the safety level as needed when this is not sufficient or it is overestimated.

4. THE COMBINATION OF TOOLS IN REGULATION DEVELOPMENT MECHANISM: RISK ANALYSIS, HAZARD IDENTIFICATION, FSA, GBS, SLA

In order to take one step further and be able to work with sound data, to provide flexibility and to have a sound framework there might be many possible solutions but the one that seems to be more promising is the development of what it could be known as Goal Based - Safety level approach (GBSLA) [12].

Casualty data and risk models (with sensitivity analysis incorporated) would serve as an input, that used in combination with risk analysis techniques hazard identification techniques, such as those used in FSA, would help to develop goals with sufficient safety level. Should the safety level not be sufficient or the level of risk too high this could be enhanced depending on factors such as the societal willingness to pay for reduced risk, or the societal willingness to accept increased risks. A combination of the three elements can be seen in Figure 4.

Following the development of goals, either qualitative or quantitative, functional requirements would be established taking into consideration the relevant hazards that are needed to be covered to meet the goal, a suitable degree of hierarchy and lack of ambiguity.

The above two elements, in particular the functional requirements, are the most difficult to determine. These have to be related to functions (e.g. stability and buoyancy) that need to be defined. For each of the functions acceptance criteria is needed and this criteria needs to be established. These criteria will focus on requirements such as reliability, availability, maintainability [13]. Therefore a functional requirement requires one or more functions to reach a goal with requirements and their thresholds.

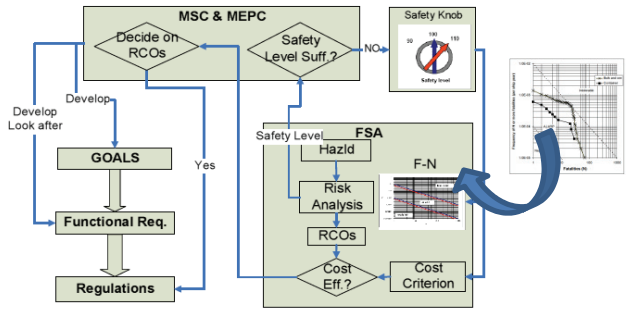

Figure 4: The combination of risk analysis, hazard identification, FSA, GBS and SLA (source IMO) [12]

The rest of the tiered approach would be more simple to establish, taking into consideration that the verification of conformity would need to be able to use risk analysis (probably the same one used during the development of goals and functional requirements) to verify that the rules or regulations developed, the GBSLA rules, can comply with the functional requirements. The connection between the functional requirement and the rule or regulation, if developed, would be done with agreed methodologies.

With regards to the use of FSA in the safety level approach it has to be considered that FSA is evaluated by comparison to other industries and the safety level of the current IMO provisions is implicit. The use of safety level approach will oblige to decide whether to compare to other industries or develop a specific maritime safety level.

Finally, when considering the application of a holistic approach this could require an integrated approach to the ship which would define a procedure for the risk-based evaluation of the needed safety level, in this regard the models could be more complex.

5. NEW SOLAS CONVENTION

With all the above there are elements to develop a new SOLAS Convention, but one of the questions is how the SOLAS of the future should look like.

A new SOLAS could have *inter alia* different approaches in its architecture as a Convention:

- there is no need to develop rules and regulations in the future if the goals and functional requirement (as incorporated) can be met with risk analysis techniques. Technical or operational solutions addressing the functional requirements would then be proposed, approved and implemented on board; or
- the rules and regulations are developed within a framework taken into account the tiered approach indicated above; or
- a mixed approach, depending of the chapters and type of regulation or rules contemplated.

With regards to the first architecture it can be argued that there wouldn't be a need to be prescriptive at all: quantifiable goals and functional requirements would suffice. This would lead to a SOLAS Convention with just a set of goals and functional requirements that would take SOLAS to a higher level, as outlined in Figure 5. This could be one of the SOLAS of the future: simple set of goals and quantifiable functional requirements with a description, a rationale and expected performance. The safety level would work as a "knob". The level would increase or decrease depending on the performance in terms of safety. In this particular case, the monitoring of the compliance with functional requirements would require risk assessments to conform the goals and functional requirements. This could be a SOLAS with a tool derived from alternative design arrangements and/or FSA that would provide full flexibility for designers. SOLAS could become a framework, a "high level" principles convention.

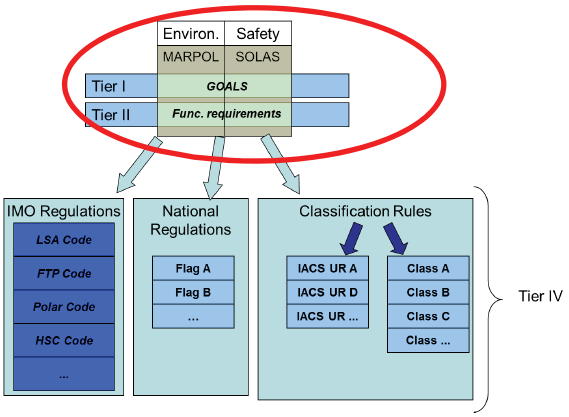

Figure 5: "High level" SOLAS and MARPOL with no regulations (Source IMO).

With regards to the second approach, the GBSLA would be the framework that would monitor how SOLAS develops consistently. The SOLAS Convention would contain a set of goals and functional requirements and, in addition, a regulation set derived from these functional requirements. There would be a "high level" SOLAS and a "low level" SOLAS (or better Codes under SOLAS), with GBSLA regulations, rules and requirements which would address the detailed requirements provided now (the current prescriptive regulations). In order to develop these regulations, IMO Member States would have to use in different stages FSAs. Rules and regulations would be derived from the complete application of FSAs, through risk control options that are cost effective in accordance to FSA Techniques and agreed at the Committees. Thereafter, the regulations at IMO would be verified as conforming and those rules coming from Recognized Organizations or national administrations monitored by IMO or by the national administration itself.

It could be foreseen that some ship designs could take full advantage of the flexibility provided by the high level SOLAS while others, such as small ships with no-special added value or built in small series, would just have to follow the GBSLA regulation.

5.1 GRANDFATHERING SOLAS AND USING THE CURRENT CONVENTION AS A BASIS

Changes in the safety regimes do not necessarily mean that ships have to be phased out. The denunciation of SOLAS 60 with the ratification of SOLAS 74 in its article VI *"prior treaties"* left a number of ships constructed under an old regulatory regime with difficulties to incorporate SOLAS 1974. The issue of the potential need to upgrade these ships was solved with the classical approach "*up to the administration*" providing some leeway for the stakeholders. Nowadays, while amending SOLAS, grandfathering is often used in order not to impact on existing ships. It is also generally agreed that the existing regulations have the same "safety level" as the new ones (as it happened in stability criteria SOLAS 90 and A.265 (VIII) vs SOLAS 2009, both granting the ships with the same safety level). This simplistic approach to safety levels can be avoided in a new SOLAS.

A potential new SOLAS, with a new regime, would also include the previous safety regime. In the new regime, the useful lessons learnt in the past that lead to the current SOLAS 1974 would be needed to establish the safety level using FSA techniques, following a "bottom-up" approach, instead of taking for granted that the safety level is the same. This process would allow IMO to do a sound grandfathering in which the current SOLAS is the underpinning foundation. This needs to be done carefully, as the safety level will not be static in the future, but will change depending on the risks perceived by the members and non-governmental organisations.

This "bottom-up" approach, considering the current SOLAS as the base, would also affect the development of goals and functional requirements. In this case a step approach would be needed taking into account *inter alia* hazard identification. However the exercise of trying to match the current regulations with the potential functional requirements may limit the functional requirements themselves, as current regulations could partially or fully cover one or some functional requirements, and the rule development could have responded to non-clear mechanisms. If the current SOLAS chapters and structure, that mixes technical and operational requirements, was followed functional requirement run the risk of being self-limiting and dependent of the current technical solutions and of external conditions.

5.2 A HOLISTIC OUTLINE OF THE CONVENTION

Thinking about the future, considering what to do with the current regulations after the safety level is established, many different approaches can be followed, but should the intention be to become a long lasting and innovative convention a clear mind approach should be taken.

There can be many different approaches, not incompatible among each other, based on GBSLA.

A more conservative, more step wise:

- restructuring each of the chapters adding goals and functional requirements (that would be incompatible with existing functional requirements provided in some of the chapters such as II-2 and IV). In this approach SOLAS would also need a detailed methodology to harmonize among chapters (similar to alternative design regulations in a goal based framework);
- without even amending the articles and the chapter I *"General Provisions"*(applicability, regime of inspection and certification); and

- with each chapter containing prescriptive regulations, which initially would be the current rules, or adopting new Codes (ship specific or Chapter specific) to make the convention lighter. New regulations/requirements would progressively be added by means of risk control options, when FSAs have been carried out.

With this, in the short term, the Convention would remain the same but with the above mentioned addition of goals and functional requirements that would later be the basis for the regulation development, when needed.

A more far-reaching approach by reviewing the whole convention could be as follows:

- chapters dealing with the verification of compliance and its assurance can merge in one. This means that a new Chapter I, general provisions, can be a combination of the inspection and certification, management for the Safe Operation of Ships, Special measures to enhance maritime safety and the mandatory audit scheme for member states. As safety can be defined and quantified (or qualified) the same can be applied to the inspection of ships. Ships can have a risk profile and therefore the flag state inspection regime could be tailored and reduced. That could also include inspections addressing the root causes when the ship owner hasn´t covered it through internal inspections [14].
- specific regulations may be needed for data collection and modeling, including elements of special measures to enhance maritime safety (investigation of marine casualties and incidents),in response to the need for improvement of data collection and increase its availability and establish an approved methodology for novel concepts. This would support the monitoring and development of safety regulations and provide sound scientific and practicable basis for the development of future safety regulations;
- chapters dealing with the design of the ship[3]could merge based on the holistic approach. They could also contain the functional requirements related to the technical elements of other chapters (e.g. Carriage of cargoes and Carriage of dangerous goods) and could include the Load lines Convention, elements of the COLREG and alternative design and arrangements in order to provide a framework to avoid the prescriptive requirements; and
- those chapters dealing with the human element and its integration on the ship could also merge in one. This would need to consider ways of encouraging a safety culture beyond mere compliance with regulatory requirements and take into account the burden any new or changing regulation(s) place on the seafarers and how this burden can be minimized[4].

As a new safety regime should tend to be more holistic fewer chapters would be needed and the current prescriptive regulations might be merged in Codes or left as is.

5.3. DEALING WITH STAKEHOLDERS

The decision to go in one direction or the other would depend upon the views expressed by the member states and non-governmental organizations and the possibilities of success for each of the directions. This is conditioned, *inter alia*, by:

- The real need to have access to more flexible designs, and effectively implement new technologies for ship owners, designers and shipyards. The current convention doesn´t encourage new designs;
- The interest to be really holistic in a Convention versus the need to comply with numerous regulations that might not had been sufficiently justified;
- Developing nations and member states without the necessary resources to implement a new SOLAS. The new safety regime has to take into consideration member states with no resources to fully implement SOLAS. For all those a prescriptive approach will be the way to provide a means for compliance if there is limited access to the use of risk based tools, such as FSAs.
- Whether insurance companies and financial stakeholders and charterers are ready to accept such approaches and whether legal aspects can also be suitably covered.
- The effective enforcement by Flag Administrations and verification by Port State Control Officers. A series of documents approved with risk assessments and an inventory in a ship construction file would be the element to judge why the ship isn´t complying with prescriptive regulations. This would add an administrative burden for the Flag Administrations.

With regards to the future use of risk assessment techniques and how they affect stakeholders there are different issues to discuss:

- How the different societal willingness to accept the risks is managed by the stakeholders to establish a common playing field. The perception of risk is not similar for all member states, but SOLAS has been built by countries with a common and tactility agreed acceptable risks.

[3] Chapters II-1, II-2, III, VIII, X, XII and XIV.

[4] It could contain the operational measures of chapters II-2, III, VI, VII, etc… and particularly IX, XI-1, IV and V.

- How SOLAS can be designed so that it can be understood by all members. In this regard the current SOLAS is mostly prescriptive and all member states know the minimum requirements to achieve. Many member states could not be ready to have a risk based approach and would stick to prescriptive requirements. This is why the GBSLA framework with GBSLA regulations seems more achievable than a higher level SOLAS.
- How new SOLAS would have to be in order that there no differences between those who have technology and those who don´t. A new regime in a new convention would open the debate for the inclusion of technology transfer similarly to Annex VI of the MARPOL Convention.

6. CONCLUSIONS

In order to face innovation and new technologies SOLAS needs to change its current format.

Naval architects and Marine Engineers need more flexibility in the design of complex ships to adapt to the demand and be able to design without sometimes unjustified limitations.

Ship owners should not be limited by the current framework. SOLAS should not be a burden for the technologies and an administrative burden by itself.

The combination of GBSLA, instrumented with FSA techniques, provide the necessary framework for an updated SOLAS Convention. In establishing this structure well developed goals and functional requirements and a common understanding on the risk models and FSA tools are the base of the success of this approach that will allow to develop GBSLA rules.

Noting that changes might need to be taken step by step, a "far-reaching" SOLAS, that grandfathers the current SOLAS, should be a goal by itself.

In order to achieve a far reaching SOLAS it is necessary to combine a "top-bottom" and a "bottom-up" approach so that the new instrument lasts in time and is not just a structure for the current regulations.

All stakeholders would need to agree and understand the processes involved in a "far-reaching" Convention taking into consideration the tools that will be needed to develop future regulations or to design future ships.

7. ACKNOWLEDGEMENTS

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