STATUS AT IMO: WHERE ARE WE HEADING WITH GOAL-BASED STANDARDS?

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SUMMARY

The various ongoing activities regarding goal-based standards at IMO are summarized. At present there are two parallel tracks for the further development. One short-term track aiming at developing goal-based standards for new ship construction for bulk carriers and oil tankers. These are formulated as overall goals and functional requirements that classification society rules together with technical requirements by IMO and the flag administration shall fulfil. One crucial part is the verification of rules and at present a pilot project is running where the draft verification framework developed so far, is tested on IACS Common Structural Rules. The second track denoted "safety level approach" aims at extending goal-based standards in the long-term also to other areas in a holistic way in order to facilitate the development of rules and regulations targeting safety rather than technical details. This could be a future general structure for more rational and transparent IMO requirements supported by the FSA methodology.

1. INTRODUCTION

Goal-based standards (GBS) have been on the Maritime Safety Committee (MSC) agenda since the 78th session in 2004. The term has already been established and is starting to get caught to the ongoing discussion regarding different development of standards, rules and regulations for the maritime industry. However, a unified view on what GBS are, or will be, is still not settled and there seem to be as many interpretations of the term as there are interpreters. This presentation is in this respect no exception. Based on a review of the discussion so far, it outlines some possible further steps towards a more consolidated regulatory structure under IMO.

2. BACKGROUND TO GOAL-BASED STANDARDS IN IMO

Following previous discussions at IMO regarding the need for higher unified structural standards for the new-building of ships, the first concrete proposal in the direction of goal-based standards was put forward by Bahamas and Greece in October 2002 to the 89th session of the IMO Council in the context of developing the IMO Strategic Plan [1]. The submission argues that "To remove the possibility of competition between Classification Societies in the quality of the construction of ships, IMO should develop initial standards that will permit innovation in design but ensure that ships are constructed in such a manner that, if properly maintained, they can remain safe for their economic life."

After an extensive debate at MSC 77 which incorporated representatives from Administrations, ship owners, shipbuilders and classification societies, it was agreed that a new item on "Goal-based new ship construction standards" should be included in the agenda for MSC 78 [2]. This was finally confirmed by the IMO Assembly in December 2003 in the strategic plan for the period up to 2010, where in the context of developing and maintaining a comprehensive framework for safe, secure, efficient and environmentally sound shipping it was decided that "IMO will establish goal-based standards for the design and construction of new ships" [3]. Goal-based new ship construction standards was also included as a high-priority item for MSC in the long-term work plan [4].

In a joint submission by the Bahamas, Greece and IACS to MSC 78, a five-tier system for GBS was proposed according to figure 1.

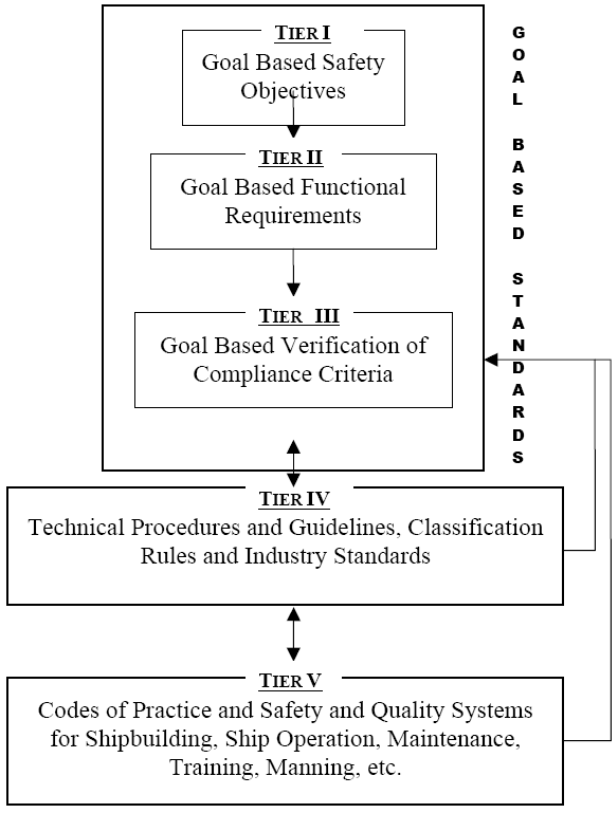

Figure 1: Proposed goal-based regulatory framework, [5].

At the MSC 78 there was general agreement on using this submission as the basis for the further development

of GBS at MSC 79. Furthermore, the need for setting acceptable levels of risk was discussed, and it was also argued by some delegations that the IMO standards should be seen as a new working method and not be too prescriptive but allow for a continuous development of the lower tier standards [6].

To MSC 79, the MSC Chairman put forward ten critical questions for further consideration [7]. These included *inter alia* questions on to what extent GBS should be prescriptive, whether the GBS approach should be extended also to other safety issues besides the hull structure, if Tier II should include specific quantitative acceptance criteria and how to perform the verification of classification rules and other standards.

During MSC 79 and MSC 80 there was an extensive debate between those who were in favour of developing a more open risk-based approach that could be applied holistically and those who thought it would be premature at this stage and would prolong the finalization of the most compelling need, i.e. GBS for ship hull construction. In order to make the risk-based approach more clear the delegations supporting this were invited to submit documents to MSC 81 further describing how this could be developed and especially how the current safety level inherent in IMO instruments could be determined. In spite of these different views, MSC agreed on the following basic principles for GBS [8]:

IMO goal-based standards are:

- broad, over-arching safety, environmental and/or security standards that ships are required to meet during their lifecycle;
- the required level to be achieved by the requirements applied by classification societies and other recognized organizations, Administrations and IMO;
- clear, demonstrable, verifiable, long-standing, implementable and achievable, irrespective of ship design and technology; and
- specific enough in order not to be open to differing interpretations.

Several submissions on risk-based methodology and on the linkage between Formal Safety Assessment (FSA) and GBS were sent to MSC 81 in May 2006. In conjunction with the meeting, Denmark, Germany, Japan, Norway, Sweden and the United Kingdom also arranged an open workshop to promote the understanding of the "safety level approach" (risk-based approach) [9]. Considering all these submissions and after an extensive debate, MSC 81 agreed to work on the prescriptive approach and the safety level approach in parallel, namely to continue with the development of GBS for bulk carriers and oil tankers, based on the work done so far on the subject, with a view to finalization at MSC 83; and also to work on GBS based on the safety level approach [10].

The present status of these two parallel tracks is summarized in the following.

3. GOAL–BASED STANDARDS FOR NEW SHIP CONSTRUCTION FOR BULK CARRIERS AND OIL TANKERS

This track is in general considered as the first step towards GBS, and presently only addresses rules for the hull structure of these specific ship types. This may be a good starting point since SOLAS Ch. II-1 Part A-1 today only refers to the requirements of classification societies recognized by the flag state administration without setting any top-level goals. The few additional SOLAS regulations concerning structural design of ships are also specifically directed towards bulk carriers and tankers.

3.1 THE FIVE TIER SYSTEM

The Tier system has so far remained more or less as the original proposal in figure 1, except that Tier I has been renamed to *Goals* and that Tier IV also is understood to incorporate technical requirements, guidelines and procedures developed by IMO in order to meet the goals and functional requirements in Tier I and Tier II.

Tier I, Goals, has in principle been agreed applicable to all types of new ships according to the following [8]:

"Ships are to be designed and constructed for a specified design life to be safe and environmentally friendly, when properly operated and maintained under the specified operating and environmental conditions, in intact and specified damage conditions, throughout their life.

.1 Safe and environmentally friendly means that the ship shall have adequate strength, integrity and stability to minimize the risk of loss of the ship or pollution to the marine environment due to structural failure, including collapse, resulting in flooding or loss of watertight integrity.

.2 Environmentally friendly also includes the ship being constructed of materials for environmentally acceptable dismantling and recycling.

.3 Safety also includes the ship's structure being arranged to provide for safe access, escape, inspection and proper maintenance.

.4 Specified operating and environmental conditions are defined by the operating area for the ship throughout its life and cover the conditions, including intermediate conditions, arising from cargo and ballast operations in port, waterways and at sea.

.5 Specified design life is the nominal period that the ship is assumed to be exposed to operating and/or environmental conditions and/or the corrosive environment and is used for selecting appropriate

ship design parameters. However, the ship's actual service life may be longer or shorter depending on the actual operating conditions and maintenance of the ship throughout its life cycle."

Tier II, Functional requirements, are at present formulated under the following four headings and 15 subheadings, all referring to requirements at the new-building stage [11]:

DESIGN
II.1 Design life
II.2 Environmental conditions
II.3 Structural strength
II.4 Fatigue life
II.5 Residual strength
II.6 Protection against corrosion
II.7 Structural redundancy
II.8 Watertight and weathertight integrity
II.9 Human element considerations
II.10 Design transparency

CONSTRUCTION
II.11 Construction quality procedures
II.12 Survey

IN-SERVICE CONSIDERATIONS
II.13 Survey and maintenance
II.14 Structural accessibility

RECYCLING CONSIDERATIONS
II.15 Recycling

Tier III, Verification of Compliance, has shown to be the most difficult to finalize and so far only rules developed by the classification societies have been considered. In general it is understood that the verification of class rules should be done by an independent group of experts under the auspices of MSC and that those who request their rules to be verified should provide relevant background information and documentation in order to prove compliance with the functional requirements. The critical part will be to establish acceptance criteria and a reasonable level of depth for the work of the group of experts considering the huge amount of research and in-service data put into the rule development by the major classification societies. The verification process of class rules has been outlined according to figure 2.

In order to facilitate the development of the verification process, MSC 82 decided to launch a pilot project to conduct a trial of the proposed Tier III evaluation process on IACS CSR (Common Structural Rules) for oil tankers and bulk carriers. The pilot project can be seen as a mock-up of the future group of experts but the purpose at this stage is not to evaluate the CSR but rather the process itself including necessary documentation and information needed, criteria for the evaluation and criteria for the nomination of members to participate in the future IMO group of experts. The pilot project is now running and is requested to submit a report to MSC 83. In the documentation package submitted to the pilot project by IACS, they have made a self assessment of the extent to which CSR meet each of the Tier II functional requirements.

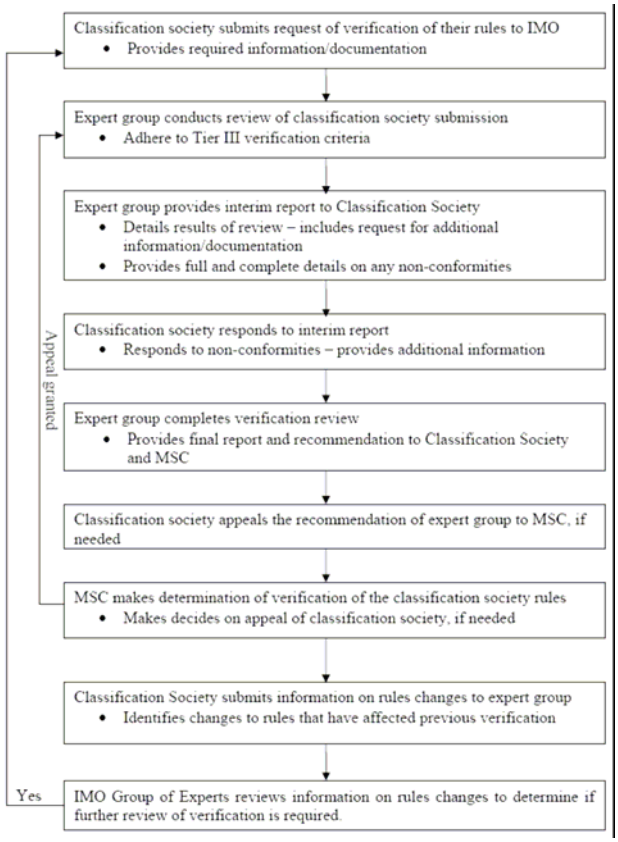

Figure 2: Verification process for class rules, [12].

3.2 SOLAS AMENDMENTS AND REQUIREMENTS FOR A SHIP CONSTRUCTION FILE

In parallel to the trial verification, a correspondence group has been established to monitor the pilot project and to develop draft SOLAS amendments for goal-based standards for new ship construction for bulk carriers and oil tankers. The idea is to include Tier I in the SOLAS regulations while Tier II and Tier III could be included in a separate mandatory Code or resolution.

While GBS in general are considered to be rules for rules, there will in addition be separate SOLAS requirements for a Ship Construction File (SCF) to follow an individual ship through its lifetime. It includes explicit information on how that specific ship has been designed in order to meet the functional requirements.

4. GOAL-BASED STANDARDS BASED ON THE SAFETY LEVEL APPROACH

The so called safety level approach has no well defined structure yet. It was first introduced at MSC 81 as a collective term by those who supported more holistic and less prescriptive GBS. The approach was in general supported by MSC for the long-term development, but this support encompassed different views on what to be achieved. These possibly were spanning from general views that IMO primarily should focus on establishing functional requirements and monitor the overall safety of ships rather than develop detailed technical requirements, to those who promoted detailed target safety levels (or risk acceptance) to be developed for all kind of hazards. Several delegates also expressed their concern that even to evaluate the current safety level incorporated in the present regulations would be an enormous task. Others pointed out that risk-based high-level standards already exist in many other fields such as for offshore and land-based construction and have proven to be successful with methodology and tools already available. A generic worked example of the safety level approach submitted by Germany has been suggested as a basis for the further consideration of the tier structure [13].

It was understood that the objective for the safety level approach was to develop goal-based standards for the design and construction of new ships of all types. MSC 81 agreed on the following list of items that needed to be considered [10]:

- to develop risk model, considering, inter alia, such factors as assumptions, models, scatter diagrams, random variables and their probability distributions, failure scenarios and terminology;
- to develop goal-based standards guidelines;
- to determine the current safety level in a holistic high-level manner and determine the relationship between the different design measures, e.g., structure, stability, manoeuvrability, fire protection, etc.;
- to examine and reconsider the five-tier system and, if needed, adapt appropriately to develop a structure suitable for the safety level approach;
- to examine and, if appropriate, modify Tier I and Tier II as developed for oil tankers and bulk carriers for use in the safety level approach;
- to consider the relationship between overall failure of the ship and the contribution of individual failure modes; and
- to further develop and refine the long-range work plan.

A separate correspondence group for the safety level approach was also established for the first time at MSC 81. In its report to MSC 82, information from different sources on the current level of safety of ships was presented and it was noted that there is need for a common agreed systematic process for comparing and reviewing such information at the IMO level.

A comprehensive submission to the correspondence group was delivered by IACS based on DNV analysis of Lloyd's casualty database. It presented annual accident frequency and individual risk based on accident data for the period 1990-2003 for 16 generic ship types.

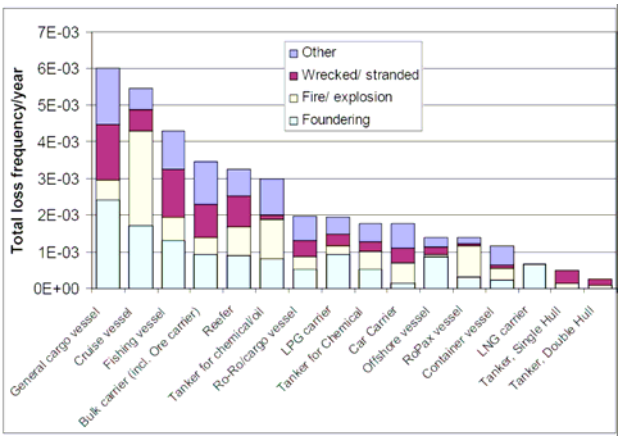

Figure 3: Total loss frequency for different ship types, [14].

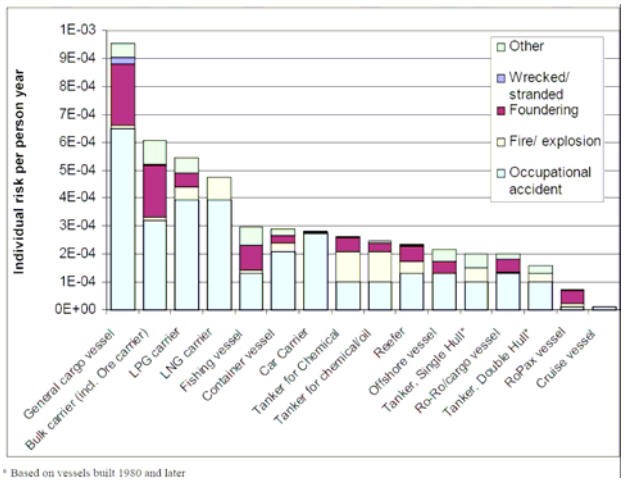

Figure 4: Individual risk on different ship types, [14].

A comparison of the individual risk given in figure 4 with general risk acceptance criteria is presented in figure 5.

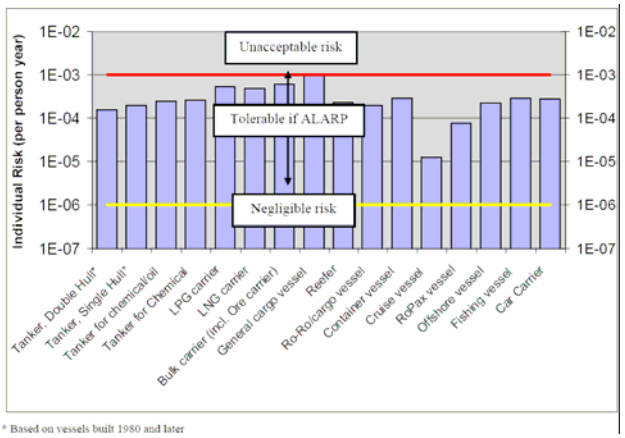

Figure 5: Individual risk on different ship types, [14].

The statistics gives clear indication of two critical areas. First it is noted that general cargo ships show a high risk level both in terms of total loss of the ship and in terms of fatalities to individuals on board. A second observation is that occupational accidents are by far the dominating category for fatalities on most types of ships. Both of these critical areas were noted and discussed at MSC 82 based on other submissions. It was decided to include a new substantive item on "General cargo ship safety" in the provisional agenda for MSC 83 and it was decided to include "Human element considerations" (ergonomic design) as a separate functional requirement in Tier II within the ongoing development of GBS for oil tankers and bulk carriers.

There was not sufficient time at MSC 82 for a thorough discussion on GBS based on a safety level approach but a provisional long-term work plan was agreed with the following items [11]:

- determination of the current safety level in a holistic high-level manner divided by ship types in order to develop Tier I goals;
- consideration of the outcome of MSC's work on FSA, in particular concerning risk acceptance criteria, and including existing FSA studies, for use in the development of the safety level approach;
- consideration of the tier structure so far agreed for GBS for oil tankers and bulk carriers for use in the safety level approach;
- examination and broadening of the Tier II functional requirements as developed for oil tankers and bulk carriers to other issues for use in the safety level approach;
- examination of risk models to consider the contribution from different design measures, e.g., structure, stability, manoeuvrability, fire protection, etc., and from human element and organizational structures;
- development of goal-based standard guidelines for the safety level approach, including development of a common terminology;
- consideration of the Tier III verification process.

The correspondence group will continue its work for MSC 83 and among the terms of reference it should consider the linkage between FSA and GBS and progress the development of GBS guidelines for the safety level approach. It is also worth noting that significant groups and projects outside of IMO presently are working on subjects directly related to the development of GBS for ships based on this approach; among these the International Ship & Offshore Structure Congress Technical Committee on Design Principles and Criteria (ISSC TC IV.1) [15], and the European SAFEDOR research project [16].

5. POSSIBLE FURTHER DEVELOPMENT OF GBS

There is in general support within IMO to reconsider the basic principles and structure of new regulations. In the Objectives of the Organization in the 2000s formulated by the Assembly [17] there are two specific items on the rule-making process in the directive to the Committees:

- to take measures to implement the proactive policy agreed in the 1990s more actively than in the past, so that trends which might adversely affect the safety of ships and those on board and/or the environment may be identified at the earliest feasible stage and action taken to avoid or mitigate such effects. In implementing this directive, Formal Safety Assessment should be used to the extent possible in any rule-making process;
- to focus their attention on … avoiding excessive regulation…

Although the work on goal-based standards emanated partly from other considerations, it falls well in line with these high-level objectives. There are also previous examples where more rational and structured rule-making have been applied. The revision of SOLAS Ch.II-2 concerning fire protection was finalized in 2000. It adopted an approach where safety objectives and functional requirements are formulated initially and where these are to be achieved either by compliance with the included prescriptive requirements or by alternative design and arrangements based on engineering analysis to be evaluated and approved by the Administration.

However, looking back at new regulations developed since 2000, many of those have still been developed as *ad hoc* reactions and not actually on the basis of FSA. Nor have they been fitted to an overall regulatory structure.

Regrettably, the debate regarding GBS has to a large extent been focused on whether regulations should be prescriptive or risk-based. Everyone is today aware of the fact that there is no such thing as absolute safety and therefore everyone should also be prepared to consider risks. Safety regulations are introduced to minimize the risks to a reasonable and acceptable level. Whether this is done by prescriptive requirements or by one-off direct risk analysis may not be the issue. The generic purpose of GBS is to define *what to be achieved* by the standards and *not how* it is achieved. It is difficult to see that there should be any conflict regarding this at the political high-level within IMO. On the contrary, it would facilitate the transparency and understanding to start from the top in the proactive rule-making process instead of starting from the technical details which, unfortunately, too often is the case still.

The verification of regulations, rules and standards aiming at fulfilling the goals and functional requirements is a different task and may be much more difficult. Especially if it is to be applied to existing regulations. The ongoing pilot project for GBS Tier III for bulk carriers and oil tankers will possibly give some further insight in how this may be executed. The costs and efforts can perhaps be justified for classification rules which have been enforced by IMO without any previous evaluation but it may be questioned whether this actually is the most effective effort considering other existing mandatory requirements. For new regulations and rules the situation is somewhat different since IMO already has pointed out that FSA should be used in rule-making to the extent possible.

5.1 THE LINKAGE BETWEEN FSA AND GBS

The linkage between FSA and GBS was discussed already at MSC 80 where the working group on FSA agreed that the FSA process, in general, could be used to [18]:

- conduct holistic assessments (e.g., ship types, whole system reviews, etc.) with a view to establishing the level of risk and set goals accordingly;
- identify and/or formulate high-level goals and functional requirements;
- support high-level goals to determine associated hazards and develop appropriate risk control options;
- assess specific issues (e.g., focus on diesel engine fires) to determine associated hazards and associated risks and develop appropriate risk control options;
- identify inherent safety levels in existing standards and, from that, make explicit the inherent risk acceptance criteria;
- verify compliance of regulations (e.g., classification society rules) with high-level goals and functional requirements; and
- find gaps in functional requirements.

Although these conclusions have not yet been elaborated in detail within the GBS development, it is quite obvious that there is a strong linkage, where GBS forms a rational structure and FSA a rational methodology. The purpose of FSA is to assess risks and identify the most effective risk control options. At a high-level, the first part, risk assessment, is also a necessity for defining the GBS functional requirements, and the second part may precisely be the needed verification that rules and regulations are effective to keep risk ALARP (As Low As Reasonable Practicable). Therefore the FSA methodology in general can be seen as fundamental for the development of requirements at different levels within a rational GBS structure.

Goal-based standards		**Formal Safety Assessment**
Tier I	**Goals** (overall safety level criteria)	
Tier II	**Functional requirements**	- Identification of hazards, leading to functional requirements - risk analysis, leading to balanced risk acceptance criteria
Tier III	Verification for approval	
Tier IV	**International regulations, rules and standards** (IMO, Class, ISO, ...)	- risk control options - cost benefit assessment - recommendations for decision-making
Tier V	**Local standards and procedures**	

Figure 6: Linkage between FSA and GBS.

5.2 STEPS AHEAD

The debate on GBS so far has a tendency to get stuck in a discussion on details of methods and criteria, and if continuing so, the task of developing a holistic and rational structure for regulations may seem to be unreachable. However, there may also be less dramatic steps forward that gradually will lead to a common understanding and a more transparent rule-making process. Such possible steps could be to:

- agree on a *generic structure for GBS* including top-level goals that can be applied to different areas of maritime safety and environmental protection;
- develop *general guidelines for rule-making procedures* to follow this GBS structure; initially these could be based on already existing guidelines and procedures for new working items, FSA etc. and gradually be further developed;
- formulate *functional requirements* for all new areas of regulation and for every considered revision of existing regulations. To a large extent these could probably be identified based on the present regulations, but where needed they should be further supported by more systematic hazard identification and risk analysis. The decided review of SOLAS Chapter III under the DE sub-committee could be a start of this;
- develop *procedures for monitoring casualty statistics and analysing risks* for ships and individuals based on the same hazards/functional requirements identified under the previous step. Such systematic monitoring could e.g. be used for guiding the IMO Committees in prioritizing new work items;
- require that all new or revised IMO regulations, as well as class rules and other mandatory standards, should be followed by a *commentary in an agreed format*, explicitly stating which functional requirements that are addressed, and the substantial basis for the regulation (risk analysis, cost-benefit).

If followed, these steps could lead to a more proactive, transparent and systematic way of rule-making without initially requiring any new methods nor any more hard figures or criteria than available today. Furthermore, they can been taken without any significant changes or

additions to the present working procedures and resources of IMO. They would gradually build up a firm framework under which different risk assessment methodologies may develop to support the process. Finally, at some point it could be considered timely to introduce this framework to all existing regulations and then it would facilitate more thorough and balanced risk-based regulations for the future.

6. CONCLUSIONS

IMO has many times in the history proven its ability to react on urgent matters emanated from accidents with ships. Through the last three years of work on GBS, IMO has also proven its determination to fulfil its objectives of a more proactive policy for the future.

GBS can be seen as a generic rational structure for international rules and regulations on maritime safety and environmental protection. By putting focus more on what to be achieved than on how, it will introduce a clear distinction between political decisions and technical solutions and add transparency to the regulatory framework.

The basic principles for GBS agreed at this stage are not locked to specific designs or technologies nor to specific rule formulations. Irrespective of whether lower tier regulations, rules or standards are formulated as probabilistic or deterministic, risk-based or prescriptive, their evaluation will always incorporate the judgement of risk and practicability. In the essence this is nothing new, it is what IMO has been doing all the time, although not always explicit and traceable. GBS may add the holistic structure that is needed and FSA will continue to be an important methodology for identifying and evaluating the necessary requirements.

7. ACKNOWLEDGEMENTS

Views expressed in this paper are those of the author and should not be construed to represent the views of the Swedish Maritime Safety Inspectorate nor the IMO working group on goal-based standards.

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