INTERNATIONAL MARITIME ORGANIZATION

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MARITIME SAFETY COMMITTEE
87th session
Agenda item 18

MSC 87/18/2
9 March 2010
Original: ENGLISH

FORMAL SAFETY ASSESSMENT

Comments by SAFEDOR on the FSA Experts Group report (FSA on LNG carriers)

Submitted by Denmark

SUMMARY	
Executive summary:	This document comments on the report from the first intersessional meeting of the Formal Safety Assessment (FSA) Expert Group (EG). This document sets out the SAFEDOR responses to the FSA EG concerns regarding the FSA on LNG carriers (annex 3 to document MSC 87/18).
Strategic direction:	12.1
High-level action:	12.1.1
Planned output:	12.1.1.2
Action to be taken:	Paragraph 4
Related documents:	MSC 87/18; MSC 83/21/1 and MSC 83/INF.3

1 This document comments, at annex, on the report of the first intersessional meeting of the Formal Safety Assessment (FSA) Expert Group (EG) and sets out the SAFEDOR responses to the FSA EG concerns regarding the FSA on LNG carriers (annex 3 to document MSC 87/18).

2 As a partner in the SAFEDOR project, Denmark has collected responses from the SAFEDOR experts who performed the FSA on LNG carriers.

3 The following comments are related to the major items discussed at the first intersessional meeting of the Formal Safety Assessment Expert Group, as set out in annex 3 to document MSC 87/18.

Action requested of the Committee

4 The Committee is invited to note the information and take action as appropriate.

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ANNEX

RESPONSES BY THE SAFEDOR FSA EXPERTS

To limit the number of pages, only parts of the question posed by the FSA EG are repeated. Responses by the SAFEDOR FSA experts are given in *italics*. The numbering below refers to the main report, document MSC 87/18 by the FSA EG.

Whether the expertise of the participants in the FSA study was sufficient for the range of subjects under consideration (TOR 1.7)

Paragraph 1 Although the homogeneous character of and lack of information on the participants were pointed out, the group generally agreed that the expertise of the participants in the FSA study was reported and likely sufficient. Concerns were raised regarding the potential impact of a homogeneous group on expert judgment.
Short CVs are given for HAZIDs and where expert elicitation is used as such analyses are subjective – therefore we need to know the expertise of the persons in question. For the rest of the FSAs, which are based on data that can be reanalyzed by anyone, there should not be a need for providing CVs.

The validity of the input data and its transparency (TOR 1.3)
The reasonableness of the assumptions and whether the scenarios adequately addressed the issues involved (TOR 1.2)

Paragraph 2 Some members were of the view that the data, statistics and analyses used in the FSAs were relatively comprehensive and reliable for a high-level study like this one; however, for a more detailed FSA, information about root causes and accident scenarios is needed.
The accidents included in the analyses were included in submission MSC 83/INF.3, but not in the main submission MSC 83/21/1. Appendix A.1 to annex 1 of document MSC 83/INF.3 contains 26 pages with information about the 182 accidents that were considered and is publicly available for verification by the interested reader.

Other members noted that the casualty database used in the analysis was not available, so one could not access the data so as to verify which accidents were included, or otherwise check the validity of the many claims made and of the ensuing risk analysis.
The information contained herein includes i.a. year of accident, ship name and year of build, type of cargo containment system, incident description and source of information. As noted in the report, no single casualty database was complete, and several sources of information were used.

Further, it was realized that the number of LNG-related incidents was limited and thus the historic database alone was of limited value as the sole input to the risk analysis.
This is mentioned in the report, and the source of the information for each accident is clearly provided. Anyone is invited to improve the analysis.

Paragraph 3 When sufficient casualty data are not available due to the nature of the casualty (in this case, explosion of leaked natural gas), it is necessary to use data from modelling, simulations and experiments. If input from modelling, simulations and experiments is not used, this necessarily leads to a great deal of "expert assumptions" which may be borrowed from other ship types or from cases of other industries.

It is very unclear what this comment addresses. However, expert assumptions have been used in this FSA, and this is justified by the lack of better alternatives, in particular for events late in the chain of events, where knowledge is limited and uncertain. There have been some experiments and simulation studies on LNG with regard to explosion, pool fires, etc, and the available literature has been consulted. However, due to the great uncertainty that still persists on these matters, experts have been consulted in order to interpret and extrapolate the needed results from these experiments and simulation studies.

In these cases, the use of such input (modelling, simulations, experiments and expert judgments) should be justified.
It was beyond the scope of the FSA to carry out own experiments or simulation studies on LNG fires, explosions, etc. and the estimates have been based on the best available knowledge at the time of analysis. In order to synthesize available information and state-of-the art knowledge, experts have been consulted since they may be better suited to evaluate the different results.

Paragraph 4 Concerns were expressed that the validity of some assumptions, for instance assuming that the probability of water ingress given a collision or fire escalation was the same as that for passenger ships, and of a great number of other assumptions was poor.
Due to the lack of data and uncertainty in knowledge, assumptions have been made. Assumptions will always be an inherent part of an FSA. This needs to be acknowledged and that assumptions should be explicitly highlighted so that they may be challenged. This was done in the FSA report, and a critical review and challenging of these assumptions would be welcome. Indeed, if new knowledge becomes available, it is stressed that the assumptions should be revisited, as appropriate. Since the comment is rather general about the validity of assumptions in an FSA and not directed towards particular assumptions in the FSA report, but assumptions will need to be challenged and discussed on a case-by-case basis if some of them seem unrealistic.

Regarding the two assumptions highlighted:
The FSA team, in consultation with experts, did not see any reason why the probability of water ingress, given collision with another vessel, should be significantly different from other ship types where data are available. This is also the assumption behind the IMO probabilistic damage stability regulations. If new evidence exists rendering this assumption unrealistic or if it can be argued convincingly that it is not true, it should be changed. Otherwise, it is believed that it represents the best available estimate of the probability of water ingress given collision.

The assumption of escalation of fires based on passenger ships, as noted above, was actually an assumption that the success rate of the fire-fighting system for LNG vessels is similar to that of HSC and passenger ships. Again, this assumption was made as data are available for passenger ships, while there are insufficient data for LNG carriers (few ships/fewer fires). In consultation with experts on ship fires, this assumption was justified and, if there are no strong arguments as to why the fire-fighting systems should have very different success rates on the different ship types, it is suggested that the estimates represent the best available knowledge to date and should be exploited in the analysis.

As a final note, the use of experts and assumptions should not automatically be regarded as a defect of an FSA. On the contrary, experts and reasonable assumptions are employed in order to be able to exploit better information and data that are available. Using only LNG-specific data, which are scarce, would, we argue, give poorer results even though no assumptions may be needed than utilizing a large amount of data available for other ship types that require some assumptions in order to be used. It is believed that the additional information obtained in this way, by making some assumptions, is indeed valuable and it

would be wrong not to utilize it. Nevertheless, every effort need to be made to ensure that the assumptions are realistic, and critique should then be based on particular assumptions that seem unrealistic and not be directed towards the use of assumptions in an FSA in general.

Whether risk control options and their interdependence were properly evaluated and supported by the assessment (TOR 1.4)
Whether uncertainty and sensitivity issues have been properly addressed in the FSA study (TOR 1.5)

Paragraph 5 Concerning RCO 3 (increase double-hull width), the group noted some concerns regarding the side effects of increasing the size of ships (e.g., increase of CO2 emission per tonne-mile transport of cargo due to an increase of hull size or decrease of cargo capacity and environmental impacts as well as other safety impacts due to an increase of draught and width of hull).

Noted the lack of statistical evidence to support the claim, that the current side spaces are insufficient for absorbing the hull damage by collision.
It is noted that this RCO was not found to be cost-effective. If this conclusion is believed to be wrong, it may be challenged. However, it seems that the arguments above support the view that this RCO is not cost-effective and therefore only add to the confidence of the conclusion. Therefore, it is agreed in principle that all side effects should be considered, as commented by the reviewers, but in practice in this particular case it is argued that the conclusions would not be affected and the fact that this RCO turned out not cost-effective remains valid.

Paragraph 6 The group noted that no RCO interdependencies were analysed.
It is acknowledged that RCO interdependencies were not included in the initial report, and that maybe they should have been included. However, it has been proved later that the interdependencies of the RCOs would not influence the final recommendations on any of the RCOs, and therefore they would not influence the results of the FSA in any way. It is acknowledged that future FSAs should indeed include such interdependency studies, in particular for RCOs that may be sensitive to such interdependencies.

Paragraph 8 It was noted that uncertainty, sensitivity and interdependence should have been further considered in the FSA.
It is noted that a qualitative sensitivity analysis of the various assumptions and a review of uncertainties were indeed included in the report, and although this did not quantify the uncertainty directly, it could estimate whether the net effect would be over- or underestimation of the risk. The FSA could have been extended to include this more rigorously and quantitatively, but the overall results would not be influenced.

Paragraph 9 The group noted that the risk control options were considered and identified in general according to the FSA Guidelines. Some members questioned the gap between step 1 and the rest of the FSA, the use of collisions and groundings as causes and the use of probabilities in the risk analysis.
The gap between step 1 and the rest of the analysis is natural in that, as one digs deeper, more insight and knowledge about the subject of the FSA is gained rendering some of the suggestions from the HAZID less relevant. The HAZID is mainly used as a good starting point for the main task – the risk analysis, and one should not be obliged to adhere to the results of the HAZID if the subsequent risk analysis arrives at different conclusions about the different scenarios (objective information and evidence carry more weight than the subjective information from the HAZID). It is argued that, in this FSA, the HAZID did provide a starting point for the risk analysis and as such it served its purpose.

There may be underlying causes for some of the "causes" in the FSA report, and if a higher level of details would be required, these could be further investigated. However, for the purpose of the high-level FSA, using collision and grounding as initiating events or causes is sufficient, and a more detailed investigation of root causes would not necessarily provide better estimates of the (average) probability of collision and grounding.

Whether the methodology was applied in accordance with the FSA Guidelines and the Guidance on the use of HEAP and FSA (TOR 1.1)

Paragraph 10 The group noted that the FSA was carried out in accordance with the FSA Guidelines and the Guidance on the use of HEAP and FSA. The lack of an RCO interdependency analysis, the lack of a concordance analysis among experts and the gap between step 1 and the rest of FSA were found to be deficiencies in terms of conformance. The group noted that the FSA report had not included a human reliability analysis.
No concordance analysis was carried out in the HAZID. However, this does not invalidate the results (see above) and does not seem relevant for the outcome of this particular FSA. No explicit human reliability analysis was carried out, simply because of the high-level nature of this FSA. Root causes were not studied in detail and human error would be implicitly included in the probabilities derived from accident data. Hence, it could be argued that human reliability was still taken into account, although implicitly.

Consideration on the proposed final recommendations in each FSA study (TOR 2)
Whether the scope of the assessment was met in the FSA study (TOR 1.6)

Paragraph 12 The group generally agreed that the final recommendations of the FSA study should be further studied if the Committee wishes to consider them. Although the recommendations seem sensible, some members did not find adequate justification in the FSA study for these recommendations.
The SAFEDOR partners agree with the recommendation, but would welcome a more active approach to improving safety.

Paragraph 14 Therefore, the group recommends to the Committee that these recommendations (.2 and .3) should, if necessary, be proposed by Member Governments to the Committee or related Sub-Committees (in case there are relevant agenda items).
The SAFEDOR partners agree with the recommendation, but would welcome a more active approach to improving safety.

Paragraph 15 With regard to other proposals in the final recommendations of the FSA (i.e. improved bridge design and a risk-based maintenance plan for critical navigational equipment), the group, having noted that those measures had already been implemented by major LNG operators, recommended the Committee that those recommendations would, if necessary, be proposed by Member Governments to the Committee or related Sub-Committees (in case there are relevant agenda items).
The SAFEDOR partners agree with the recommendation, but would welcome a more active approach to improving safety.