GOAL-BASED NEW SHIP CONSTRUCTION STANDARDS

Linkage between FSA and GBS

Submitted by the International Association of Classification Societies (IACS)

SUMMARY

Executive summary: This submission argues that FSA and GBS share common objectives, and both concepts have a natural place in a modern regulatory framework. The linkage between FSA and GBS is explained for each GBS tier and each step of FSA. References are made to document MSC 81/INF.6. Specific comments to the report of the FSA WG at MSC 80 may be found in the attached annex.

Action to be taken: Paragraph 13

Related documents: MSC 79/INF.5, MSC 81/INF.6, MSC 80/6/6, MSC 80/24, MSC 79/23, MSC 79/6/15, MSC 80/WP.9, MSC 80/WP.8, MSC 72/16

1 Both at MSC 79 and 80 there has been considerable debate relating to the understanding of the relation between GBS and FSA, and more specifically as concerning hull structures, to the relation between Structural Reliability Analysis (SRA) and GBS.

2 Generally, IACS is of the opinion that GBS and FSA share the same objective of establishing a rational and transparent basis of safeguarding and enhancing safety and protecting the marine environment. Other characteristics are also common. For example both GBS and FSA are structured and produce an output that is clear, auditable, transparent, etc.

3 Other characteristics differ. For example, FSA is focused on being a tool for developing rules and regulations following a holistic scientific method (objective, rational, etc.), whilst GBS is more focused on the structure and style of the regulatory system (state clear goals, state what to be achieved but not how to achieve it, long standing principles, independent of technology, etc.).
4 The table below shows terms used to describe FSA and GBS taken from various IMO documents and public presentations of the two approaches.

<table>
<thead>
<tr>
<th>Formal Safety Assessment</th>
<th>Goal-Based Standard</th>
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<tbody>
<tr>
<td>Structured</td>
<td>Repeatable</td>
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<tr>
<td>Systematic</td>
<td>Repeateable</td>
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<tr>
<td>Comprehensive</td>
<td>Defensible</td>
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<tr>
<td>Objective</td>
<td>Reliable</td>
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<tr>
<td>Rational</td>
<td>Robust</td>
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<tr>
<td>Auditable</td>
<td>State that shall be achieved</td>
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<tr>
<td></td>
<td>No method on how to achieve</td>
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<tr>
<td></td>
<td>Open for innovation</td>
</tr>
<tr>
<td></td>
<td>Ensure against sub-standard</td>
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<tr>
<td></td>
<td>Clear</td>
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<td></td>
<td>Demonstrable</td>
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<td>Long standing</td>
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<td></td>
<td>Adaptable</td>
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<td>Independent of technology</td>
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5 The two terms ‘goal-based’ and ‘risk-based’ describe two aspects of a modern regulatory framework. For example the National Energy Board of Canada uses the term ‘goal-oriented and risk-based’, the US Nuclear Regulatory Commission refer to their ideology as ‘risk-informed, performance-based’ and the UK Ministry of Defence refer to their regulations as ‘goal-based’. Other regulators use similar terminology.

6 A regulatory system based on the FSA will inevitably become goal-based, because the safety goals will be stated in terms of the risk evaluation criteria. Use of FSA also disclose implicit safety levels in current regulations and disclose the cost effectiveness of risk control options required by existing regulations as well as in new and proposed regulations, contributing to transparency. Examples can be found in all FSA studies submitted to IMO.

7 IACS is of the opinion that FSA and SRA may be used in conjunction with the current GBS as follows:

1. Tier I (Goals): In order to formulate/set the goals, the FSA steps 1 and 2 (‘Hazard identification’ and ‘Risk analysis’ including SRA) will be highly relevant. An FSA makes explicit current risk levels and this serves to establish realistic safety targets.

2. Tier II (Functional requirements): In this tier the FSA steps 2 and 3 (‘Risk analysis’ and ‘Identification of RCO’) may be applied, taking into account that only functional requirements are described in Tier II.

3. Tier III (Verification process): An FSA study could constitute the documentation to demonstrate that the prescriptive rules in Tier IV meet the goals. The review would therefore follow the FSA review process (MSC 80/WP.9), and the goal would be required to be set in terms of risk evaluation criteria. For structural GBS, an SRA would be the additional basis for verification, where appropriate, noting that for detail design requirements the driving criteria may be based on empirical relationships where good performance is justified by experience and in other cases may relate to e.g. workmanship. An example is provided in document MSC 81/INF.6.

8 In the goal-based standard resulting from MSC 80 (MSC 80/WP.8), the goals are not clearly associated with safety of passengers or crew or the protection of the maritime environment. The formulations mainly focus on ship safety, referring to issues like the design and fatigue life of the ship. Such issues may obviously be dealt with by using the FSA and SRA.
approaches too. However, FSA applications have so far primarily focused on the safety of people in ship accidents, and included commercial losses as a secondary effect. FSA studies have also demonstrated that some risk control options can be justified by commercial considerations alone, in addition to the life-saving potential. It is believed that GBS also have to focus more on safety of personnel and environmental protection, and the goal should be linked to what can be achieved without entailing excessive costs. In FSA this goal is described by the ALARP principle\(^1\).

9 There have already been developments at IMO in the direction of risk-based and goal-based regulations. For example, the new damage stability regulations\(^2\) have defined a probabilistic design procedure, estimating the conditional probability of surviving a collision with water ingress: A; where the requirement is defined as a minimum probability level: R. The design is accepted if A>R. This regulation is clearly both risk-based (probabilistic) and goal-based.

10 In SOLAS chapter II-2, regulation 17, there are provisions for basing the fire risk assessment on a formalized risk-based analysis. The goal is that new designs should be as safe as or safer than required by the current prescriptive regulations. Each time such a design analysis is carried out, the implicit safety in the current prescriptive regulations will be disclosed. This regulation is therefore also risk-based, although IMO has not formulated a goal-based standard, e.g. by specifying the acceptable risk level. The individual functional requirements are also formulated in each regulation, each of which can be linked to a fault tree (fire safety concept tree), (see document FP 43/3/5). This demonstrates that FSA may be used also to structure a risk-based and goal-based regulation.

11 The current version of the GBS standard at IMO (MSC 80/WP.8), focusing on hull structures, refers to issues like ‘design life’ and ‘fatigue life’ for ships. These issues are not yet clearly associated with safety of life at sea and protection of the marine environment. Such issues may be better dealt with by using the FSA and SRA methodologies. For example as many parameters are uncertain or unknown at the design stage it is obvious that a clear interpretation of the term ‘design life’ would refer to a time period where the failure probabilities were below some target. The terms ‘safety margin’ and ‘safety factors’ also have clear probabilistic interpretations (from SRA methods, see document MSC 80/INF.6). It is also correctly stated that the safety margins account for uncertainties in design parameters. The term ‘fatigue life’ also has a clear probabilistic interpretation (about 2.5% probability of cracking during ‘fatigue life’). This quantile is used as characteristic value in many design codes (not only for ships).

12 The combination of FSA and SRA provides a rational and transparent methodology for demonstrating that the prescriptive rules developed take into account all physical or model uncertainties that are inherent in the various design parameters, meet the goals and functional requirements of GBS Tier I and Tier II. An example about the use of FSA and SRA for the hull structures is given by IACS in document MSC 81/INF.6.

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\(^1\) The ALARP principle, As Low As Reasonably Practicable, is defined in the IMO FSA Guidelines (MSC/Circ.1023 – MEPC/Circ.392), appendix 5, page 45.

\(^2\) Resolution MSC.194(80), in MSC 80/24/Add.1, annex 1, Adoption of amendments to the International Convention for the Safety of Life at Sea, 1974, as amended.
Action requested of the Committee

13 The Committee is invited to consider the information provided in the development of goal-based new ship construction standards during its deliberations.

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ANNEX

COMMENTS TO THE OUTCOME OF FSA WG AT MSC 80

1 IACS would like to offer some additional comments to document MSC 80/24, paragraph 7.19 (quoted in italics):

The Committee noted that the group had an extensive discussion regarding the linkage between FSA and GBS and had agreed that the FSA process, in general, could be used to:

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

2 Paragraph 7.19.1 and 5 points to the fact that an FSA will disclose implicit safety levels in existing designs. Also the cost effectiveness of current rules and regulations may be identified. In this way IMO may either decide that the current safety level is right, and this may be used as a requirement (e.g. for innovative design solutions), or the regulations may be changed in order to improve safety or cost effectiveness. However, using the implicit safety level as requirement should not be done without verification that the safety level is ALARP.

3 Paragraph 7.19.2. This use follows from 7.19.1. However, the ship safety goal itself may also be established by comparing to safety levels in other industries, or in other modes of transport (as explained in document MSC 72/16).

4 Paragraph 7.19.3-4. This is the standard intention of FSA, and how it has been used at IMO up till now. Step 3 of FSA is intended to identify generic risk control options that result in a safe ship satisfying the risk evaluation criteria. In a goal-based regime, such risk control options should be understood as one way of fulfilling the goals – other alternatives that are as safe could alternatively be implemented.
Paragraph 7.19.6. The FSA can be used to document that the high level safety goals are met, and may therefore serve as a ‘rule commentary’. The verification will be a verification of this FSA (or SRA for hull structures).

Paragraph 7.19.7. It should also be noted that the HAZID (FSA Step 1) can be used to define the scope of the regulations.

IACS would also like to offer some additional comments to document MSC 80/24, paragraph 7.20 (quoted in italics):

_Bearing in mind that the above list is not exhaustive, the Committee noted the group’s view that the first three FSA steps (HAZID, risk assessment, RCOs) are suitable for informing the development of high-level goals (Tier I) and functional requirements (Tier 2) of GBS. Equally, the last three steps (RCOs, CBA, Recommendations) could feed into Tiers IV and V of GBS, by helping to select between alternative technical or regulatory solutions to specific problems._

IACS can agree with this. In addition, it is quite common to refer to a preparatory step in FSA. In this step agreement is sought on the risk evaluation criteria, which closely correspond to Tier I. The HAZID and risk analysis will help formulating the functional requirements (Tier II) and the risk control options represent Tier IV (technical solutions that may be formulated as Tier IV rules). If these requirements have been justified by an FSA, Tier III corresponds to defining the verification procedure for an FSA, and the FSA document itself correspond to the rule commentary. For GBS, the detailed requirements are derived by SRA, and Tier III corresponds to defining the verification procedure for an SRA. The SRA documentation represents the rule commentary (the term ‘rule or code commentary’ is a standard SRA term), see document MSC 81/INF.6.