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FORMAL SAFETY ASSESSMENT

Report of first intersessional meeting and the correspondence group of the Formal Safety Assessment (FSA) Experts Group

Submitted by the Chairman of the FSA Experts Group

SUMMARY	
Executive summary:	This document reports on the first intersessional meeting and the correspondence group of the Formal Safety Assessment (FSA) Experts Group
Strategic direction:	12.1
High-level action:	12.1.1
Planned output:	12.1.1.1 and 12.1.1.2
Action to be taken:	Paragraph 53
Related documents:	MSC 83/21/1, MSC 83/21/2, MSC 83/INF.3, MSC 83/INF.8; MSC 85/17/1, MSC 85/17/2, MSC 85/INF.2, MSC 85/INF.3; MSC 87/18/1, MSC 87/INF.2; MSC-MEPC.2/Circ.6 and MSC 83/INF.2

General

1 MSC 86 approved the intersessional arrangements through correspondence among the nominated experts, coordinated by Japan, and an intersessional meeting of the FSA Experts Group. The first intersessional meeting of the Formal Safety Assessment (FSA) Experts Group met from 2 to 6 November 2009 under the chairmanship of Mr. K. Yoshida (Japan). The group agreed to prepare the report though correspondence among the nominated members coordinated by the chairman.

2 The group was attended by experts nominated by the following Member Governments:

ARGENTINA
BELGIUM
CHINA
DENMARK
FINLAND
GERMANY
GREECE
INDIA
ITALY
JAPAN
MARSHALL ISLANDS
NETHERLANDS
NORWAY
REPUBLIC OF KOREA
RUSSIAN FEDERATION
SPAIN
SWEDEN
UNITED KINGDOM
UNITED STATES

and experts nominated by the following non-governmental organizations:

INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES (IACS)
OIL COMPANIES INTERNATIONAL MARINE FORUM (OCIMF)
INTERNATIONAL ASSOCIATION OF INDEPENDENT TANKER OWNERS (INTERTANKO)
CRUISE LINES INTERNATIONAL ASSOCIATION (CLIA)
THE INSTITUTE OF MARINE ENGINEERING, SCIENCE AND TECHNOLOGY (IMarEST)
INTERFERRY
THE ROYAL INSTITUTION OF NAVAL ARCHITECTS (RINA)

Terms of reference

3 MSC 86 approved the intersessional arrangements through correspondence among the nominated experts, coordinated by Japan, and an intersessional meeting of the FSA Experts Group, with the following terms of reference:

.1 to finalize the review of FSA studies submitted by documents MSC 83/21/1, MSC 83/21/2, MSC 83/INF.3, MSC 83/INF.8, MSC 85/17/1, MSC 85/17/2, MSC 85/INF.2 and MSC 85/INF.3, and, in particular, on each FSA study, to:

.1 consider whether the methodology was applied in accordance with the FSA Guidelines and the Guidance on the use of HEAP and FSA;

.2 check the reasonableness of the assumptions and whether the scenarios adequately addressed the issues involved;

.3 check the validity of the input data and its transparency (e.g., historical data, comprehensiveness, availability of data, etc.);

.4 check whether risk control options and their interdependence were properly evaluated and supported by the assessment;

.5 check whether uncertainty and sensitivity issues have been properly addressed in the FSA study;

.6 check whether the scope of the assessment was met in the FSA study and propose any recommendations for re-analysis or re-calculation; and

.7 check whether expertise of participants in the FSA study was sufficient for the range of subjects under consideration,

and provide a report on the above issues, which should include a discussion on any strengths and weaknesses, the lessons learned regarding the FSA Guidelines and the Guidance on the use of HEAP and FSA, and their application and the evidence used to support the conclusions;

.2 to consider the proposed final recommendations in each FSA study and advise the Committee for consideration and decision; and

.3 to submit a report to MSC 87.

Other FSA studies

4 The group recalled that MSC 86 had endorsed that the FSA study contained in documents MEPC 58/17/2 and MEPC 58/INF.2 could be reviewed during the intersessional period, subject to the decision by the MEPC, and that the group could start reviewing the final FSA studies by SAFEDOR, which concern dangerous goods on board open-top containerships and would be submitted to MSC 87, at the intersessional meeting, if time permitted.

5 With regard to the FSA study on dangerous goods transport with open-top containerships that were submitted to MSC 87 (MSC 87/18/1 and MSC 87/INF.2), the group agreed to review them if time allows, as instructed by MSC 86. Concerning the FSA study on Crude Oil Tankers (MEPC 58/17/2 and MEPC 58/INF.2), the group, having noted that MEPC 59 could not finalize the issue of CATS (Cost to Avert one Ton of oil Spill), did not review those documents, bearing in mind that MEPC 59 had not deferred these documents to the FSA Expert Group and MEPC 60 would re-consider these documents possibly in the working group on FSA.

Common findings on FSA studies carried out by SAFEDOR

6 Having reviewed FSA studies on cruise ships, RoPax ships, LNG carriers and containerships, carried out by SAFEDOR and submitted by Denmark, which are listed in the aforementioned terms of reference (paragraph 3), together with additional information on HAZID (hazard identification) provided in its website, the group identified the following common aspects (paragraphs 7 to 38). Detailed reviews of each FSA are set out in annexes 1 to 4, respectively.

Whether the scope of the assessment was met in the FSA study (TOR 1.6)

7 The group noted the statement by the submitter that these were high-level FSA studies, which aimed at estimating risk levels of some ship types, and that, according to their results, the current risk levels of these ship types, as determined by the FSAs of SAFEDOR, are in the ALARP region.

8 The group also noted that these FSAs followed the five steps specified in the FSA Guidelines, but recognized that these FSAs did not fully comply with the FSA Guidelines. The group noted that some of the reasons of the incompleteness lay on insufficient availability of casualty data (i.e. lack of information on root-cause and events resulted in the casualty, etc.), as well as on gaps found between outcome of step 1 and analysis in step 2 and beyond. Details of the discussion of the group are described in following paragraphs.

9 Nevertheless, the group acknowledged that the great effort had been taken in these FSAs to follow the FSA Guidelines and to utilize possible methods and technologies which brought up ideas to improve FSA. The group appreciated SAFEDOR for its enormous effort on conducting these FSAs.

10 Because FSA is a tool of proactive approach for IMO rule making, the group noted, while reviewing process of these FSAs, that FSA should not and could not be conducted based only on historical data but should consider un-experienced hazards and risk which could be extracted from technical and scientific analysis and considerations and judgements by experts. In this connection, members recognized that such proactive actions were taken in most of these FSAs.

Consideration on the proposed final recommendations in each FSA study (TOR 2)

11 Since these FSAs suggested potential risk control options (RCOs) for future enhancement of safety and/or environment protection, the group, following extensive review, provided recommendations to the Committee on the final recommendations included in each FSA study as indicated in each annex (paragraphs 14 to 16 in annex 1, paragraphs 11 to 14 in annex 2, paragraphs 11 to 15 in annex 3, and paragraphs 10 to 13 in annex 4).

12 The group noted that, due to weakness in the databases used in the FSA studies and the choice of methodology used (database examination only but not in conjunction, where deemed advisable, with first principles/simulation/experiments), many of the RCOs are of mitigating nature (mitigating of consequences, post-accident) rather prevention of casualty.

13 Several observations and questions for some of the proposed RCOs were expressed by some members, relating, among others, to their appropriateness, proper assessment, possible interconnection and transparency of RCOs' risk reduction calculations.

14 Taking into account the findings and notes in paragraph 7 to 13 above, the group recognized that the conclusions and recommendations of these FSAs had merits for the consideration of the Committee, in particular, the risk level (see paragraph 7 above). Because the reports of these FSAs concluded that the risk level of the ship types, dealt with by these FSAs, are in ALARP region, the group recognized that further studies are required to identify which specific RCOs are cost effective; and this was also reported by the members of SAFEDOR who presented the FSAs to the group. Because these FSAs did not fully/perfectly comply with the FSA Guidelines, although these FSAs followed the five steps as much as possible, additional thorough investigations and analyses would be required if IMO wishes to take actions on the recommended RCOs in order to improve the safety level (to reduce the risk level) of those types of ships dealt with by these FSAs.

15 It was further noted that, given the complexity of the subject and the lack of detailed and sufficient data and risk modelling in the maritime industry, it is unlikely that a FSA perfectly according to the FSA Guidelines could be produced, and that the FSA Guidelines and the HEAP and FSA Guidance should be updated to include a review process that allows for some flexibility whilst ensuring the utmost standards remain. Some members, however, urged caution with such flexibility, in that it may undermine the adherence to the guidelines and may create confusion or inconsistencies in FSA application, and, in their view, such flexibility is not consistent with the notion of a "Formal" Safety Assessment.

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

16 The group noted that the available HAZID reports of the SAFEDOR FSAs provided information of participants in the FSAs' HAZID sessions to some extent. However, without more detailed biographies for each expert, it is difficult to ascertain their sufficiency. The group considered that such information should be recorded in the report of FSA.

17 The group, taking into account the importance of use of the expert judgement in FSA studies, which directly affects the results of a FSA study, agreed that, in future, a brief background of each expert (e.g., a short CV) engaged in the FSA study as well as the structure, selection and composition of the project team, HAZID team and any other team, if established for any type of decision making, should be clearly explained in the FSA report. The method of decision making should also be included in the report (see also paragraph 49).

18 The group noted that the composition of a group of FSA experts will affect the outcome of the FSA process, and agreed that the importance of the expert selection should be emphasized in the FSA Guidelines by expanding the specification of 10.1.5 of the guidelines.

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)

19 The group noted that the risk levels obtained from the SAFEDOR FSAs were largely based on the current commercially available casualty data (e.g., from LRFP and LMIU), which often are incorrectly categorized, not verified and normally lack detailed descriptions of accidents and causal factors (particularly the root causes), and that the resulting Risk Control Options (RCOs) focused on mitigation rather than prevention. The group also noted the difference between these casualty databases and was of the view that any available casualty data should be examined for suitability of use in FSA studies and in accordance with the defined scope/objective.

20 Furthermore, there was a concern over the completeness of the data utilized, as some members of the group noted that significant casualties from their individual experience were lacking. For certain of the FSAs, some members questioned the validity of such input data (e.g., RoPax casualty data were used for FSA on cruise ship or LNG carriers because of the limited historic database of these ship types).

21 The group noted that each FSA study used additional casualty data sources (e.g., casualty investigation reports and/or survey records) that provided detailed information, however this information was not used for describing scenarios for the risk analysis, and that these detailed casualty reports and records should be used to establish tools, e.g., event trees, fault trees and risk models, for analysis.

22 The group agreed that more information on root causes and casualty details are preferably needed for future FSA studies, in particular for consideration of preventive measures, and this should be reflected in the FSA Guidelines (see also paragraph 49). In this context, the group, recognizing that International Casualty Investigation Code was developed, adopted and being used as an IMO mandatory instrument, recommended to the Committee to urge Member States to report their casualty investigations as appropriate to the GISIS casualty database. Furthermore, the group stressed the importance of collecting near miss data (refer to MSC-MEPC.7/Circ.7).

23 The group noted the usefulness of the GISIS casualty database, and recognized that a system should be established within the Organization to conduct scientific and technological analysis of the casualty data submitted to IMO. Therefore, the group recommends to the Committee to request the Secretariat to consider the following points, with a view to improving the GISIS casualty data and, if relevant, complementing it with other available data:

.1 databases should not confuse cause and effect, but contain information on the root causes of accidents, and allow for multiple causation factors;

.2 databases should be able to describe the casualty in complete detail whenever possible, but be flexible enough to also handle casualties for which limited information is available;

.3 all sources used should be clearly stated, and there should be a distinction between the “factual” fields (e.g., date) and the ‘judgmental’ fields (e.g., causal factor). Background information on decisions and judgements should be readily available;

.4 search engines for GISIS casualty database should be further developed to allow searching by types of ship, casualty date and place, ship particulars, initiating event, and in general the main information contained in the casualty report forms (MSC-MEPC.3/Circ.3);

.5 cooperation with the European Maritime Safety Agency (EMSA) regarding casualty databases could be considered. EMSA is developing an European Casualty Information Platform (EMCIP), which includes most desired features mentioned above; and

.6 it is necessary to devise a new and efficient method to utilize the huge source of data available inside the seafaring community which up to now remains mainly untapped (e.g., near-miss data). Data on psychological factors as well as adequateness of man-machine interface of hardware systems based on practical on-board experiences should be taken into account.

24 There was a proposal that database used in FSA studies should be totally public and transparent, including the raw data, and this means no restrictions on disclosure, and no use of proprietary software. Some members expressed that such limitation should not be taken, because FSA should use any available data even when they have limitation for disclosure. It was noted that these discussions were not relevant for GISIS.

25 One member, supported by others, recommended that, in addition to the above, an IMO team should be formed to develop, on an urgent basis, a new database especially for FSA use by collecting, assessing and cataloguing all current casualty information which is readily available in the public domain (e.g., intent, published flag state investigation reports, etc.), including information contained in free public database. However, it was noted that establishment and maintenance of such database by IMO would require cost, and an extensive time period would be required to set up and populate it.

26 It as also noted that because such IMO casualty database would not be of an exhaustive database, commercially available database should continue to be used, for the purpose of statistical analysis, with great care of their adequacy and completeness (e.g., in many cases these are inadequate and incomplete).

27 The group was of the opinion that for new/novel designs the development of risk models is imperative to identify, qualify and quantify their risks, bearing in mind that such future risks may not be derived from past casualty data of existing ships.

28 The group was of the view that the inter-relationship between identified hazards should be also taken into account to accurately analyse the risks. In this context, network analysis methodology might be useful.

29 The group noted the usefulness of presenting the discounted cash flow tables for the net present value (NPV) calculations, in the report of FSA studies. This will facilitate the review of these calculations.

30 Several members stressed that FSA studies should not be limited to the available casualty databases to drive the casualty scenario development and, thus, the results of an FSA, but all and any additional means of information should be employed to identify and assess the hazards (step 1).

31 With regard to the reasonableness of the assumptions, some members questioned on some parts of the event trees in certain FSAs (for example, the use of data from other ship types for fire escalation in LNG carriers). There were also comments made with regard to the large number of assumptions and, in most cases, the insufficient justification of the various assumptions made. While several such assumptions could actually be reasonable, it is not possible to distinguish them, due to the lack of sufficient explanation of justification for these assumptions in the FSA report.

32 The group therefore recommends that a full explanation and justification of assumptions should be provided, along with a sensitivity analysis (how important was the assumption for the results of the FSA?). It was a general view of the group that, where possible, such assumptions should be supported by technical and scientific methods (such as modelling, simulation and experiment).

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)

33 The group, recognizing that the SAFEDOR FSAs identified many RCOs for mitigating risks, was of the view that more emphasis should be given to prevention oriented RCOs in future FSAs. Indeed, it was noted that the RCO selection appeared to be somewhat independent of risk profile, as some RCOs addressed lower risk events and not high risk items.

34 Some members were of the opinion that in general these FSAs did not sufficiently consider possible interdependences of the recommended RCOs, and that an usual weakness seemed to be that the evaluation of the risk reduction factor of each RCO was not always transparent. Finally, they were of the view that the "screening" of RCOs was not always clear (why these particular RCOs were recommended and not others which may readily come to mind?).

35 It was pointed out that interdependences should be considered when more than one RCOs would be implemented at the same time as a set, and risk reduction factor by such combination should be also evaluated.

36 For these reasons, the group agreed that explanations of how and why specific RCOs are selected in step 3 for use in cost effectiveness analysis (in step 4) should be given. The group further agreed of the necessity to review the FSA Guidelines in this context (see paragraph 49).

37 The group noted that the sensitivity and uncertainty analysis are important parts of FSA studies, in particular to properly assess the robustness of the conclusions and potential impact of recommendations. In this respect, the group noted that the requirement for an analysis of sensitivity is not clearly indicated in the current FSA Guidelines, while the Guidance on the use of HEAP and FSA only notes that uncertainty and sensitivity is to be reviewed. Therefore, the group agreed the expectations for sensitivity and uncertainty analysis should be included in the FSA Guidelines (see also paragraph 49) and their broad application should be required in order to ensure robust recommendations.

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

38 The group noted that these high level FSAs (holistic and general assessment of each ship type) followed the five steps of FSA methodology, but did not fully comply with the FSA Guidelines and the Guidance on the use of HEAP and FSA (see paragraph 7 to 10). In that regard:

.1 the group noted that there was a gap between step 1 HAZID and the subsequent FSA steps in some FSAs; e.g., some hazards identified in step 1 were not dealt with in step 2. The group agreed that steps 2 to 4 should take into account all the major identified hazards and the criteria for selection of hazards to use in step 2 should be explained and justified based on the description of causes and effects;

.2 with regard to the human element, the group noted that the FSA reports had not included a human reliability analysis and was of the opinion that careful consideration should be given to the influence and consequence of each RCO identified with human element, and noted that it is necessary to review the FSA Guidelines and the Guidance on the use of HEAP and FSA in this context; and

.3 with regard to the use of experts judgement in FSAs, the group agreed the methodologies and results of such judgement should fully explained in the FSA report as required in FSA Guidelines (paragraph 3.3.2 of MSC 83/INF.2).

.4 with regard to the level of agreement in experts judgement among an FSA team, the group agreed that the methodology to reach the consensus or agreement as well as the degree of agreement, if consensus was not reached, should be explained in FSA reports (see also paragraph 49).

Questions to the former SAFEDOR FSA team

39 Since the SAFEDOR project was completed and the project team was disbanded, the results of the reviews of the FSAs carried out by SAFEDOR could not include any re-calculation, re-analysis or any further work on the FSAs. In this context, however, the group, thanking again the effort by SAFEDOR, requested the former SAFEDOR FSA team to provide additional information and answers to the questions of the group, provided in each annex as appropriate.

Lesson learnt on the FSA Guidelines and the Guidance on the use of HEAP and FSA

40 Through the review of these FSA reports, the group discussed on the potential future improvement of the FSA Guidelines as follows.

41 The group found the necessity to use unified terminologies (e.g., frequency versus probability) in an FSA study, and agreed that the FSA Guidelines should be reviewed in this context.

42 The group noted that IMO mandatory instruments, (e.g., SOLAS, MARPOL and mandatory codes) are continuously revised to improve safety, security and marine environment protection, and applications of such mandatory instruments including any revisions depend on the date of build of the ships. This means that ships cannot be treated uniformly in statistical casualty data analysis, and thorough consideration should be given to the implementation of new regulations that may significantly influence the impact of each casualty case in an analysis. The group was of the view that risk models should properly take into account the implication of rule changes, and such consideration should be highlighted in the FSA Guidelines as well as FSA reports.

43 The group noted that the absence or insufficiency of human element consideration in the risk analysis of these FSAs. It was pointed out that inclusion of human element is important and this necessitates proper casualty data with information on root causes.

44 The group recognized the importance of human element consideration in the FSA process, and, having noted that FSA guidelines mentioned human element consideration, the group agreed the need of strengthening the methodology for human element considerations in the FSA guidelines.

45 The group also recognized the need for strengthening the investigation on root cause of casualties, and noted that casualty data should contain information on root cause of the casualty.

46 The group, noting that an index for cost-benefit analysis related to safety of life has been established in FSA Guidelines, agreed that indices for use in cost-benefit analysis regarding environmental protection and commercial impacts, should be established in the FSA Guidelines (see paragraph 49). The group noted the efforts of MEPC to establish environmental risk evaluation criteria such as CATS (the Cost to Avert One Tonne of Spilled Oil) in this regard. It was also highlighted that the appendix of the FSA Guidelines presenting GCAF and NCAF as example of cost effectiveness indices for safety of life should be clarified.

47 The group recognized that side effects of RCOs should be taken into account in the analysis of step 4 (for example, a RCO against a risk might create or increase another risk). In this context, the group noted that another international forum (i.e. ISSC: International Ship and Offshore Structure Congress) is now considering "sustainability" in its committee for design principles and that committee might consider this issue.

48 There was an opinion that a summary report of FSA should be clear enough and understandable for decision making by relevant bodies of IMO, while its main report should be complete and detailed enough for review.

49 Taking into account the discussions described in the above paragraphs, the group recommends that the FSA Guidelines and the Guidance on use of HEAP and FSA should be considered for improvement in the following matters:

.1 description/discussion of experts participation in FSAs (i.e. expansion of specification for 10.1.5 of the FSA Guidelines);

.2 description of the structure, selection and composition of the project team, HAZID team and any other team, if established for taking any decision making (i.e. expansion of specification for 10.1.5 of the FSA Guidelines);

.3 information and analysis on root causes and details of casualties, with a view to obtaining RCOs focused on prevention rather than mitigation;

.4 development of risk models;

.5 unification of terminologies;

.6 reporting the method and justification for the final selection of RCOs;

.7 indices for cost-benefit analysis for risks other than safety of life;

.8 clarification o the use of NCAF and GCAF (see paragraph 46);

.9 methodologies to analyze possible side effect of RCOs;

.10 methodologies for sensitivity and uncertainty analysis;

.11 consideration of the human element (to have more detailed and specific guidance);

.12 methodologies to reach the consensus or agreement as well as reporting the degree of agreement, or concordance;

.13 how to present reports (see paragraph 48); and

.14 how to review FSA studies.

FSA study on dangerous goods transport with open-top containerships

50 Regarding the FSA study on dangerous goods transport with open-top containerships (MSC 87/18/1 and MSC 87/INF.2), the group found it difficult to review the FSA during this intersessional period, considering that they were submitted recently and there was not sufficient time to examine them. The group also recognized that this FSA was conducted in a particular operation (dangerous goods transport with open-top containerships) which may require dedicated knowledge of such transport and related rules and regulation.

51 Therefore, the group reached the conclusion that it was not possible to conduct a thorough review on this FSA report during this intersessional meeting and agreed to conduct such review at the next session (i.e. MSC 87, if the FSA Experts Group is held). The group requested the SAFEDOR FSA team participate in the next session in order to present the FSA report and respond to questions.

Arrangement at MSC 87

52 Subsequently, the group requested the Committee that a meeting of the FSA Experts Group be held at MSC 87, which would commence its work at the start of the session, taking into account the workload and the schedule of experts who should also participate in the expected GBS Working Group as well as the Joint Working Group on the Human Element to be established at MSC 87.

Action requested of the Committee

53 The Committee is invited to approve the report in general and, in particular, to:

.1 note the group's review of FSA studies referred to the group, in particular the common aspects identified by the group (paragraphs 6 to 38 and annexes 1 to 4);

.2 endorse the group's view of the final recommendations in each FSA study (paragraphs 11 to 15 and, in particular, paragraphs 14 to 16 in annex 1, paragraphs 11 to 14 in annex 2, paragraphs 11 to 15 in annex 3, and paragraphs 10 to 13 in annex 4);

.3 note the group's appreciation of the former SAFEDOR FSA team and the group's additional questions to the team (paragraph 39);

.4 endorse the group's recommendation on improvements to the FSA Guidelines and the Guidance on use of HEAP and FSA, with a view to future amendments (paragraph 49); and

.5 endorse the group's requests regarding the arrangement of the meeting of the FSA Experts Group at MSC 87, in particular the need to review remaining FSA studies (paragraphs 51 to 53).

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ANNEX 1

REVIEW OF FSA ON CRUISE SHIPS (MSC 85/17/1, MSC 85/INF.2)

The following are the major points discussed, concerning the FSA on cruise ships, in addition to issues described in the main report.

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

1 Although some members felt that more details for each expert were needed and sufficient number of expert on designing these types of ships should be included, the group noted that the expertise of participants in the HAZID of the FSA study was reported and sufficient. However, similar information on the remaining FSA steps in regard to the expertise was not found.

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)

2 The group noted some data discrepancies included in the main report (MSC 85/17/1) and detailed report (MSC 85/INF.2) (e.g., fatalities in fire/explosion accidents in table 6-5, 7-3 and 9-1; and asked for this matter to be referred to the former SAFEDOR FSA study team (see paragraph of the main report).

3 The group noted that the casualty data from RoPax were used in the FSA study on cruise ships recognizing that only limited casualty data on cruise ships were available due to the relatively small fleet/casualty number. The group also noted some casualty data were omitted (i.e. cases of OCEANOS 1991). The group further noted that the worst case scenario was used in the study, utilized the RoPax data, and was of the view that the sensitivity assessment was necessary.

4 Some members were of the opinion that the use of RoPax casualty data in this FSA study for cruise ships was unjustified, due to significant differences in design and operation between the two types of ships. They also expressed concerns on the large number of assumptions regarding probabilities in the event trees and consequences of accident scenarios, many of which they found unjustified. Others mentioned that there are similarities of design between them.

5 In the view of the comments above, the group agreed on the need for better input casualty data for cruise ships and was concerned about the validity of use of the casualty data of RoPax and reasonableness of the assumptions.

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)

6 The group noted that the FSA had considered the collision and groundings to be the main hazards to cruise ships and focused on a few RCOs to improve damage stability, using as a sensitivity analysis to select the RCO, as well as improvement of bridge design and navigational equipment.

7 The group noted that collision and groundings are consequences but not causes and focusing on them as first events shifts regulatory focus to RCOs for damage mitigation and not accident prevention.

8 Some members expressed the opinion that the calculations for risk reduction of the RCOs were not transparent.

9 The group noted that the report of the FSA mentioned that the FSA did not further consider the fire hazards, bearing in mind that the fire hazard appeared to be one of major contributors to the frequency of casualties but the consequence of the case would be small as the results of recent improvement of fire safety requirements.

10 With regard to the cost-benefit analysis used in the study, the group, while noting that the methodology of calculating GCAF and NCAF was explained, found it difficult to follow the calculation and justification of such values due to the lack of sufficient information.

11 The group agreed that the risk control options of these FSAs were derived, in principle, according to the FSA Guidelines. The group noted that uncertainty and sensitivity analysis had been conducted and reported. The group also noted that expert judgement was inevitable in step 3, because FSA itself was pro-active casualty prevention activities and insufficient availability of casualty data. Some members expressed their concern especially as regards the great number of assumptions on probabilities and other variables.

12 The group noted that no interdependency analysis on RCOs had been performed.

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

13 Based on the above consideration, the group noted that the FSA followed the steps specified in the FSA Guidelines but did not fully comply with them. Some members felt that access to casualty database, gap between step 1 and the rest of the FSA, treatment of RCO interdependencies and calculation of concordance among experts were points of departure from the FSA Guidelines. Other concern was expressed that lack of casualty information on cruise ships made the chosen risk analysis method unreliable. However, bearing in mind that FSA is a tool for pro-active approach to prevent accidents rather than wait for accidents happening, it was also pointed out that development of casualty scenarios should not be done only based on historical casualty data. The group noted that the FSA reports had not included a human reliability analysis.

Consideration of 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)

14 The FSA on cruise ships report (MSC 85/17/1) concluded that the following cost effective RCOs would be recommendable for their possible introduction into the relevant legislation.

Final recommendation: implementation of guidelines for Bridge Resource Management (BRM)

15 The group, while recognizing the possible usefulness of the final recommendation (BRM), noted that the FSA did not ask to take immediate action on the final recommendations. Therefore, the group recommends the Committee that, as proposed in the final recommendations, further detailed research in the area of BRM would be needed.

Final recommendation: further investigation on damaged stability

16 The group noted, as stated in paragraph 7 of document MSC 83/17/1, that further investigation on damage stability may be necessary if this RCO would be taken for consideration.

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ANNEX 2

REVIEW OF FSA ON ROPAX SHIPS (MSC 85/17/2, MSC 85/INF.3)

The following are the major points discussed, concerning the FSA on RoPax ships, in addition to issues described in the main report.

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

1 Although some members pointed out the lack of sufficient information of each expert, the group, noting the relevant information on the SAFEDOR website, generally agreed that the expertise of participants in the HAZID of the FSA study was reported and sufficient. However, similar information on the remaining FSA steps was not found.

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)

2 The group noted the gap between the identified hazards (HAZID: step 1) and the remaining parts of the risk assessment (steps 2 to 4) in that the hazard details identified in HAZID were not used in later steps, but generic casualty categories (e.g., collision, fire/explosion, wrecked/stranded, machinery damage/failure, etc.) were used instead. The group was of the view that steps 2 to 4 should take into account all the major identified hazards unless the selection criteria are explained and justified. The human element, especially, should be considered further.

3 Having noticed that the FSA used old casualty data on RoPax Ships, the group agreed that the effect of new mandatory regulations introduced after those accidents, in particular the comprehensive revision of SOLAS chapter II-1, should be taken into account when considering RCOs.

4 The group partially agreed with the validity of the input data and reasonableness of the assumptions. Some members, however, pointed out that as in other FSAs, collisions, groundings, impacts and other accident hazards are treated as causes and not as consequences of other root-cause events (such as for instance, a steering gear failure that leads to a collision). This may skew the ensuring analysis including what may be appropriate RCOs, which are mostly mitigation-oriented.

5 The group agreed on the need for improved input data regarding scenarios and human element as well as its validity when considering present regulations.

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)

6 The group noted that the FSA focused on mitigating risk control options (RCOs) which would hypothetically reduce total risks and directly relate to loss of life (fatality), and that no RCO interdependencies were examined.

7 With regard to the cost-benefit assessment, in particular regarding the FSA's sensitivity analysis using attained subdivision index A (stipulated in SOLAS chapter II-1), the group, while noting the above-mentioned explanation (paragraph 3), found some difficulties in following the analysis and justification. After discussion, the group was of the opinion that the FSA needs more robust sensitivity/uncertainty analysis.

8 The group noted that the risk control options of these FSAs were derived, in principle, according to the FSA Guidelines. The group also noted that estimations by modelling and simulation and expert judgement would be inevitable in step 3, because FSA itself was pro-active casualty prevention activities and insufficient availability of casualty data.

9 The group noted that the FSA study conducted sensitivity and uncertainty analysis and the results were reported. Some members observed the merit of the presentation and results. However, some members were of the opinion that these analyses were not conducted in an adequate manner.

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

10 Based on the above consideration, the group noted that the FSA followed the steps specified in the FSA Guidelines but did not fully comply with them. Some members felt that access to casualty database, gap between step 1 and the rest of the FSA, treatment of RCO interdependencies and calculation of concordance among experts were points of departure from the FSA Guidelines. The group noted that the FSA reports had not included a human reliability analysis.

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)

11 The FSA on RoPax report (MSC 85/17/2) concluded that the following cost effective RCOs would be recommendable for their possible introduction into the relevant legislation.

***Final recommendations*:** measures to improve the damage stability; all measures aimed at improving navigation safety (better bridge management and improved navigational aids)

12 With regard to measures to improve damage stability and survivability of RoPax ships as the first priority, the group noted that the SLF Sub-Committee had already included in its agenda item on the issue and that the EU-funded GOALDS project, which is relevant to the issue, had just started. Since the FSA strongly recommended to undertake further research in this area, the group recommends the Committee to wait for the results of relevant ongoing researches and the outcome of the SLF Sub-Committee.

13 It was noted that the recommended RCOs are of general nature, this may be resulted from the nature of the high level FSA.

14 With regard to measures aimed at improving navigation safety, the group recommends to the Committee that those recommendations, if necessary, should be proposed by Member Governments to the Committee or relating sub-committees (in case there are relevant agenda items).

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ANNEX 3

REVIEW OF FSA ON LNG CARRIERS (MSC 83/21/1, MSC 83/INF.3)

The following are the major points discussed, concerning FSA on LNG carriers, in addition to issues described in the main report.

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

1 Although the homogeneous character and lack of information on the participants was pointed out, the group generally agreed that the expertise of participants in the FSA study was reported and likely sufficient. Concerns were raised regarding the potential impact of homogeneous groups on expert judgement. The importance of expert judgement is briefly discussed in the report.

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)

2 Some members were of the view that data, statistics and analysis used in the FSA were relatively comprehensive and reliable for high level study like this, however for a more detailed FSA, information about root causes and accident scenarios are needed. Some other members noted that the casualty database used in the analysis was not provided, 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 ensuring risk analysis. Further, it was realized that LNG related incidents were limited and thus the historic database alone was of limited value as the sole input to the risk analysis.

3 When sufficient casualty data is not available due to the nature of the casualty (in this case, explosion of leaked natural gas), it is required to use data from modelling and simulations and experiments. Without use of the input from modelling and simulations and experiments, this necessarily leads to a large portion of "expert assumptions" which may be borrowed from other ship types or from cases of other industries. In these cases, use of such input (modelling and simulations, experiments and expert judgement) should be justified.

4 Concerns were expressed that the validity of some of assumptions, for instance assuming the probability of water ingress given collision or fire escalation the same as that for passenger ships, and a great number of other assumptions.

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)

5 Concerning on of the RCO 3 (increase double hull width), the group noted some concerns regarding the side effects of increasing size of ships (e.g., increase of CO_2 emission per tonne-mile transport of cargo due to increase of hull size or decrease of cargo capacity and environmental impacts as well as other safety impacts due to increase of draught and width of hull), and also noted that the lack of statistical evidence to support that the current side spaces are insufficient to absorb the hull damage by collision.

6 The group noted that no RCO interdependencies were analysed.

7 With regard to RCO 1 (risk-based maintenance), the group discussed the issue extensively, and, while ISM Code (paragraph 10.3) has already required this approach implicitly, the group was of the opinion that the risk-based maintenance be further used in shipping industry, bearing in mind that other industries such as offshore industry and nuclear industry have adopted it for establishment of sound, robust and reliable maintenance scheme.

8 It was noted that uncertainty, sensitivity and interdependence should have been further considered in the FSA.

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.

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

10 The group, having noted that the FSA was carried out to follow the FSA Guidelines and the Guidance on the use of HEAP and FSA, found the lack of RCO interdependency analysis; the lack of concordance analysis among experts; and gap between step 1 and the rest of FSA as deficiencies in terms of conformance. The group also noted that the FSA report had not included a human reliability analysis.

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)

11 The FSA on LNG ships (MSC 83/21/1) concluded that the following cost effective RCOs would be recommendable as final recommendations for possible introduction into the relevant legislation:

.1 risk-based maintenance of navigational systems;

.2 ECDIS for improvement of navigational safety;

.3 AIS integrated with radar for improvement of navigational safety;

.4 track control system for improvement of navigational safety;

.5 improved bridge design for improvement of navigational safety;

.6 risk-based maintenance of propulsion system; and

.7 risk-based maintenance of steering systems.

***Final recommendations**:* mandatory carriage requirements for the navigational equipment on board LNG carriers (i.e. ECDIS, AIS integrated with radar, and track control system)

12 The group generally agreed that the final recommendations of the FSA study be further studied if the Committee wishes to consider them. Some members, although the recommendations seem sensible, did not find adequate justification in the FSA study for these recommendations.

13 The group noted that some of recommendations on mandatory carriage requirements for the navigational equipment on board LNG carriers have already been realized through relevant amendments to SOLAS and performance standards, as follows:

.1 regarding ECDIS, by resolution MSC.282(86) on SOLAS regulation V/19, which is expected to enter into force on 1 January 2011;

.2 regarding AIS integrated with radar, by resolution MSC.192(79) on the Revised recommendation on performance standards for radar equipment (not mandatory), which recommended that radar equipment installed on or after 1 July 2008 conform to performance standards;

.3 regarding track control system, by SOLAS regulation V/19 (2.8.2), all ships of 10,000 gross tonnage and upwards are required to have a heading or track control system.

.4 the group also noted current IMO guidelines on ergonomic bridge design (MSC/Circ.982).

14 Therefore, the group recommends to the Committee that the recommendations (subparagraphs .2 and .3 in paragraph 13), if necessary, should be proposed by Member Governments to the Committee or relating sub-committees (in case there are relevant agenda items).

***Final recommendations**:* improved bridge design and a risk-based maintenance plan for critical navigational equipment

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, recommends the Committee that those recommendations, if necessary, would be proposed by Member Governments to the Committee or relating sub-committees (in case there are relevant agenda items).

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ANNEX 4

REVIEW OF FSA ON CONTAINERSHIPS (MSC 83/21/2, MSC 83/INF.8)

The following are the major points discussed, concerning the FSA on containerships, in addition to issues described in the main report.

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

1 Some members agreed that the expertise of participants in the FSA study was sufficient. However, some other members noted that there are no details on the Delphi method and no estimate of the experts' degree of agreement.

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)

2 The group noted the difference between LRFP and LMIU data on containerships and was of the view that those discrepancies should be examined, in particular for the calculation of damage probabilities. Some members noted that one cannot check which accidents were included in the casualty database.

3 The group noted that the identified hazard (Bad working conditions during lashing, which is the highest risk index) was not used in the later analysis and RCOs, and asked this matter be referred to the SAFEDOR FSA study team (see paragraph 39 in the main report). The group considered that identified hazards having highest risk index should have been taken into account in other steps. It was noted that the top 8 hazards in the HAZID step were not taken into account in the rest of the FSA.

4 Some members generally agreed with the validity of the input data and reasonableness of the assumptions. However, some other members questioned some of the assumptions regarding probabilities and consequences as not fully justified.

5 Some members questioned the methodology of assessing two ship sizes (feeder and large) and then using as average size to generalize the results of the analysis. In addition, it was noted that recommended RCOs had no clear connection to these ship sizes.

6 The group noted that a loss or damage of containers, in particular by damage of containers contains dangerous/harmful cargo, may result in marine environmental damage. It was also noted that containers slopped out form a ship may result in hazard of collision with other ships.

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)

7 The group noted that, while two reference ships of feeder and liner were selected as generic ships in the FSA for analysis, those two reference ships seemed not used in the cost-benefit analysis, and considered that it would affect the recommendations.

8 Bearing in mind that uncertainty issues should be further considered in the FSA, some members agreed that risk control options were properly considered and assessed in the FSA. Some other members, however, expressed the opinion that the omission of the top hazards in the HAZID step would seriously skew the results of the study.

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

9 Based on the above, the group noted that the FSA followed the five steps specified in the FSA Guidelines but did not fully comply with them. Some members felt that in some respects conformance with the guidelines is lacking (gap between step 1 and the test of the FSA, no interdependency analysis, etc.). The group noted the FSA report had not included a human reliability analysis.

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)

10 The FSA on container ships (MSC 83/21/2) concluded that the following cost effective RCOs would be recommendable for their possible introduction into a relevant legislation.

***Final recommendations**:* mandatory carriage requirements of AIS integrated with radar and track control system, as well as high bilge level alarms in cargo holds for open-top containerships

11 The group generally agreed that the final recommendations of the FSA study should be further studied if the Committee wishes to consider them. Some members, however, expressed caution because of their perception of deficiencies in this FSA study.

12 The group noted that recommendations on mandatory carriage requirements for the navigational equipment on board containerships (i.e. AIS integrated with radar, and track control system) have already been realized to some extent through relevant amendments to SOLAS and performance standards, as follows:

.1 regarding AIS integrated with radar, by resolution MSC.192(79) on the Revised recommendation on performance standards for radar equipment (not mandatory), which recommended that radar equipment installed on or after 1 July 2008 conform to performance standards;

.2 regarding track control system, by SOLAS regulation V/19 (2.8.2), all ships of 10,000 gross tonnage and upwards are required to have a heading or track control system; and

.3 the group noted that bilge alarm in open cargo holds of open-top container vessels is recommended by MSC/Circ.608/Rev.1 (voluntary basis).

13 Therefore, the group recommends to the Committee that these recommendations, if necessary, should be proposed by Member Governments to the Committee or relating sub-committees (in case there are relevant agenda items).

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