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FORMAL SAFETY ASSESSMENT

Report of the Correspondence Group on Environmental Risk Evaluation Criteria

Submitted by Greece, Co-ordinator of the Correspondence Group

SUMMARY	
Executive summary:	This document reports the outcome of the Correspondence Group on environmental risk evaluation criteria
Strategic direction:	12.1
High-level action:	12.1.1
Planned output:	12.1.1.1
Action to be taken:	Paragraph 41
Related documents:	MEPC 55/18; MEPC 56/18; MEPC 56/18/1; MSC 83/INF.2; MEPC 57/17 and MEPC 57/21

Introduction

1 The Committee may recall that MEPC 56 had noted that the one matter that needed consideration within the context of the Formal Safety Assessment Guidelines relevant to its work was the draft Environmental Risk Evaluation Criteria.

2 The Committee may also recall that, when it had deliberated this issue at MEPC 56, a number of delegations had recognized the need to carry out a more in-depth analysis of the proposed environmental risk evaluation criteria for the purpose of the Formal Safety Assessment (FSA) before inclusion of such criteria in the IMO FSA Guidelines (MSC/Circ.1023-MEPC/Circ.392, as consolidated in MSC 83/INF.2).

3 In this context, MEPC 56 had recognized that environmental risk assessment criteria are still under development and there was limited experience in their practical application. The Committee had therefore, agreed that gaining practical experience with risk acceptance and cost benefit criteria is of importance in order to establish the criteria and threshold values for use in the decision-making process.

4 Noting that further work, including more research, was needed on the subject, MEPC 56 had subsequently agreed to establish a correspondence group, under the coordination of Greece, with the following terms of reference (TORs):

.1 to review the draft environmental risk acceptance criteria as set out in annex 3 to document MEPC 55/18, taking into account document MEPC 56/18/1 (Greece) and the comments made in plenary with a view to finalize the Criteria; and

.2 to submit a written report to MEPC 57.

5 In accordance with the above TOR, at MEPC 57 Greece presented document MEPC 57/17 on behalf of the Correspondence Group. It was pointed out that if one interpreted the term "environmental risk acceptance criteria" within a broad context, the analysis should include not only spills of cargo carried by oil tankers, but also bunker spills from any ship, shipbuilding and ship recycling residues, ballast water, coatings, garbage, sewage, gas emissions, noise, radioactive and other hazardous materials, bio-fouling, chemicals, other dangerous cargoes, and others. However, in light of the terms of reference of the group as set out in documents MEPC 55/18 and MEPC 56/18/1, these limited the scope of the analysis as they essentially focused only on oil pollution. Nevertheless, it was implicitly understood that the analysis should not only be confined to "cargo spills" from oil tankers, but also include oil pollution from any ship including bunker spills.

6 The coordinator of the Correspondence Group further pointed out that much progress had been made but divergent views still remained on some key issues which required further discussions, in particular:

.1 on establishing an appropriate Severity Index (SI) in the Hazid step;

.2 whether "costs of averting a spill (CATS)" or an alternative criterion would offer the needed decision-making quality; and

.3 the acceptable boundaries of the ALARP region, slope of F-N diagram and what is the variable of horizontal axis.

7 The delegations who spoke all supported the view that the work of the Correspondence Group should not be considered as the end of the analysis of environmental risk criteria in FSA and in light of the complexity of the subject, more time should be given to the group to bring its work to a logical conclusion.

8 The delegation of the Netherlands supported the use of spill volume within the concept of CATS as the key variable in the cost benefit assessment (step 4 of the FSA).

9 The delegation of the United Kingdom underlined that environmental risk evaluation criteria for FSA needed to include all releases and impacts to the environment from shipping, given the current and predicted foci of legislators. In this connection, it informed the Committee that the United Kingdom had completed a research project and was keen to share the results of this project with members of the Correspondence Group with a view to evolving criteria that are inclusive of all environmental impacts of maritime transport for the development of FSA during ship life cycles[1].

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[1] See also http://www.mcga.gov.uk/c4mca/final_report_rp_591-2.pdf.

10 Following its deliberations, the Committee noted that, due to the short time available to the Correspondence Group, the work could not be completed in the intersessional period and that further work was needed on the subject. It therefore, agreed to continue with the work of the Correspondence Group (led by Greece) with the following terms of reference:

.1 review the draft environmental risk acceptance criteria as set out in annex 3 to document MEPC 55/18, taking into account document MEPC 57/17, other relevant documents discussed at previous sessions on the subject and the comments made in plenary with a view to finalize the criteria; and

.2 submit a written report to MEPC 58.

11 In the light of the work to be carried out, the Committee agreed to request MSC to retain the item in the Provisional agenda for MSC 85.

12 Following MEPC 57, the following Member States participated in the work of the Correspondence Group:

DENMARK
FRANCE
GERMANY
GREECE
JAPAN
NETHERLANDS
NEW ZEALAND
NORWAY
TURKEY
UNITED KINGDOM
UNITED STATES

The following non-governmental organizations also participated:

INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES (IACS)
INTERNATIONAL ASSOCIATION OF INDEPENDENT TANKER OWNERS (INTERTANKO)
THE INTERNATIONAL TANKER OWNERS POLLUTION FEDERATION LIMITED (ITOPF)

Method of work

13 Work of this Correspondence Group for MEPC 58 followed a method similar to that for MEPC 57. This time, work was kicked off by the submission of a document by the Correspondence Group coordinator, describing a proposal for a way forward (more on this in the next section and in the annex to this report). Subsequently, Correspondence Group members submitted input in two rounds of submissions. The first round mainly included feedback to the coordinator's proposal and any other submissions and the second round included further comments, feedback, and additional submissions. Members were given an opportunity to comment on a draft version of this report, and some did. Some of these comments were taken on board in the final version of the report. The website already created for the work of the Group for MEPC 57 was maintained, with submissions and supporting material added for the Correspondence Group's work for MEPC 58.

14 The first round submissions were received from the following delegations: Norway, IACS, ITOPF, and INTERTANKO. The second round of submissions were received from delegations as follows: the United States, Japan, Germany, Turkey, Japan and Greece.

15 The coordinator's document and all other submissions are set out in the annex to this document, appended herein, and are listed in the chronological order in which they were received.

The coordinator's proposal for a way forward

16 Three issues were left open at MEPC 57 following the discussions. These were the following:

.1 what is an appropriate severity index?

.2 what (if any) is a good alternative to CATS? and

.3 the slope of F-N curves, the ALARP region and related matters.

17 To that effect, the coordinator of the Correspondence Group submitted to the Group a document entitled "*An approach to incorporating environmental risk evaluation criteria within IMO's guidelines for Formal Safety Assessment: the oil pollution case*". The document is essentially a proposal to move forward as regards issue 2, that is, what may be an alternative to CATS. In the coordinator's view, issues 1 and 3, namely the severity matrix (or SI index) and the F-N curves, are issues that can be settled easily after issue 2, which is perhaps the most difficult issue to settle. Again, in his view, the issue of coming up with a scheme that can achieve proper decision-making quality in the FSA's cost-benefit step and, at the same time, one that can be reasonably adopted within the time frame of the Correspondence Group, is the most important term of reference of the Group established after MEPC 57. To that end, the coordinator's document proposes a scheme for assessing the cost-effectiveness of specific RCOs for reducing the risk of oil spill pollution. The scheme concerns mainly steps 3 and 4 of the FSA methodology.

18 Two scenarios are assumed: (a) the status quo, and (b) a scenario in which a specific RCO is applied to waterborne transport on a global basis. RCOs may not only be ship-based, e.g., they may include measures to reduce spill frequency (such as VTMIS). The purpose of an RCO is to reduce the risk of oil pollution, and this can be done by either reducing the probability of oil pollution or mitigating its consequences, or both.

19 For step 4 of the FSA, one can say that a specific RCO under consideration is cost-effective globally if its total cost globally is less than the difference in expected total spill costs between (a) and (b) above. Some arguments on why it is preferable to use a difference rather than a ratio in this step of the FSA are made.

20 For the special case of oil spill cost functions that are (or are considered to be) linear in spill volume, the document shows that the approach reduces to CATS, although a different way to compute the threshold value is used.

21 The document then goes on to extend this approach in two directions: (a) integrating environmental criteria with fatality criteria already used in FSA (as per FSA guidelines) for those RCOs that may simultaneously reduce pollution risk and fatality risk, and (b) extending to environmental consequences other than oil pollution. Complete details are in section A of the annex to this report.

Submissions by Correspondence Group members

22 The following is a summary of the main points made in the submissions received by Correspondence Group members prior to the preparation of the draft report, listed in the chronological order in which they were received (full submissions are set out in the annex, section B).

Norway

23 We find the coordinator's document useful as a discussion document. What is appreciated most is that it lends its support to a CBA approach, but we have to agree on the criteria. The document's point that (benefit-cost) differences should be used instead of (benefit/cost) ratios is overstated and at IMO both numbers should be discussed and be a basis of decision-making. We are also pleased to see that the document seems to support that the risk matrix follows from the criteria.

IACS

24 The proposal raises interesting points. An issue is whether these criteria are applied regionally or globally. Another one is if punitive costs should be included. Some pollution control RCOs may increase the risk to humans (e.g., dispersants). IACS is unsure if financial costs will realistically capture the environmental aspects. One concern is that it may be very difficult for typical naval architects and class plan approval engineers to apply this methodology.

ITOPF

25 The document is well focused on the remit given to the Correspondence Group and takes into consideration the most relevant of comments made to and discussions held within the Group. Unfortunately, we do not see that the suggested approach, which is a worldwide one, alleviates the major conceptual and practical challenges faced by using CATS. Some of the input data assumed by the model simply do not exist. The prediction that RCOs in general will have positive impacts both on the frequency and size of spills appears reasonable, given the experience with safety improvements in shipping in past decades.

INTERTANKO

26 INTERTANKO supported developing a method to incorporate additional parameters of oil impact to find an alternative, more accurate version of CATS for application to the development of environmental risk criteria. While incorporating oil type, spill volume, and location factors into environmental risk criteria calculations may seem an overly daunting task, INTERTANKO believes that it can be achieved with satisfactory and defensible results. This can be accomplished – with existing data, or enhancements thereof – through relatively simple algorithms incorporating the factors that we know influence costs.

United States

27 Small spills provide a dramatically larger cost per barrel than large spills. The focus on both cargo and bunker spills is good. Adding other types of oils such as vegetable and other non-petroleum oils might be appropriate to consider in the future. The same is true for inland spills. Methodology focus is on net benefits, which is good, and a combination of fatality and environmental costs and benefits is also sound. Total spill cost should be partitioned into direct parties (e.g., vessel owner/operator, cargo owner, etc.) and third parties (e.g., local populace,

fishing communities, etc.) to get at equity issues in accordance with FSA guidelines. The document is correct in asserting that cost is a non-linear function of spill volume, but does not appear to adequately take this into consideration.

Japan

28 We would greatly appreciate the proposal by the Correspondence Group coordinator, putting our discussion forward toward the goal of our terms of reference. We consider it very useful as a discussion document. We would basically support the present proposal, especially proposing an overall framework of FSA as well as a methodology to use monetary basis to incorporate the safety FSA with environmental FSA. We also appreciate the proposal to use differences instead of ratios in choosing an RCO.

Germany

29 The three elements discussed by the Correspondence Group towards MEPC 57 (severity index, CATS and ALARP boundaries) need further discussion before a possible amendment of the FSA guidelines can be agreed to. A consolidated table for the SI on environmental damage is offered for further discussion:

SI	Monetary loss (m$)	Oil spill volume (t)	Recovery time (years)	Disruption of ecosystem
5	300	10000-100000	10-100	Long term
4	30	1000-10000	3-10	Medium term
3	3	100-1000	1-3	Short term
2	0.3	10-100	0.1-1	Small, detectable
1	0.03	1-10	immediate	Negligible

We are of the opinion that the newly suggested approach of the Correspondence Group coordinator has to be applied before any conclusions on its possible merits and practicability can be drawn. A document on setting an ALARP area related to societal environmental risk acceptance is being published. An FSA on oil tankers is currently being finalized.

Turkey

30 We have started a nationwide study on the Identification of the Turkish Marine Environmental High Risk Areas (MEHRAs) and the Feasibility of Emergency Response Centres along the Turkish Coasts. As part of the project, MAM has developed a GIS (Geographical Information System) based risk analysis for the maritime transport of hazardous materials in Turkish waters. The risk analysis in its general form uses IMO’s FSA as a starting point and develops upon it with a more elaborate analysis for the geographical distribution of accident probability and the severity of consequences.

Japan

31 We have carried out a non-linear regression analysis between the cost of oil spill and oil spill volume based on IOPCF data (see Fig. 1 below). We have compared CATS with this historical data, and made some comments based on these analyses. We are preparing to submit an information document to MEPC 58 with regard to the results of these analyses.

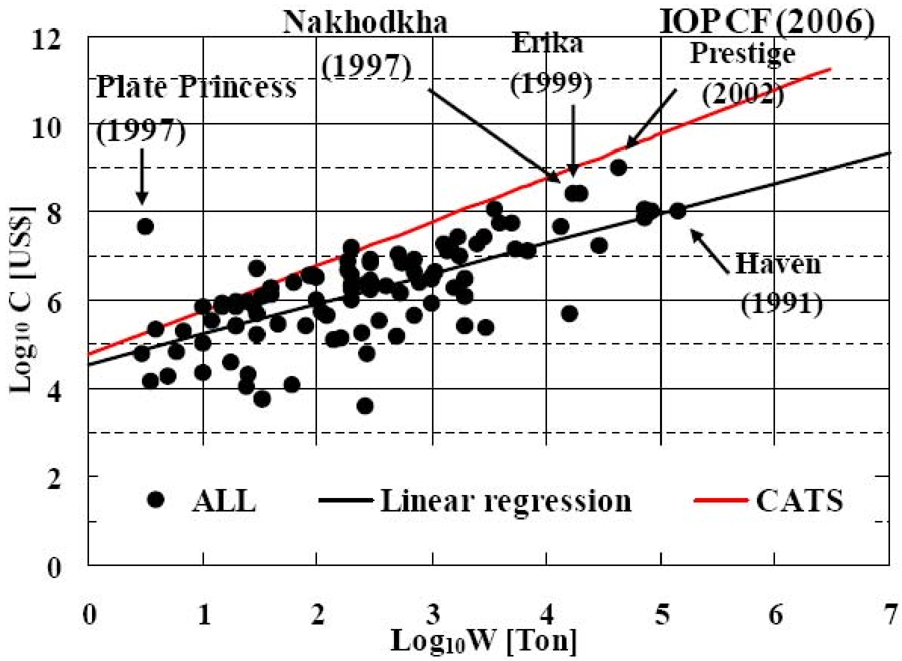

Fig.1 Relation between cost of oil spill and oil spill weight in double logarithm axes. C denotes cost of oil spill [US$]. W denotes oil spill weight [ton]. Non-linear Regression formula to estimate cost of oil spill (C [US$]) with oil spill weight (W [Ton]) derived from historical data: $C = W^{0.68} \cdot 10^{4.6} = 35951 \cdot W^{0.68}$.
Formula using CATS value: $C = W^{1} \cdot 10^{4.78} = 60000 \cdot W$

Greece

32 The formulation provided by our coordinator provides a tool whereby all factors that affect clean-up cost can be incorporated. It would be worthwhile to attempt to incorporate in the formulation the current available data in order to examine what value results. The linkage with fatalities is another advantage, enabling RCOs to be evaluated with a unified criterion if so desired. For the purposes of this group we should at least arrive at a simple figure which is more realistic than the 60,000 USD/tonne figure proposed by CATS. Using the Japanese formula, obtained after regression analysis, a spill of 100 tonnes costs 8,236 USD/tonne, and a spill of 10,000 tonnes costs 1,887 USD/tonne. If Japan could take their approach one step further, to propose a *linear approximation* for their formula, it would certainly be very beneficial. That is, what is the ratio of the average spill cost, divided by the average spill volume? Such a figure could be used as an interim simplified criterion.

33 After the release of the report in draft form, further clarifying positions were received by some delegations. These are listed in their entirety in section C of the annex and are also summarized below (expressions of agreement and suggestions for minor corrections omitted):

Norway

34 Our position is very clear, the summary of which is that we do not support the coordinator's proposal. Its main problem in our view is that it does not address the problem. It has not been submitted to IMO before, therefore it is too early to refer to its support by a small correspondence group. Also it is too early to refer to the Japanese study, as we actually do not know what they will eventually submit and as early versions of it that we have seen did not include environmental costs or the insurance factor (as in CATS).

Greece

35 The fact that the coordinator's proposal has not been previously submitted to IMO is irrelevant, as there was no need to do so before the formation of this Correspondence Group. It is this Group's task to investigate alternatives to CATS, and the coordinator submitted this proposal even though he did not have a formal obligation to do so. The approach can be combined with safety criteria already used in FSA and it can be extended to other environmental criteria. It certainly needs reliable data to do so, but so does any approach. The advantage of the proposed approach is that it can go as deep as the available data allows it to go. After all the concerns raised on CATS, one should move forward and be constructive.

United States

36 Although the United States supports the intent of a more rigorous and deliberative policy-making approach at the IMO level (with regards to the FSA and cost benefit analysis), the United States does not believe the necessary data is available to apply the proposal set forth in the proposed way forward. The United States believes there are too many uncertainties and regional differences for the proposal to determine if a specific RCO is cost-effective globally. The United States position on CATS is that it is not fully sufficient for use in the cost benefit step of FSA regarding environmental criteria. However, the United States feels it may be worthwhile if each administration explored to determine if there is variability within their own nation with regards to the costs associated with a response.

Germany

37 Little time has been spent discussing the severity index for use during hazards and the setting of an ALARP area. Assuming that the Correspondence Group will continue on its path, Germanischer Lloyd is willing to contribute to organizing a workshop to discuss related matters and to support progressing faster towards future environmental risk evaluation criteria. The proposal from Japan essentially suggests a functional dependence of CATS on spill size/weight. This has been discussed before and one conclusion to this could be to call for a study to look into this specifically.

Conclusion

38 In accordance with its TORs, this Correspondence Group has reviewed the environmental risk acceptance criteria, as set out in annex 3 of MEPC 55/18, taking into account document MEPC 57/17, other relevant documents discussed at previous sessions on the subject and the comments made in plenary of MEPC 57, with a view to finalize the criteria. A proposal was put on the table by the Group's coordinator that, in his view, provides a way forward for the Cost-Benefit part of the FSA, and can also be combined with the fatality criteria that are used in FSA and (ultimately) can be extended to other environmental criteria. Several members expressed the view that the approach is a good basis for discussion, and some stated that it is flexible enough to be able to provide answers to critical questions, such as whether or not a specific RCO is cost-effective, provided the right data are available. One delegation explicitly clarified their non-support of the coordinator's proposal as, in their view, it does not address the problem. Although two members expressed the view that much of the data that are necessary to implement this approach are not available, two other members suggested that one could try to use it in spite of the difficulties, and in fact Japan independently cited a to-be-released study that described a way to do that.

39 Japan's study on the cost of oil spills, a brief summary of which was provided to this Correspondence Group and which is to be submitted separately to MEPC 58 in the context of environmental risk evaluation criteria in FSA, might prove critical in the work of this Group. The relevance is in terms of both quantifying the non-linearity of spill costs with respect to volume and, ultimately, providing a preliminary "cost per tonne of spilled oil" (average spill cost divided by average spill volume) that can be used as a cost-effectiveness criterion. From the form of non-linear function provided (spill cost = $35,951^{*}(\text{spill volume})^{0.68}$), it is speculated that an equivalent average per tonne cost should be considerably lower than the 60,000 USD/tonne value implied by CATS. Although perhaps straightforward to calculate, at the time of writing this report, an estimate of this average value was not available to members. This concept, together with the value, could be further discussed at MEPC 58 taking into account an assurance factor and others.

40 Tight time limitations were again the main reason for not being able to discuss all other pending issues of this non-trivial topic as thoroughly as one would wish. Issues such as the risk matrix and the ALARP curves are relevant in that regard, and the proposal by Germany certainly seems worthy to note. In that respect, these issues continue to be pending, but it is felt at least by some that this discussion should follow after the cost-effectiveness criteria are decided upon.

Action requested by the Committee

41 The Committee is invited to consider the report of this Correspondence Group and decide on further action on this topic as appropriate.

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ANNEX

SUBMISSIONS BY COORDINATOR AND CORRESPONDENCE GROUP MEMBERS
Listed by chronological order of receipt.
Section A: Submission of proposal by the coordinator.
Section B: Submissions by Correspondence Group members received before preparation of draft report.
Section C: Submissions by Correspondence Group members received after preparation of draft report.

A. Submission of Proposal by the Coordinator
21 April 2008

AN APPROACH TO INCORPORATING ENVIRONMENTAL RISK EVALUATION CRITERIA WITHIN IMO's GUIDELINES FOR FORMAL SAFETY ASSESSMENT: THE OIL POLLUTION CASE

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Abstract

This document describes an approach to incorporating environmental risk evaluation criteria within IMO's guidelines for Formal Safety Assessment (FSA). Such criteria are currently absent from FSA, and the discussion to include them has just started. Said criteria are relevant for evaluating on a cost-benefit basis Risk Control Options (RCOs) for reducing oil spill pollution risk. Oil pollution may come from any ship, including bunker spills from non-tank vessels. RCOs are not necessarily ship-based, and may include vessel traffic management information systems (VTMIS) and other options. The proposed approach may be useful in extending FSA to cover environmental risk evaluation criteria and combines such criteria with criteria already in use in FSA. It can also readily be extended to environmental consequences other than oil pollution.

Key words: Formal Safety Assessment, Environmental Risk Evaluation Criteria, Oil Pollution.

1. Introduction

At its broadest interpretation, an analysis of environmental risk in maritime transport certainly should not be confined to oil pollution, let alone pollution from oil tankers. In fact, the spectrum of the potential environmental consequences of a maritime accident is very broad, encompassing not only spills of cargo carried by oil tankers, but, among others, bunker spills from any ship, shipbuilding and ship recycling residues, ballast water, coatings, garbage, sewage, gas emissions, noise, radioactive and other hazardous materials, bio-fouling, chemicals, other dangerous cargoes, and others.

If one confines the analysis to oil pollution, the question is whether it should be confined only to "cargo spills" from oil tankers, or include oil pollution from any ship. This document supports the belief that confining the analysis only to cargo spills from oil tankers is too restrictive. Significant environmental impacts have been noted from bunker spills from cargo vessels.

Therefore, the scope of the analysis will include bunker spills, therefore it will encompass oil pollution that may happen from any ship.

So far, work on Formal Safety Assessment (FSA) has limited the quantification of accident consequences only to possible fatalities (and indirectly also to injuries). No explicit environmental criteria are thus far included in the FSA Guidelines[2]. At its 56th session, the Marine Environment Protection Committee (MEPC) noted that the one matter that needed consideration within the context of the Formal Safety Assessment Guidelines relevant to the work of the MEPC was the draft Environmental Risk Evaluation Criteria. In fact, MEPC 55 had considered the draft Criteria set out in document MEPC 55/18 (annex 3) and agreed that the draft criteria still needed in-depth consideration from the marine environmental protection perspective. Subsequently, Members were invited to give their views on the draft Environmental Risk Evaluation Criteria for consideration by MEPC 56.

MEPC 56 considered document MEPC 56/18/1 (submitted by Greece), which drew attention to some issues pertaining to the development of Environmental Risk Evaluation Criteria and emphasized that the need of IMO (and other regulatory bodies) to assess environmental risk and formulate relevant policy necessitated the development of a risk matrix to assess effects on the environment.

In fact, document MEPC 56/18/1 pointed out some weaknesses in the proposals for environmental risk acceptance criteria (as mainly presented in document MEPC 55/18, annex 3), and urged further proposals and discussion.

MEPC 56, noting that further work, including more research, was needed on the subject, agreed to establish a correspondence group (CG), under the coordination of Greece, in order to review the draft Environmental Risk Acceptance Criteria in FSA, and submit a written report to MEPC 57.

This report has been submitted (document MEPC 57/17) and presented at MEPC 57, which renewed the terms of reference of the Correspondence Group until MEPC 58 (see document MEPC 57/WP.10, section 17).

The issues that are currently open and merit discussion are the following:

.1 the issue of what is an appropriate severity index;

.2 the issue of what (if any) is a good alternative to CATS[3];

.3 the slope of F-N curves, the ALARP region and related matters.

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2 See IMO document MSC/Circ.1023-MEPC/Circ.392, as consolidated in MSC 83/INF.2.

3 CATS: Cost to Avert one Tonne of Spilled oil. See Skjong, R., E. Vanem, Ø. Endresen, "Risk Evaluation Criteria", SAFEDOR-D-4.5.2-2005-10-21-DNV; 21 October 2005. Available at www.safedor.org.

It is not the scope of this document to deal with either the severity matrix (or SI index), or the F-N curves. These are issues that are still open for discussion, but to some extent can be settled easily after issue 2, which is perhaps the most difficult issue, is settled. Clearly the issue of coming up with a scheme that can achieve a proper decision-making quality in FSA's cost-benefit step and at same time one that can be reasonably adopted within the time frame of the Correspondence Group is the most important term of reference of the Correspondence Group after MEPC 57. To that end, a scheme for assessing the cost-effectiveness of specific RCOs for reducing the risk of oil spill pollution is proposed herein. The scheme concerns mainly Steps 3 and 4 of the FSA methodology.

Related background: the reader may take a look at documents MEPC 55/18 (annex 3), MEPC 56/18/1 and MEPC 57/17 for a description of the basic issues, including a sample of scientific documents in this area.

2. RCOs for Reducing the Risk of Oil Spill Pollution

It should be first mentioned that any RCO that reduces pollution risk may also, in general, reduce the risk of fatalities, of injuries, and maybe also the risk of damage or of loss of the ship and/or cargo. Incidents that lead to fatalities will not necessarily also lead to oil pollution, or vice versa. However, a specific methodology already exists in FSA for looking at a subset of these attributes (fatalities and injuries only). But attention should be made when combining the economic benefits of fatality risk reduction to those due to environmental risk reduction (more of this in section 4). Quantification of risk reduction as regards damage or loss to ship and/or cargo has not been dealt with thus far in Step 4 of the FSA, and will not be dealt with here either.

Before we speak about possible RCOs, let us assume two scenarios: (a) the status quo, and (b) a scenario in which a specific RCO is applied to waterborne transport on a global basis. The purpose of this RCO is to reduce the risk of oil pollution, and this can be done by either reducing the probability of oil pollution or mitigating its consequences, or both. We need a way to decide whether or not this RCO is cost-effective and hence should be recommended for adoption.

Focusing only on oil spill pollution risk, it comes as no surprise to see that there are a significant number of uncertainties in trying to estimate that risk, existing and future. Parameters such as time of spill, location of spill, volume of spill, type of oil spilled and others are not known in advance, but still may have significant implications on the anticipated total cost of oil pollution. In addition, significant difficulties may arise in terms of quantifying the economic consequences of oil pollution.

Starting with the status quo, let us define E(TOT) as the expected annual total cost of all spills worldwide. This cost basically consists of two components:

(a) The expected annual total **damage** cost of these spills, damage taking into account economic consequences to the shipowner, the cargo owner, fisheries, tourism, other industries that may be impacted negatively by the spill, and quantifiable damages to the environment, and

(b) The expected annual total **clean-up** cost of these spills, either at sea or when they hit the shoreline. This cost depends on the response level and response tactics, which here we assume to be a constant. Addressing oil spill response alternatives is outside the scope of this work.

Details on a proposed analytical method for calculating E(TOT) are presented in appendix A. For the moment, let us assume that this cost is known and that we would like it to be as low as possible. To do so, we contemplate ways to reduce it.

To reduce this cost, we introduce a specific **risk control option** (RCO), to be applied either globally (to all ships) or locally (to all ships of a certain category, or to a certain geographical area). The total cost of applying this RCO is ΔK, assumed to be known[4]. ΔK is a function of what is the RCO and how the RCO is applied: to all ships? To all geographical areas? Etc.

Typical examples of RCOs include:

- Tanker double sides
- Tanker double bottoms
- Smaller tanks
- Twin screws (for tankers)
- Inert gas in ballast tanks
- More steel
- Fuel tanks not close to ship hull
- ECDIS
- VTMIS
- Coulombi egg/ passive vacuum
- A specific design that limits discharge once it happens
- (purely theoretically?) rescinding double bottoms
- Etc.

Note that some of the RCOs may not be ship-related, e.g., a more advanced VTMIS system that reduces the risk of collision. Some other RCOs are ship-related.

[4] For comparison purposes, ΔK is assumed to be expressed as an equivalent annualized value. This means that if the cost of the RCO involves a lump sum investment, it should be converted to an equivalent annual basis. Such conversion is straightforward.

Effects of an RCO may generally include the following:

(1) The spill frequency may change because of it (presumably it will be reduced).

(2) The probability distribution of the spill volume may change (presumably less oil is likely to be spilled because of the RCO, and the expected spill volume will be reduced).

So the new situation, with the specific RCO under consideration implemented, and for the specific way that this is carried out, will achieve a different (presumably lower) expected annual total cost of all spills worldwide, E_{RCO}(TOT). As before, this cost basically consists of two components:

(a) The expected annual total damage cost of these spills, and

(b) The expected annual total cleanup cost of these spills, either at sea or when they hit the shoreline.

As before, the analytical method for calculating E_{RCO}(TOT) is presented in appendix A (it is very similar to the method for calculating E(TOT)). For the moment, let us assume that this cost can be computed.

3. Cost benefit assessment

With the above in mind, once we know E(TOT) and E_{RCO} (TOT), we can calculate the expected cost differential between the status quo and the situation in which the RCO under consideration is applied.

ΔE(TOT) = E(TOT) - E_{RCO}(TOT), total expected cost averted due to the global application of the RCO.

For Step 4 of the FSA we can then say that:

- The specific RCO under consideration is cost-effective globally if its total cost $\Delta K < \Delta E(TOT)$, otherwise it is not.

- Among alternative RCOs that pass this criterion, the one that achieves the highest positive difference {ΔE(TOT)-ΔK} is preferable.

Note that we are talking about the RCO that achieves a maximum *positive difference* ΔE(TOT)-ΔK, *not* the one that maximizes the *ratio* of ΔE(TOT)/ΔK. These are not the same, as shown in the example below.

Example: Assume three hypothetical RCOs, as follows (cost figures are in US $ billion/year)

RCO	ΔK	ΔE(TOT)	ΔE(TOT)-ΔK	ΔE(TOT)/ΔK
RCO1	2	5	3	2.5
RCO2	3	6.5	3.5	2.17
RCO3	4	8	4	2

Among these three RCOs, RCO3 is preferable since it achieves the highest (positive) difference of $\Delta E(TOT)-\Delta K$, even though the other two RCOs achieve a higher $\Delta E(TOT)/\Delta K$ ratio. If the maximum ratio RCO is chosen (RCO1), it would lead to one billion dollars per year less expected benefits than those under RCO3. As a general rule, one should pay attention to ratio tests, since they ignore scale.

A question that might arise is, since RCOs that reduce pollution risk may also reduce the risk of fatalities, how can this be incorporated into the analysis?

4. Combining environmental risk and fatality risk

In FSA, the criterion for quantifying the impact of fatality reduction due to a certain RCO uses the concept of CAF (Cost to Avert a Fatality) and is roughly expressed as follows:

- If $CAF = \Delta C/\Delta R < VHL$, then RCO is cost-effective, otherwise not.

- Among alternatives that pass this test, choose the one with the minimum CAF.

In the above formula, ΔC is the expected cost of the RCO, ΔR is the expect reduction of fatalities due to the RCO, and VHL is an estimate of the value of human life (the value currently used in FSA studies is 3 million US dollars per person)[5]. Both ΔC and ΔR are assumed to be expressed on an annual basis.

It is possible to combine fatality and environmental criteria as follows:

- The specific RCO under consideration is cost-effective globally if its cost $\Delta K < \Delta E(TOT)+VHL*\Delta R$, otherwise it is not[6].

- Among alternative RCOs that pass this test, choose the one that achieves the highest positive difference $\{\Delta E(TOT) + VHL*\Delta R - \Delta K\}$.

Again note the non-use of a ratio test in this step, which avoids possible pitfalls[7].

The above is a general yet simple framework, which can be implemented as long as the data necessary for conducting the necessary calculations to compute the above variables is available. Such data is available, and it is speculated that even preliminary estimates may be developed before the full analysis is implemented.

Appendix A provides more details on the approach, along with its relationship to the approach of CATS.

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5 In FSA, CAF is differentiated between GCAF and NCAF, G for Gross and N for Net. In case NCAF is used, ΔC is replaced by $\Delta C-\Delta B$, where ΔB accounts for expected benefits due to the RCO (other than lives saved).

6 This condition is if the GCAF criterion is used. For NCAF, the condition becomes $\Delta K < \Delta E(TOT)+VHL*\Delta R + \Delta B$.

7 See IMO document MSC 82/INF.3 (submitted by Greece) for a discussion on possible pitfalls on the use of ratio tests in this step of the FSA.

5. Extensions to other environmental consequences

The approach above can be readily extended if environmental consequences other than oil pollution are also examined. This is not currently under the terms of reference of this Correspondence Group, but one can predict that eventually it will be the subject of analysis in FSA, and probably sooner rather than later. These other environmental consequences may include shipbuilding and ship recycling residues, ballast water, coatings, garbage, sewage, gas emissions, noise, radioactive and other hazardous materials, bio-fouling, chemicals, other dangerous cargoes, and others.

Then, for a specific case above, E(TOT) and E_{RCO}(TOT) can be redefined as the expected annual total costs associated with its environmental consequences, before and after the application of a specific RCO for reducing the risk of such consequences (respectively). For instance, one may contemplate a measure to mitigate SOx emissions, a measure to reduce recycling residues, and so on. It is of course assumed that there is a way to compute these costs, but this is another matter. The approach of the United Kingdom to environmental risk criteria[8] is perhaps the most relevant here, addressing not only oil pollution, but the broader spectrum of environmental consequences.

6. Conclusions

We have proposed an approach for Steps 3 and 4 of the FSA that takes on board environmental risk evaluation criteria within IMO's guidelines for Formal Safety Assessment (FSA). Such criteria are relevant for evaluating on a cost-benefit basis Risk Control Options (RCOs) for reducing oil spill pollution risk. The proposed approach may be useful in extending FSA to cover environmental risk evaluation criteria, and combines such criteria with criteria already in use in FSA. The approach is readily implementable as long as data for the model described is readily available.

Correspondence Group members who have access to data that can be used to calculate the costs defined in this document may want to provide such data for the analysis.

Issues still to be looked at include the issues of RCO interdependencies, which can be tackled the same way as currently in FSA.

APPENDIX A
ANALYTICAL METHODOLOGY

This appendix presents the approach presented in the main body of this document in more detail. The focus is on oil spill pollution.

1. RCOs for Reducing the Risk of Oil Spill Pollution

To create a useful and practical framework for evaluating oil pollution risk, and, perhaps more important, how said risk can be changed by applying a specific RCO, conceptually we assume that the oil spill generation process is governed by a number of independent random processes. The first random process generates spills time-wise on a global basis. The second random process determines the geographical location of the spill. The third random process determines

8 (See annex to document MEPC 57/17 and also report on their website http://www.mcga.gov.uk/c4mca/final_report_rp_591-2.pdf).

the volume of the spill. A fourth process may determine the type of oil. More random processes may deal with prevailing weather conditions at the time of the spill, and so on.

First for the status quo, let us define the following parameters.

λ: Rate of occurrence (frequency) of oil spills, worldwide (in spills/yr). Assuming that spills occur independently of one other and that there is no memory in the spill generation process, one can safely assume that a Poisson process is the process behind oil spill generation worldwide.

P_i: Conditional probability that spill occurs in location I (i=1,..,I), given a spill occurs. Here we assume that the world is divided into I major locations, that is, Europe, North America, etc. The way the world is divided into such locations, the size of each location, and other parameters is a user input, and depends on the scenario to be analysed.

$f_v(v)$: Probability density function (PDF) of the volume of a spill ($0<v<\infty$).

p_j: Probability of oil type j (j=1,.., J). This is the conditional probability of a spill being of oil type j, given a spill occurs. J is the number of possible oil types, that is, gasoline, diesel oil, crude, etc.

Note that the approach can be generalized for the case each oil type and/or location has its own spill volume PDF, or even for the case where each location has a different distribution of oil types. Note also that if I=J=1 (one type of oil: all petroleum products, one location: the world), the approach simplifies considerably, but we may lose some information that is useful (we may also consider the intermediate case J=1, I>1, or vice versa).

An oil spill will have economic consequences, which are assumed to be quantified as follows.

$D_{ij}(v)$: damage cost function = expected economic damage if spill of type j hits area i with a volume of v. This function is generally a non-linear function of v. The expectation is taken over the possible ranges of all other random variables that are not explicitly considered here, for instance, weather conditions when spill occurs, etc.

$C_{ij}(v)$: cleanup cost function = expected cost of cleaning up a spill of type j that hits area i and has a volume of v. This function depends on the response level and response tactics, which here we assume to be a constant. Addressing oil spill response alternatives is outside the scope of this document.

$TOT_{ij}(v)$ = expected total cost of a spill of type j that hits area i and has a volume of v $=D_{ij}(v)+ C_{ij}(v)$.

It is assumed that all of the above cost functions are known, that is, can be calculated from available data (ITOPF, IOPC funds, national data, etc.).[9] This is an assumption that is probably easier stated than implemented, as available data may be of non-uniform or dubious quality. But if such data is not available, it will be very difficult to conduct a meaningful cost-benefit assessment.

[9] Correspondence Group members are asked to identify sources and (if possible) provide relevant data.

Based on the above inputs, the following can be calculated:

$\lambda\, p_j$ = worldwide frequency of spills of type j
$\lambda\, P_i$ = frequency of spills in area i
$\lambda\, p_j\, P_i$ = frequency of spills of type j in area i
$E(v) = \int v\, f_v(v)dv$ = expected volume of a spill worldwide[10].
$E(D_{ij}) = \int D_{ij}(v)\, f_v(v)\, dv$ =expected economic damage of a spill of type j in area i.
$E(TOT_{ij}) = \int TOT_{ij}(v)\, f_v(v)\, dv$ =expected total cost of a spill of type j in area i.
$\lambda\, E(D_{ij})$ = expected annual economic damage of all spills of type j in area i.
$\lambda\, E(TOT_{ij})$ = expected annual total cost of all spills of type j in area i.
$E(D) = \lambda \sum\sum p_j\, P_i\, E(D_{ij})$ =expected annual economic damage of all spills worldwide.
$E(TOT) = \lambda \sum\sum p_j\, P_i\, E(TOT_{ij})$ =expected annual total cost of all spills worldwide.

An RCO that reduces the risk of oil pollution may generally do any or all of the following:

1) It may change the spill frequency from λ to μ (presumably $\mu \leq \lambda$).
2) It may change the PDF of the spill volume $f_v(v)$ to $g_v(v)$ (presumably it will shift it to the left, i.e. less oil is likely to be spilled because of it, and the expected spill volume will be reduced; see Figure 1 below).
3) It may also impact probabilities p_j and P_i, if applied non-uniformly.

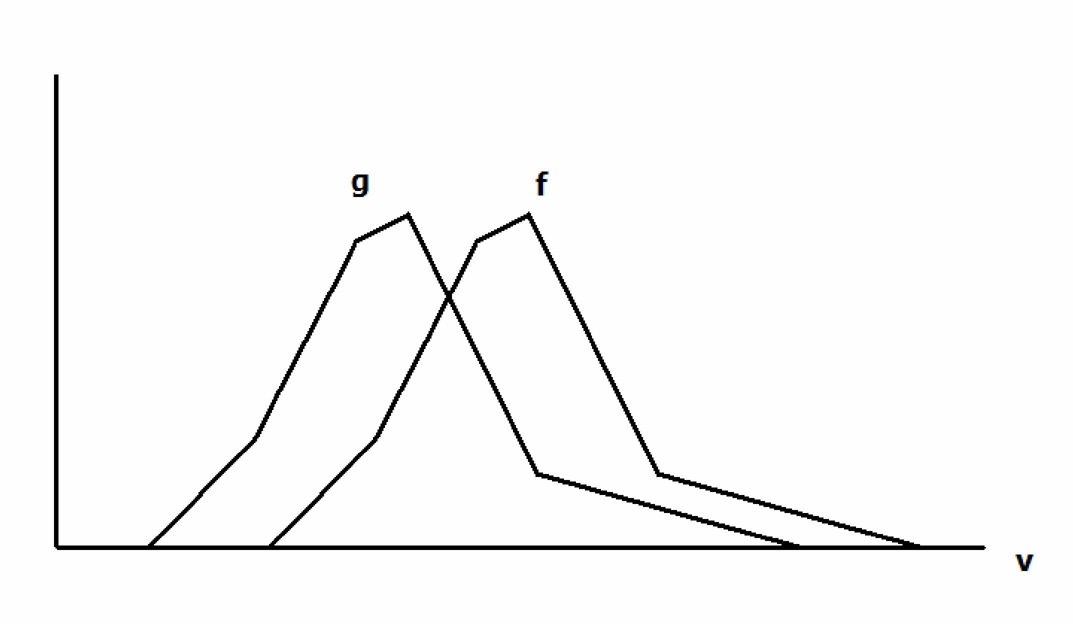

Figure 1: Shift of the spill volume PDF to the left because of an RCO

Important assumption: We assume that we have a way of inferring the new frequencies, PDFs and probabilities as defined above. This is not necessarily easy, but we assume it can be done, with the use of probabilistic modelling, Bayesian analysis and/or the help of expert opinion. This is not very different from what is currently done in FSA to quantify the impact of a specific RCO on fatality risk reduction. If assumptions and/or expert opinion are necessary to do so for our case, the same already happens in any FSA.

10 All integrals are from zero to infinity. $\int f_v(v)dv = 1$. E(.) is the expectation operator, in a probabilistic sense.

So the new situation, with the specific RCO under consideration implemented, and for the specific way that this is carried out, will look as follows:

μ: new rate of occurrence (frequency) of oil spills, worldwide (spills/yr). This is again a Poisson process and μ is generally a function of the specific RCO. One would expect that $\mu=\lambda$ if the RCO concerns only measures to mitigate the impact of the spill (e.g., smaller cargo tanks). However, if the RCO concerns measures to prevent the spill (e.g., twin screws, VTMIS, etc), then one would expect that $\mu < \lambda$.

Q_i: Probability that spill occurs in location i (i=1,..,I). That also may be a function of the RCO, as the introduction of the RCO may not have uniform impact geographically (example: introduce a VTMIS in the Aegean).

$g_v(v)$: New PDF of volume of spill ($0<v<\infty$). This will also be a function of the specific RCO.

q_j: Probability of oil type j (j=1,.., J). This may be a function of the RCO, as the RCO may have non uniform impact on certain types of oil (example: introduce an RCO for gasoline tankers).

$D_{ij}(v)$: damage cost function = expected economic damage if spill of type j hits area i with a volume of v. (non-linear function of v). This is assumed the same as before, as the RCO will do nothing if the same volume of v is spilled.

$C_{ij}(v)$: cleanup cost function = expected cost of cleaning up a spill of type j that hits area i and has a volume of v. This function depends on the response level and response tactics, which here we assume to be a constant. This is also assumed same as before.

$TOT_{ij}(v)$ = expected total cost of a spill of type j that hits area i and has a volume of v $=D_{ij}(v)+C_{ij}(v)$- same as before.

In the same spirit,

$\mu\, q_j$ = new frequency of spills of type j
$\mu\, Q_i$ = new frequency of spills in area i
$\mu\, q_j\, Q_i$ = new frequency of spills of type j in area i
$E_{RCO}(v) = \int v\, g_v(v)dv$ = new expected volume of all spills worldwide.
$E_{RCO}(D_{ij}) = \int D_{ij}(v)\, g_v(v)dv$ = new expected economic damage of a spill of type j in area i.
$E_{RCO}(TOT_{ij}) = \int TOT_{ij}(v)\, g_v(v)dv$ = new expected total cost of a spill of type j in area i.
$\mu\, E_{RCO}(D_{ij})$ = new expected annual economic damage of all spills of type j in area i.
$\mu\, E_{RCO}(TOT_{ij})$ = new expected annual total cost of all spills of type j in area i.
$E_{RCO}(D) = \mu \sum\sum q_j\, Q_i\, E_{RCO}(D_{ij})$ = new expected annual economic damage of all spills worldwide.
$E_{RCO}(TOT) = \mu \sum\sum q_j\, Q_i\, E_{RCO}(TOT_{ij})$ = new expected annual total cost of all spills worldwide.

2. Cost benefit assessment

With the above in mind, we can calculate the expected cost differentials between the status quo and the situation in which the RCO under consideration is applied.

$\Delta E(D) = E(D) - E_{RCO}(D)$, expected economic damage averted due to the global application of the RCO, and

$\Delta E(TOT) = E(TOT) - E_{RCO}(TOT)$, total expected cost averted due to the global application of the RCO.

Notes:

(1) The operators E and Δ can be interchanged, i.e. $\Delta E(TOT) = E(\Delta(TOT))$.

(2) The stakeholders who are the beneficiaries of money savings ΔE(D) and ΔE(TOT) are not the same, and they are not the same with those who incur cost ΔK[11] to reduce environmental risk! We do not deal with this issue here (distribution of costs and benefits), assuming that our "black box" is "society". But it is an issue that needs to be addressed, otherwise those who pay but do not receive benefits will react.

Still, we can say that:

- The specific RCO under consideration is cost-effective globally if its total cost $\Delta K < \Delta E(TOT)$, otherwise it is not.
- Among alternative RCOs that pass this criterion, the one that achieves the highest positive difference $\{\Delta E(TOT)-\Delta K\}$ is preferable.

As shown in the main body of the document, this approach can be extended to combine environmental risk and fatality risk. This need not be repeated here.

Let us now examine some special cases.

3. Special cases

One special case is if we assume that:

$\mu=\lambda$ (i.e. the RCO concerns post-accident measures only, not prevention)

$q_j = p_j$ (i.e. RCO is neutral to the type of oil)

$Q_i = P_i$ (i.e. RCO is neutral to the spill location)

Then:

$$\Delta E(TOT) = \lambda \sum\sum p_j P_i \int [D_{ij}(v)+ C_{ij}(v)] .[f_v(v)- g_v(v)]dv$$

Then the RCO is cost-effective if $\Delta K < \Delta E(TOT)$

Even more special case is the linearity case:

11 Again, ΔK is an equivalent annualized value.

Assume both functions D and C are linear in v, i.e. assume $TOT_{ij}(v) = b_{ij}v$. Then:

$\Delta E(TOT) = \lambda \sum\sum p_j P_i b_{ij} \int v [f_v(v) - g_v(v)]dv$

Or $\Delta E(TOT) = A\Delta E(V)$,

where $A = \lambda \sum\sum p_j P_i b_{ij}$, a constant, and

and $\Delta E(V) = E(v) - E_{RCO}(v)$, the difference in expected volume of one spill between the status quo (without RCO) and the RCO implemented.

In this case, the RCO is cost-effective if:

$\Delta K < A\Delta E(V)$, or

$\Delta K / \Delta E(V) < A$

In fact, an even more special case is this:

If for all i and j, $b_{ij} = B$ = constant (average unit spill cost in dollars/tonne), then (since $\sum\sum p_j P_i = 1$)

$A = \lambda B$, and the RCO is cost-effective if

$\Delta K / \Delta E(V) < \lambda B$, or

$\Delta K / [\lambda \Delta E(V)] < B$

The denominator is the difference of expected total volume spilled in one year, let us name it $\Delta E_{year}(V)$.

Then the criterion is:

$\mathbf{\Delta K / \Delta E_{year}(V) < B}$

That is, the RCO is cost-effective if its total implementation cost ΔK, divided by the expected total spill volume it will avert in one year, is less than this constant B.

One can also convert this into an individual ship basis: If the RCO is to be applied to N ships, and $\Delta K/N = \delta k$ (cost per ship), then RCO is cost-effective if:

$\delta k / (\Delta E_{year}(V)/N) < B$.

The numerator is the per-ship cost of implementing the RCO (on an annual basis) and the denominator is the per ship difference of expected total volume spilled in one year. If the ratio of this two is less than B, the RCO is cost-effective.

Note: For this special case, constant B is the equivalent to what project SAFEDOR names CATS, but it is calculated by a different method. So in a sense the approach that is suggested herein is a generalization of CATS.

How this can be used: If for any reason[12] we want to assume linear cost functions of spill volume, the way to do it is this: Calculate the coefficients a_{ij}, and then the constants A and B, as shown above.

If the cost functions are non-linear, we can do these calculations again, assuming the form of non-linear function is known. Available data suggest significant non-linearities.

4. More special cases

Let us now assume that:
$\mu < \lambda$ (the only difference)
$g_v(v) = f_v(v)$
$q_j = p_j$ (RCO is neutral to the type of oil)
$Q_i = P_i$ (RCO is neutral to the spill location)

This is the case where RCO only reduces frequency, with same spill volume distribution: That is, the RCO does not concern the ship itself, but measures that can be taken to reduce the probability of spills to occur: a VTMIS system, for instance. Ships remain exactly as they are.

Even the RCO of "twin screw for tankers", *with no other change in the design of tankers*, would do the same thing: reduce spill frequency, but leave PDF of spill volume unchanged. Of course, if (as expected) twin screws involve changes in tanker design, then the PDF of spill volume may also change.

Then:
$\Delta E(TOT) = \int\{\sum\sum [TOT_{ij}(v)]\{ \lambda\, p_j\, P_i\, g_v(v) - \mu\, q_j\, Q_i\, f_v(v)\}dv =$

$= (\lambda-\mu) \int\{\sum\sum [TOT_{ij}(v)]p_j\, P_i\, f_v(v)\, dv =$

For the linear case, $TOT_{ij}(v) = b_{ij}v$, and

$\Delta E(TOT) = (\lambda-\mu) \int\{\sum\sum p_j\, P_i\, b_{ij}v\, f_v(v)\, dv =$

$= A(\lambda-\mu)E(v)$, with $A = \sum\sum p_j\, P_i\, b_{ij}$

Here the expected benefits are proportional to the reduction in spill frequency, which is logical.

5. Optimizing RCO resources

What is described in this section should not necessarily belong to an FSA. But the section may provide some interesting insights as regards cost-benefit assessment, not only for environmental criteria, but also for the "standard" FSA criteria.

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[12] Possible reasons: simplicity, political considerations, or the fact that any volume of oil spilled should be treated the same.

In a cost-benefit context, we try to address a question that is different from those typically asked in Step 4 of FSA, but is related nonetheless: Given we have a limited total budget of C, which ship type or types provide the best way to apply a specific RCO? "Best" may mean maximizing $\Delta E(TOT)$ for a given budget of C that cannot be exceeded.

Let us assume that the RCO in question concerns only ship-related measures that can be applied to the existing fleet of ships, consisting of N distinct types of ships, or combinations of ship types and size brackets. Let c_n be the total cost of implementing this RCO on ship category n (all ships of that category), for n=1,..N[13].

Define binary decision variable $x_n = 1$ if this RCO is implemented on ship category n (all of them), and 0 otherwise.

Then the total (annualized) cost of implementation of this RCO will be $\sum c_n x_n$.

What will be the expected benefit of implementing this RCO?

If it is implemented only on ship category n, then we will have an expected benefit of $\Delta E(TOT)_n$, provided of course we can calculate it.

Then the total expected benefit will be $\sum \Delta E(TOT)_n x_n$.

The assumption here is that this is an additive benefit function. This is a reasonable assumption if expected benefits attributed to different ship categories are independent of one another.

Then for a fixed total budget C that cannot be exceeded, we can formulate this as an optimization problem, as follows (decision variables are the x_ns):

Maximize $\sum \Delta E(TOT)_n x_n$
Subject to $\sum c_n x_n \leq C$
$x_n \in \{0,1\}$

Obviously this problem has a trivial solution of $x_n = 0$ for every n if C is less than the smallest of c_ns, and a trivial solution of $x_n = 1$ for every n if $C \geq \sum c_n$. Therefore the problem is only interesting if $C < \sum c_n$.

The above is a well-known integer programming problem, known as the "knapsack" problem, which can be solved exactly by dynamic programming. It can also be solved heuristically by the so-called "greedy" algorithm, which works as follows:

1. Rank-order all ship categories by descending order of $\{\Delta E(TOT)_n/c_n\}$ ratios (expected benefit per unit cost).

2. First apply RCO to ship category that has the highest ratio of $\{\Delta E(TOT)_n/c_n\}$.

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13 C and all c_ns are on an equivalent annualized basis.

3. If the remaining budget allows it, apply RCO to ship category with the next highest ratio $\{\Delta E(TOT)_n/c_n\}$. If it does not, move to category with the next highest ratio.

4. Repeat until overall budget is exhausted.

The analogy of the $\{\Delta E(TOT)_n/c_n\}$ ratio to something that resembles CAF (or in fact CATS) can be seen, even though no linearity in spill volume is assumed. Note, however, that the greedy algorithm is only a heuristic; it does not necessarily produce an optimal solution, as seen in the hypothetical example below.

Assume N=4, C=available budget = 5.
Assume also the following data (cost, benefit and budget units are in $billion/yr):

n	$\Delta E(TOT)_n$	c_n	$\Delta E(TOT)_n /c_n$
1	15	2	7.5
2	21	3	7
3	32	4	8
4	2	1	2

Here the greedy solution is to first pick ship category 3, as the one achieving the highest expected benefit/cost ratio (=8). This uses 4 units of our available budget. But then the only other ship category that can be picked within the remaining budget (=1) is category 4. This produces a total expected benefit of 32+2=34.

The greedy solution is not optimal. The optimal solution is to choose ship categories 1 and 2, with a total expected benefit of 15+21=36.

Solving this problem may help policy makers identify which ship categories are more cost-effective to implement a specific RCO if there is a limit in the allowable budget.

B. Submissions by Correspondence Group members received before the preparation of the draft report

Norway
24 April 2008

Norway has no objections to the schedule. Unfortunately, due to heavy workload, we are not sure we will be able to contribute much to the work, but we will do our best.

As related to the draft document attached by the chairman of the Correspondence Group, we consider it very useful as a discussion document and appreciate the chairman's effort. However, the final outcome of the work should be more focused on criteria to be used.

What we appreciate most with the document is that it lends its support to a CBA approach, and if we also could agree on criteria it would be very much appreciated.

We are also pleased to see that the document seems to support that the risk matrix follows from the criteria.

However, when the document argues for absolute Befit–Cost to be positive, rather than prioritizing according to marginal cost/benefit ratios, we have problems seeing this as a big issue. It seems obvious to us that at IMO both numbers will be discussed and should be a basis for decision making. From the table on page 5, we appreciate that RCO3 could be preferable from a net benefit point of view. The problem is that to calculate the benefit, a conversion factor (like CATS or similar) is necessary. In practice, at IMO, we would suppose that RCO1 would be implemented first, than RCO2 would be considered etc. RCO1 and RCO2 implemented also have a higher net benefit than RCO3 alone. Actually, if all these numbers were estimated by one agreed acceptance criteria based on Cost/Benefit, all three should be implemented. Said differently, we think IMO would prefer the "greedy" algorithm. Look at IPCC – they have also sorted RCOs according to Cost/Benefit ratios. We think this is practical as there are a myriad of possible RCOs, and a large number of potential decision maker, where society could gain if they used the same criteria.

The presentation of the problem as a global optimization problem is appreciated. However, the creation of a body that could carry out global optimization without the involvement of multiple decisions makers is in Norway's view not attractive.

We hope to be able to provide detailed comments to the document and the discussion at a later stage.

IACS
9 May 2008

IACS thanks Greece for the submission. It is an interesting proposal, which raises some interesting points. These are discussed below.

1. Regional versus global measures

The use of the regional costs/analysis would naturally lead to regional RCOs. In other words, an RCO in one area would not be cost effective in another. Does Greece suggest that IMO and ship owners be allowed to take advantage of this or would IMO produce a single set of RCOs in the rules that tankers comply with?

If it is a single set of rules, would it be an average, and therefore legally insufficient in some areas if you apply the ALARP principle, or set to the strictest level (based on cost effectiveness in the area where spills are the costliest and thus legally sufficient in all areas but punitive in some)?

2. Punitive Costs

The costs identified in the document do not seem to include any punitive measures (for example, fines) that may be used by Members/Regions to deter oil pollution. Is it expected to include these costs in the calculations as they may have a dramatic effect on the cost effectiveness of an RCO?

3. The relationship of environmental RCOs to risk to humans

In Greece's document, it is suggested that RCOs that improve the environmental risk performance will either be neutral or beneficial to the risk to humans. This is not the case, if, for example, the rules called for pollution control devices to be fitted to ships, such as booms or dispersants, there would be an increase in the risk to humans due to the risks inherent in their operation. IACS would suggest that it is too early to say what effect Environmental RCOs will have on the risk to humans, but it is essential that the effect is analysed properly for each RCO and no assumptions are made prior to that analysis.

4. Severity measure

IACS understands that the document implies that financial cost is the best severity measure for oil spills. This is an interesting suggestion but IACS is unsure that it will realistically capture the environmental aspects discussed by this group sufficiently.

5. Use of the approach in risk based design and approval

Although we are currently discussing FSA, which is risk assessment for rule making, it should also be noted that one of the benefits of FSA for human risk is that it fits well into a risk based design and approval approach. One concern of the approach suggested is that it would become very difficult for typical naval architects and class plan approval engineers to apply this methodology. A CATS type approach is much easier to use, although perhaps technically less robust. IACS feels that CATS is perhaps too simplistic and that a variable CATS would be a better solution both for FSA, but also so it could be used by the Maritime community at large.

ITOPF
11 May 2008

The document is well focused on the remit given to the Correspondence Group and takes into consideration the most relevant of comments made to and discussions held within the Correspondence Group.

We understand that the principle aim of the document is to find a good alternative to CATS as a measure of benefit when implementing safety or anti-pollution RCO measures. The method proposed in the document is to use "cost effectiveness analysis". In this case the idea is to look at those anti-pollution measures which provide world-wide benefits which exceed implementation costs and then choose the one that promises the greatest such surplus. Unfortunately, we do not see that the shift to a world-wide approach alleviates the major conceptual and practical challenges faced by using CATS, which is a "marginal" (per next tonne avoided) look.

Specific Comments:

1. In the introductory paragraph there is a mixing of "maritime accidents" with "impacts from the maritime trade". ITOPF has always found that there are important differences between the two, especially as pertains to their regulation and control. Although it is not central for the thesis of the document, we would suggest keeping the discussion of accidental impacts separate from chronic, operational impacts.

2. The second paragraph in the introduction states that "significant environmental impacts have been noted from bunker spills from cargo vessels". While we have pointed out in a past submission that bunker spills make up an important share of oil spills overall and are more likely to cause damage that requires clean-up, there

is no evidence that these are resulting in "significant" impacts. At the time we were talking about CATS. We would point out that on a per-tonne basis, spills of bunker fuels tend to cause more damage than tanker spills because some crude oils are less persistent than most fuel oils. However, bunker fuel spills tend to be smaller than crude oil or other oil-as-cargo spills.

3. One previous comment to the Correspondence Group has been turned around a bit on page 3. Where it was earlier suggested that many measures already considered useful for improving health and safety at sea would be beneficial for the environment and therefore do not need explicit consideration, this document now emphasizes that an extra benefit of pro-environmental measures will be reduced fatalities. While this might be true for some RCOs and that would be a good thing, this formulation implies that fatality-improving measures are of less importance that environmental ones.

4. The use of variables and formulas appears correct but does not actually lead to any mathematical transformations or manipulations in the document which are not easily done in words. There is nothing so difficult regarding the concept of cost effectiveness used that the formulas are required.

5. Two powerful assumptions are made in the document. These are: (1) that the total annual costs of spills worldwide are (or could be) known, both in terms of all categories of damage and all forms of clean-up costs; and (2) that this same cost could be known for the case that the RCOs under consideration would be implemented. In a past submission ITOPF has pointed out that the issue with using concepts such as E(TOT) is not simply a matter of overcoming the hurdles of business confidentiality so that the data can be made available. The real problem is that the data does not exist as assumed. Among other difficulties are the unsolved obstacles of designing operational valuation procedures for damage that meet the most basic criteria for validity and reliability. The extensive literature of natural resource damage assessment has shown the great number of difficulties involved. From a practical point of view, there are tremendous challenges to be overcome just defining damage, let alone valuing it. We agree that it might be useful to assume such variables as E(TOT) for theoretical discussions, but it would be overly optimistic to ever expect to develop even the most rudimentary estimate for them. The case with E_{RCO}(TOT) is even worse, as this would be the forecasting in an entirely hypothetical situation.

6. The prediction (on page 4) that RCOs in general will have positive impacts both on the frequency and size of spills appears reasonable, given the experience with safety improvements in shipping in past decades. These have resulted both in fewer and smaller oil spills. For instance, the average annual frequency of tanker spills of 100MT and more fell from nearly 44 in the 1970s to 23 in the 1980s, and 18 in the 1990s. Since the year 2000, the figure has nearly fallen to ten per year.

7. We agree with the IACS comment that the use of world-wide cost effectiveness measures would not be easy to implement by naval architects and others designing safety measures. While CATS could never be anything more than a theoretical construct, it is at least operational in this regard. Perhaps more thought ought to

be given to earlier ideas of finding an appropriate, arbitrary value for CATS as was done for the value of life in mainstream FSA.

Overall, we applaud the effort to find an alternative to CATS but do not believe that the shift from the per-tonne approach to a worldwide view alleviates any of the shortcomings we have faced so far.

Abbreviations

RCO	=	Risk control option
CATS	=	Cost to avert one tonne of oil spilled
FSA	=	Formal safety assessment
E(TOT)	=	expected annual cost of all spills worldwide,
E_{RCO}(TOT)	=	expected annual cost of all spills worldwide, given the implementation of a specific RCO

INTERTANKO
14 May 2008

Dear Professor Psaraftis and Correspondence Group members,

With regard to the Environmental Risk Criteria document submitted by Professor Psaraftis, I have the following comments. My apologies for the delay in getting these to the group. I have been on extensive travel, most recently to the International Oil Spill Conference where these sorts of topics were of great concern. There may be other comments from INTERTANKO.

Overall, as I have mentioned in earlier commentaries, I would support developing a method to incorporate additional parameters of oil impact to find an alternative, more accurate version of CATS for application to the development of environmental risk criteria.

As mentioned by Mr. O'Brien of ITOPF, and as I have shown in a number of my own analyses for GESAMP, the United States National Academy of Sciences, and others, there are remarkable reductions in oil spillage from tankers due to various risk control options (RCO) and perhaps, arguably, due to the increased liability exposure of tanker operators, particularly in the United States. While spill rates have declined internationally and even more dramatically in the United States, the costs of spill cleanup response, and liability and costs for third-party damages and for environmental (natural resource) damages have increased dramatically in the United States, as well as elsewhere. Outside the United States, of course, the concept of environmental damages is held differently and liability limits for cleanup and damages are largely determined by IMO conventions to which the United States are not party. There are also increases in fines and penalties that the vessel owner/operator may be subject to, which was mentioned by Mr. McGregor of Bureau Veritas. When discussing the concept of "oil spill costs", there is also an important consideration that I have encountered that I would like to mention. One's view of the costs of spills depends on the perspective from which one is measuring the costs and impacts. Are we concerned about the cost exposure to the vessel owners/operators? Are we concerned about the cost exposure to IOPC Fund, insurers, or other funding entities? Are we concerned with the cost exposure of governmental agencies? Are we concerned about the costs to society, in which case there may be complex immeasurable economic and social impacts of these spills. (For example, in work I conducted for the United States state of Washington, I was to calculate the long-term impacts of spills to native tribes for which certain shellfish form the basis of protein in the diets of young children who can have impacts on brain development and hence have diminished IQs for which there are long-term reductions in future income.)

As ITOPF has observed in a shifting of the nature of the spills to which its team responds, there are changes in the types of spills we are taking note of. In the United States, there was recently a spill (M/V **Cosco Busan**) in San Francisco Bay that suddenly got the attention of state and federal legislators. (It was a surprise to me as I testified before our Senate on this issue that no one had noticed non-tank vessels before this time!) Changes in tanker and other vessel design in the recent past have altered the types of spills that we observe. There are likely to be more changes with the full implementation of double hull provisions as well as changes in non-tank vessel bunker tank designs that are anticipated. Changes in fuel types and varying patterns of refined product demands and shipments will also affect the nature of spills in the future. We have already seen and will likely continue to see changes in the numbers and volumes of spilled oil, as well as changes in the types of oils that are being spilled. There are also changes in the locations of these spills. Spill location and oil type are extremely important factors in determining the impacts and costs of oil spills, resulting in differences in per-tonne spill costs that range over several orders of magnitude. We need to have a way to determine the effect of RCOs on the patterns of these spills on a spatial basis as well as by spill volume and oil type (e.g., hypothetically, more frequent smaller spills in particular locations *vs.* less frequent larger spills of other oil types in other locations). It is important to note that impact of spill "location" is a complex combination of factors that include: the propensity for the oil to impact the shoreline and/or other sensitive resources; the political regime in which the spill occurs, which impacts the level of liability and potential fines and penalties; the cultural regime, which can impact the acceptability of different levels of cleanup response endpoints, and other social responses to the spill.

While incorporating oil type, spill volume, and location factors into environmental risk criteria calculations may seem an overly daunting task, I believe that it can be achieved with satisfactory and defensible results. I fully agree with Mr. O'Brien that it may not be possible to truly know all of the costs of oil spills worldwide, particularly with different definitions of what constitutes a spill cost. But, nevertheless, there are studies that have shown the relationships between some of the most important factors categories of spill volume (e.g., smaller operational spills, as occur during transfers *vs*. massive releases of oil that occur due to drift groundings), oil type (perhaps three main categories: heavy persistent oils, crude oils, and non-persistent oils), and spill location (offshore *vs.* in port, high sensitive/high liability, lower sensitive/lower liability, etc.) and associated spill costs. In addition to the consequence (impact and cost) side of the risk equation, we need to consider the probability of spills, which is influenced by changes in vessel design and other RCOs (such as VTS), as well as by location. There are certainly always have been and are always going to be "hot spots" for spills – locations with more vessel traffic and oil operations.

Relatively simple risk matrices incorporating these criteria can easily be developed to create cost per tonne of oil spilled by oil type, location type, and volume category. This way, at least to some extent, the several orders of magnitude difference between per-tonne costs can be incorporated into a CATS alternative. In the end, it will likely be necessary to have some kind of cost per tonne factor, but I contend that this can be accomplished – with existing data, or enhancements thereof - through relatively simple algorithms incorporating the factors that we know influence costs.

Respectfully submitted,
Dagmar Schmidt Etkin

United States
20 May 2008

1. The challenge in determining how to value oil spill prevention is that if one tries to do it on a volumetric basis ($/bbl not spilled), small spills provide a dramatically larger cost per barrel than large spills. Part of this is due to the fixed cost that is triggered in response to any spill size, part due to an over-response to exaggerated reports of initial spill volumes and part due to the variance in actual cleanup costs given a host of environmental factors.

2. The focus on both cargo and bunker spills is good. Bunker spills can be a greater risk in certain areas: given casualty statistics, growing bunker volumes and other drivers. However, adding other types of oils such as: vegetable (e.g., coconut and palm oils shipped in high density), animal oils (e.g., industry waste), and other non-petroleum oils (e.g., bitumen in surfactant suspension, kerosene, etc.) might be appropriate to consider in the future.

3. E[TOT] should be partitioned into direct parties (e.g., vessel owner/operator, cargo owner, etc.) and third parties (e.g., local populace, fishing communities, etc.) to get at equity issues in accordance with FSA guidelines. Combining at the end is good, but visibility needs to be maintained on the equity issue.

4. Some may advocate including costs that are in fact transfers, such as legal costs. These should not be considered, as they represent no net impact on the economy, but rather are a transfer of wealth (See OMB "Economic Analysis of Federal Regulations Under Executive Order 12866" at http://www.whitehouse.gov/omb/inforeg/riaguide.html).

5. Methodology focus is on net benefits, which is good, and combination of fatality and environmental costs and benefits is also sound.

6. The United States disagrees with the details of benefits calculations, given our analysis of small spill costs versus large spill costs- the document is correct in asserting that cost is a nonlinear function of spill volume, but does not appear to take this into consideration adequately. The variation amongst spill costs on a per volume basis runs the risk of making cost-benefit analyses pointless, given the influences of other factors as described in bullet #1. This variation dropped dramatically when a fixed cost (uniform cost of gearing up for a response somewhat irrespective of spill volume) was applied in addition to a "per volume" cost.

7. This approach does not appear to integrate with other "elements of risk" such as plans, private response capability, media and stakeholder complexities.

8. Work in the OPRC-HNS technical group may affect this document/effort. Do they relate? Are they necessary for consideration? Etc.

9. Rather than use major locations in terms of geographic areas, use of the ITPOP oil density in transport areas may be more appropriate. These are often coterminous with geographical areas (e.g., Northern Europe is both a high user and a high density transport area (e.g., Rotterdam)). However, often they are not (e.g., Southern Caribbean entry around Trinidad and Old Bahamas Straits are high density transport areas but not part of a high density geographical area.).

10. The focus seems to be blue water operations, however, a tremendous amount of oil of all types transits green water, particular fresh water when you look at the intra-continental shipment routes through Europe (e.g., Rhine, Rhone, Danube), the United States (e.g., Mississippi, Great Lakes, St. Lawrence Seaway), Africa (e.g., Nile), and the Russian Federation (e.g., Volga, Lena, Ob, Don, Denepr).

11. Cost is all too easily assumed, particularly when cost is uniquely economic as under the CLC. Such costs are entirely more complex under the not-exclusively-economic valuation system of OPA90. Note that increasingly case law is changing the CLC presumptions to OPA90 presumptions.

12. While the document does not take into account response options since these may be highly variable with climate, conditions, etc., it should take into account response infrastructure. The presence of pre-positioned equipment catches, the capacity to deliver equipment and material, the presence of vast readily trained personnel, the pre-approval of ISB or dispersant usage, the presence of rescue tugs or tug escorts, all can greatly influence response efficacy.

13. A factor should be created for on-vessel response capability for response.

14. A factor should be created for on-vessel prevention capability such as overfill warning, tank and line pressure monitoring, capacity to transfer product, capacity to recover product from system lines developed for subsurface recovery.

15. A factor for lightering and salvage capability as a “pre” response factor should be included. Significant lightering capability as well as emergency patch and seal capability can greatly improve response options

Japan
20 May 2008

First of all, Japan would greatly appreciate the proposal by Professor Psaraftis as a Correspondence Group coordinator, putting our discussion forward toward the goal of our terms of reference. We consider it very useful as a discussion document.

Japan would basically support the present proposal by Greece, especially proposing an overall framework of FSA as well as a methodology to use monetary basis to incorporate the safety FSA with environmental FSA as described in chapter 4.

We also appreciate the proposal to use difference instead of ratio in choosing a RCO as described in chapter 3. After consideration, we added six more RCO options to the original Table (p.5), and renewed the table as shown in Table.1, where RCO4-6 have same difference of 4 as RCO3, and RCO7-9 have same ratio of 2.5 as RCO1.

It can be seen by comparing RCO3, 4, 5 and 6 in Table 1 that differences are same (=4). By comparing these four RCO, it could be said that RCO6, with B/C ratio of 6, is the most cost effective RCO option among others. Therefore it can be said that if difference is same, RCO which has largest cost benefit ratio might be most preferable RCO. It can be said that not only difference but also ratio is also important in choosing the most preferable RCO. By comparing RCO1, 7, 8 and 9, where B/C ratio = 2.5, RCO7 has the largest difference, and might be the most preferable options among others. Therefore it could be said that if ratio are same, RCO with the largest difference might be preferable.

The question is which RCO is the most preferable among these 9 RCO options. Let us compare the RCO6 and RCO7. RCO7 has the largest net benefit of 4.5, however it needs three times higher costs than RCO6. On the other hand RCO6 has the largest B/C ratio, which means that RCO6 gives effect or benefit most efficiently with smallest costs among other RCO. We think cost might be finite and there might be upper limit for cost so that shipping and shipbuilding industries could run smoothly. There might be a discussion to choose the most preferable RCO considering other conditions such as upper limit of costs and so on. We think final decision might be made reasonably and/or politically by decision makers.

Therefore we basically support the concept proposed by Greece choosing the largest difference, we suggest continuing to discuss about this issue.

As for CATS criteria, we have carried out regression analysis between cost of oil spill and oil spill volume based on IOPCF data. We have compared the CATS and these historical data, and made some comments based on these analyses. Japan is preparing to submit document to MEPC 58 with regard to the results of these analyses.

Table.1

RCO	(C) Cost	(B) Benefit	Net Benefit (difference) =(B)-(C)	ratio =(B)/(C)
RCO1	2	5	3	**2.5**
RCO2	3	6.5	3.5	2.17
RCO3	4	8	**4**	2
RCO4	3	7	**4**	2.33
RCO5	2	6	**4**	3
RCO6	1	5	**4**	5
RCO7	3	7.5	4.5	**2.5**
RCO8	2	5	3	**2.5**
RCO9	1	2.5	1.5	**2.5**

Germany
25 May 2008

Introduction

1. Three elements were discussed in the first Correspondence Group towards MEPC 57. These were the severity index, CATS and ALARP boundaries. It is the position of Germany that these three elements need further discussion before a possible amendment of the FSA guidelines can be agreed on. The following sections provide input mainly to the discussion on the severity index.

Severity Index

2. The severity index (SI) used in a Hazid session for ranking identified environmental hazards was discussed and two options were suggested for further consideration: SI based on oil spill volume and SI based on recovery time. Obviously, both are connected but a proper study

based on historical data linking both is missing/unknown. Therefore, the following attempts to put in perspective both views again.

3. Before deciding on the final SI in this context, one should also consider who will eventually use the SI. If naval architects would use the SI in Hazid sessions, e.g., connected to new or alternative (oil) tanker designs or associated rule development, an SI based on oil spill volume is expected easier to apply consistently.

4. A comparison of suggested severity indices is shown in the following (from MEPC 57/17):

SI	Oil spill volume (Norway)	Recovery time (Greece)	Env. + clean-up costs m$ (UK)	Environmental effect (UK)	Environmental effect (Denmark)
5	>1000 t	>100 y	300	Nationally significant	Long-term disruption
4	100-1000 t	10 – 100 y	30	Locally significant, poor recovery potential	Medium term disruption
3	10-100 t	3 – 10 y	3	Locally significant, good recovery potential	Short term disruption
2	1-10 t	1 – 3 y	0.3	localized	Small, detectable
1	< 1 t	1 m – 1 y	0.03	small	negligible

If the monetary value of cargo (oil: 1 t =7.35 barrels =920 $) and the value of an oil tanker (or damages to it) are used, an estimate for the implicit oil spill volume from the monetary loss values suggested by Denmark can be derived as follows:

SI	Monetary loss (m$)	Ship loss/damage	Value of ship loss/ damage (m$)	Implicit oil spill volume (t)
5	300	Total (large ship)	100	217600
4	30	Total (small ship)	10	21760
3	3	Damage, downtime 7 days	1	2176
2	0.3	Damage, downtime 1 day	0.1	218
1	0.03	small	0.01	22

5. Comparing the above, the following conclusions can be drawn:

- The interpretations of severity scales offered by Norway and Greece differ significantly. E.g., a 100 tonnes spill is associated with a 10 years recovery time.

- The interpretations of severity scales offered by Denmark and the United Kingdom appear similar. The costs associated with the severity scales are identical.

- Recovery time suggested by Greece seems to fit the interpretation be Denmark and the United Kingdom if shifted one order towards higher SI.

- Oil spill volume suggested by Norway seems to fit the interpretation by Denmark and the United Kingdom if shifted (at least) one order towards lower SI.

6. Combining the suggestions based on the above conclusions, leads to the following consolidated table for the SI on environmental damage which is offered for further discussion:

SI	Monetary loss (m$)	Oil spill volume (t)	Recovery time (years)	Disruption of ecosystem
5	300	10000-100000	10-100	Long-term
4	30	1000-10000	3-10	Medium term
3	3	100-1000	1-3	Short term
2	0.3	10-100	0.1-1	Small, detectable
1	0.03	1-10	immediate	negligible

CATS

7. The document offered by Professor H. Psaraftis presents a refined approach to include cost-benefit into FSA. Germany is of the opinion that the newly suggested approach has to be applied before any conclusions on its possible merits and practicability can be drawn. Therefore, it is recommended to apply the newly proposed approach to the assessment of a new tanker design or to a recently introduced rule, in retrospective, and to compare the results with the simpler CATS approach.

8. One property of CATS, as suggested by SAFEDOR, is the constant dependence on oil spill volume. This property has been controversially discussed before and it was argued that specific clean-up costs (which were considered in the derivation of CATS) are not constant for different spill size. The arguments considered above (in the discussion on the severity index) demonstrate that a constant ratio of CAF to CATS, as it was used by Norway to propose values for the SI (see above), may put a too large value on CATS for larger spills.

ALARP boundaries

9. A method to derive ALARP boundaries is available (e.g., MSC72/16) and could be used to determine the boundaries. However, the needed economic value and transport safety record of an alternative transport, say pipelines, is not easily determined. Two other approaches to set the ALARP boundaries were tested and will be published in a forthcoming document (OMAE2008-57257) in June 2008. One approach uses historic data for single and double hull oil tankers and the other approach uses the ratio of CAF to CATS (constant and linear variation). The document concludes that setting with confidence the ALARP boundaries would require a full risk analysis for oil transport by tankers. Such an analysis is currently being completed within SAFEDOR and aimed at submission to MEPC 58, too.

Turkey
26 May 2008

Risk Analysis of Maritime Transport of Hazardous Materials in Turkish Waters

Under the contract of the Turkish Undersecretary for Maritime Affairs, the Marmara Research Center of the Turkish National Science Foundation (MAM) has started a nationwide study on the Identification of the Turkish Marine Environmental High Risk Areas (MEHRAs) and the Feasibility of Emergency Response Centers along the Turkish Coasts. As part of the project, MAM has developed a GIS (Geographical Information System) based risk analysis for the maritime transport of hazardous materials in Turkish waters.

The risk analysis in its general form, uses IMO's Formal Safety Assessment, known as FSA (IMO, 1997) as a starting point and developed upon it with a more elaborate analysis for the geographical distribution of accident probability and the severity of consequences. As suggested in FSA, the following steps are prepared:

STEP 1. HAZARD IDENTIFICATION

In this part, statistical data of maritime accidents in Turkish waters are collected and analysed to identify potential hazards in terms of accident types, their locations and other important parameters. The results indicated that the most significant types of maritime casualties are the following.

i. Collision
ii. Fire & Explosion
iii. Foundering
iv. Mechanical Failure
v. Grounding & Ramming (with/without power)

The next step is prepared using the above accidents types and scenarios.

STEP 2. RISK ASSESSMENT

In the risk assessment section, all parameters which potentially may contribute to the accident probability (meteorology, bathymetry, hydrodynamics, traffic intensity, etc.) and the severity of consequences (economic, social, cultural and environmentally sensitive areas, impact factors, etc.) are collected throughout the Turkish waters and coastlines. The gathered information is stored in a GIS database which are then used to compute the geographical distribution of mathematical accident probability and severity index.

A risk matrix is developed using a six level frequency and severity indices. The resultant risk is defined as the product of the accident probability and the accident severity (or the arithmetic sum of the logarithmic frequency index and severity index):

RISK = (FREQUENCY) x (SEVERITY)

or

$I_R = I_F \, x \, I_S$

The geographical distribution of accident probability, severity and the final risk are computed and shown on nautical maps as the Risk Atlas of the Turkish Waters.

STEP 3. OIL SPILL MODELLING FOR HIGH-RISK AREAS AND SENSITIVITY MAPPING

A mathematical model is used to model the impact of potential oil spills resulting from maritime accidents at high risk areas as identified in the previous section. Several scenarios are developed and run to assess the impact of contamination and other risks involved with the incidents. Results are shown graphically on maps.

STEP 4. RISK CONTROL OPTIONS AND RECOMMENDATION FOR DECISION-MAKING

Results of the previous findings are used to identify high risk areas (MEHRAs) in Turkish waters. For locations where the risk exceeds certain levels, risk control options are proposed to reduce the existing risk level. Locations where a certain risk control option is already in use are identified (i.e. VTS at the Strait of İstanbul, and the Transit Passage Regulations currently enforced in the Turkish Straits). Hazards which are covered by existing regulations are discussed.

COMPARISON OF THE PRESENT METHODOLOGY WITH IMO's FSA

The original method of the FSA suggested by IMO in 1997, theoretically associates the risk with people, environment and property/business, in practice, however, the risk acceptance is only used to assess safety (Starling, 2006). Although the main body of the FSA report suggests a general approach, the details of the hazard identification method as described in the Appendix includes large details of shipboard accident factors for personnel casualties and hazardous substances on board.

The presently employed analysis on the other hand used a different approach mainly due to the project requirements to establish a large scale risk map for the maritime transport in Turkish waters. Especially in terms of hazard identification, the Turkish approach is more detailed in external factors effecting the accident (incl. the meteorology, hydrodynamics, traffic density, etc.) rather than internal factors causing personal injuries and individual risk. Similarly, a more comprehensive analysis is employed to depict the environmental consequences in the computation of the severity (environmental impact) factors. In that sense FSA in its original format is more appropriate to assess, for example, the risk in the general transport systems (i.e. bulk carriers) but not as efficient, for example, in establishing risk maps on a national scale.

For the present Project goals, a GIS based grid model is found to be more appropriate to compute accident probability and severity on individual grid elements which are later used to establish a risk map.

Other methods are proposed by scientists working on maritime risk assessment to improve existing FSA methods for different applications and purposes. Psaraftis (2008) proposed an improved method to account the probabilistic characteristics of environmental factors and consequences in the formal assessment analysis. His methodology is very elaborate in calculating the cost/benefit analysis based on random variables representing the probabilistic nature of oil spill and its consequences world-wide.

Hu *et al*. (2006) suggest a different approach on formal safety assessment based on relative risk model in ship navigation. They employed a mathematical model based on Poisson random process and fuzzy logic to calculate the navigation accident probability and accident severity in Chinese waters and applied this model in Shanghai Harbour.

Tan and Otay (1999), Otay and Ozkan (2003) and Yazıcı (2004) developed different stages of a physics-based approach where environmental factors effecting the maritime casualty risk are all considered to be random variables (weather, surface currents, ship hydrodynamics, traffic intensity, etc.) and solved the physical system equations by accounting all possible outcomes. The model is originally developed for narrow waterways and later applied to the Strait of İstanbul to establish the risk map of the Strait.

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Japan
27 May 2008

Summary of MEPC 58/17/1

On the cost of oil spill from tankers in relation to oil spill weight

Based on historical data of major oil spill incidents from tankers (IOPCF 2006 report), a relation between the cost of oil spill and oil spill weight is investigated with regression analysis. A non-linear regression formula is newly derived to estimate the cost of oil spill with oil spill weight. It is found from the present study that the present regression formula shows relatively good agreement with historical data and gives mean level of cost of oil spill.

The effect of oil type on the cost of oil spill is also investigated, but clear effect of oil type on the cost of oil spill could not be found as far as limited amount of present database although the effect of oil type on the cost of oil spill is well recognized according to many previous studies.

In order to observe the situation in using CATS, the present regression line is compared with a line obtained by CATS (=60,000US$/ton) although it is well recognized that CATS is developed as a practical measure to give the cut-off value for a marginal return of investing in risk reduction (Fig. 1). It is found from the present study that CATS tends to give relatively higher value or upper bound of cost of oil spill. Therefore it could be said that the non-linear regression formula derived in the present study is useful in order to estimate the average cost of oil spill with oil spill weight.

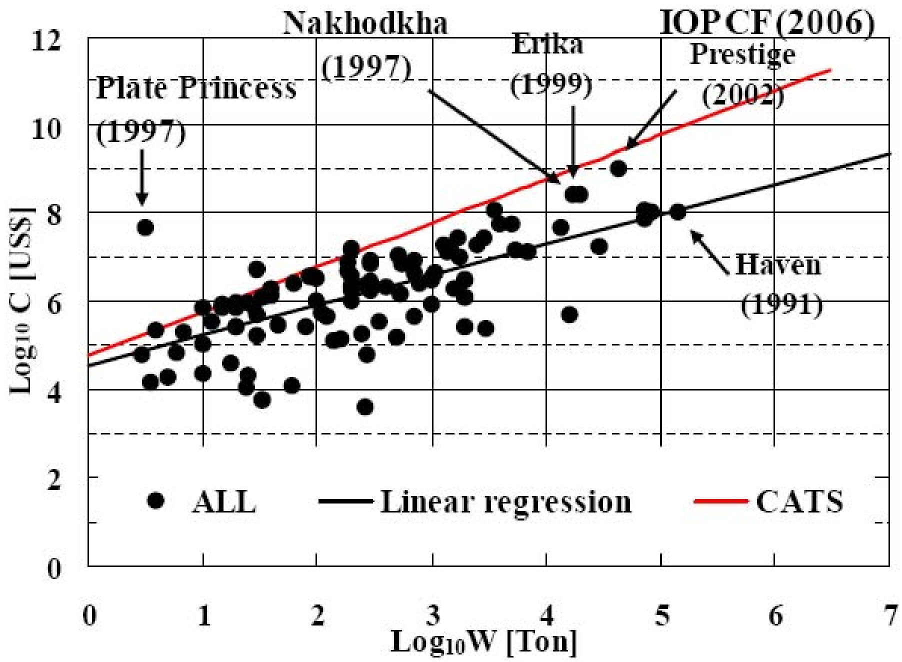


Fig.1 Relation between cost of oil spill and oil spill weight in double logarithm axes. C denotes cost of oil spill [US$], W denotes oil spill weight [ton]. Non-linear Regression formula to estimate cost of oil spill (C [US$]) with oil spill weight (W [Ton]) derived from historical data: $C = W^{0.68} \cdot 10^{4.6} = 35951 \cdot W^{0.68}$. Formula using CATS value: $C = W^{1} \cdot 10^{4.78} = 60000 \cdot W$

Greece
28 May 2008

1. CATS

The formulation provided by our coordinator provides a tool whereby all factors that affect clean-up cost can be incorporated (volume, type of oil, location, etc.).

It would be worthwhile, if not necessary, to attempt to incorporate in the formulation the current available data in order to examine what value results. But of course this will be a considerable project. The linkage with fatalities is another advantage enabling RCOs to be evaluated with a unified criterion if so desired.

Given the excellent first step provided by Professor Psaraftis, we are sure that work toward the goal of arriving at a more realistic formulation or criterion is just starting.

However, for the purposes of this group we should at least arrive at a simple figure which is more realistic than the 60,000 USD/tonne figure proposed by CATS. The more this figure can be closer to reality the better.

For fatalities the CAF criterion is well established. When CAF was developed, the figure assigned to it (threshold of $3 million) had a solid logic and theory behind it. It was as based on Societal Indicators for “quality of Life” (OECD countries).

CATS however lacks such background. We believe that all agree that it was a starting proposal, subject to refinement.

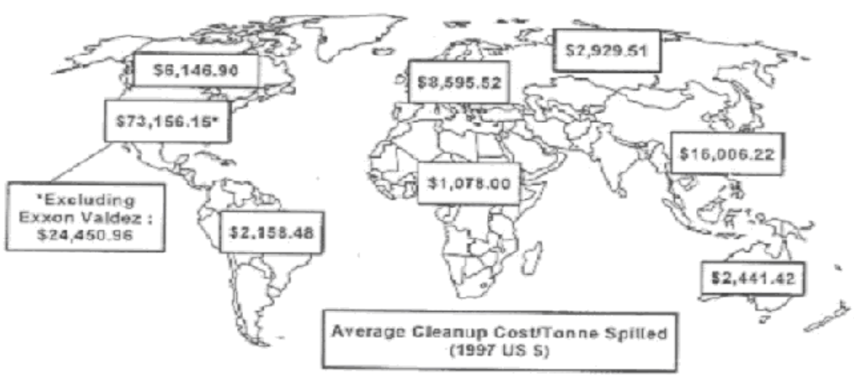
A simple average of USD/tonne of the frequently used Regional Cost estimates (see table below borrowed from Safedor presentation "Risk evaluation criteria for ships and ship systems", R.Skjong, Glasgow, May 6, 2008) produces an average figure of abt 12,000 USD/tonne (with the Asia cost estimate of 33,000 being seemingly too high and thus perhaps in need of more scrutiny?)

Region	USD/Tonne	Traffic share (%)
Middle East	1,300	7
South America	3,800	18
Africa	3,900	18
Oceania	6,900	2
Europe	13,100	11
North America	24,000	19
Asia	33,300	24
Weighted average	15,900	100

A weighted average considering traffic density produces 15,900 USD/tonne.

Even if this figure is further increased by a certain factor (to account for the conceivable willingness of society to pay more for prevention rather than clean-up), it is still very far from the CATS figure of 60,000 USD/tonne.

Another well used reference is the below ITOPF 1997 table. A weighted average assuming same traffic share as above gives about $ 10,000/ tonne (excluding Exxon Valdez). (Again the above "traffic share" was borrowed from above Safedor presentation and we have no information exactly how these percentages were arrived at – they may, or may not, need more validation or refinement – however we refer to it as an example of how weighted averages can be used to approximate reality better.)



It is our estimation that the reported Regional Cost estimates in the first table seemed over-estimated or oversimplified. And we think that the Japanese study on oil spill costs, a summary of which was submitted to the Correspondence Group, seems to confirm that.

2. Comments on other contributions

We wish to thank Japan for their work which obviously goes far to provide a more realistic spill cost estimate, by putting some numbers on the non-linear relation between spill cost and spill volume.

We note that using the Japanese formula, obtained after regression analysis, a spill of 100 tonnes costs 8,236 USD/ tonne, a spill of 1,000 tonnes costs 3,942 USD/tonne and a spill of 10,000 tonnes costs 1,887 USD/tonne. This certainly seems to approximate real life a lot better.

If Japan could take their approach one step further, to propose a linear approximation for their formula (based on their total data), it would certainly be very beneficial. That is, what is the ratio of the average spill cost, divided by the average spill volume?

Such a figure could be used as an interim simplified criterion, until further work on the formulation and re-evaluation of more detailed data provides a refined figure.

We note with interest Germany's contribution. With regard to SI we are open to appropriate severity scales after discussion or agreement by the group, but the type should be linked to recovery time. Granted that a volume linked SI could be easier to use by Naval Architects, but unfortunately "easy" is not always correct or appropriate.

With regard to comments for Professor Psaraftis' formulation, we do not understand the proposal "to apply it first to see how it compares to CATS". We understand that at this stage all data needed to apply the full formulation may not be available, but as said before, the potential is there to be as simple as one elects or as accurate as our current data allows.

With regard to ALARP boundaries it is certainly not an easy subject. Having had the benefit to be present at last SAFEDOR workshop where the tanker FSA was presented, it was eye opening to realize that one 17,000 tonne spill from a double hull tanker has the potential to move the whole current double hull fleet from the near negligible to the unacceptable risk region. Certainly the limited data is one factor for this, but it also calls for scrutiny of the boundaries and their slope (e.g., if the slope was not -1, that "anomaly" of this one spill might not be there).

3. A possible way forward.

1. Very short term: (i.e. from this Correspondence Group):

If a simple volume dependent figure is sought as an interim criterion, we would be very interested to examine the possible linear approximation figure from Japan's study.

2. Short term:

Subsequently we would like to examine if Japan's study can produce "regional cost estimates" on which "traffic share" factors can be applied (obviously this introduces the factor of "location of spill" which is more influential on cost than volume).

3. Longer Term:

Consolidate and categorize available spill data. Examine what other factors (apart from volume and location) can be isolated to show a trend with regard to cost (type of oil, etc.). Use Professor Psaraftis' formulation to include such factors.

We would like to take this opportunity to thank all group members for their valuable and constructive work.

C. Submissions by Correspondence Group members received after the preparation of the draft report[14]

Norway
10 June 2008

Norway appreciate the report.

Whilst we responded positively to some of the suggestion of the chairman, we also made it very clear what we support and what we do not support. The summary, of these two elements, which can be read from Norway's comment, is that we do not support the proposal by the chairman. To be more specific, the main problem is that the proposal by the coordinator in our view does not address the problem.

We therefore think paragraph 38 should be much shortened[15], essentially referring to the acceptance of the document by the Chairman as input to the discussion. It should be noted that the proposal of the Chairman has not been submitted to IMO before, so it is somewhat early to start referring to support from a small correspondence group.

We have had the benefits of reading early versions of the Japan proposal, and think it is too early to refer to this, in particular since we actually do not know what Japan will submit in the end. The early versions did not include the environmental cost, and it did not include the insurance factor (included in the original CATS proposal). We therefore think paragraph 39 should be removed[16].

Greece
10 June 2008

After reading Norway's points we felt we should make the following comments:

It is of course Norway's prerogative not to support the coordinator's proposal, even though its initial reaction had some positive comments, but we just wanted to point out that the fact that this proposal was not previously submitted to IMO is irrelevant. First there was no reason to do so until this Correspondence Group was formed. Secondly, it is exactly the task of this Correspondence Group to look for alternatives, following Greece's submission MEPC 56/18/1 which criticized the validity of CATS, both in terms of its value and methodology.

[14] Expressions of agreement and suggestions for minor modifications omitted.
[15] Paragraph 33 of the report.
[16] Paragraph 34 of the report.

Our coordinator certainly had no formal obligation to submit such a proposal, and he did so only to facilitate the discussion and provide an alternative to CATS, which was the most important pending issue. The proposal itself provides a general framework for the CBA part of the FSA. It can be combined with safety criteria already used in FSA and it can be extended to other environmental criteria. It certainly needs reliable data to do so, but so does any approach, including CATS. The advantage of the proposed approach is that it can go as deep as the available data allows it to go, reducing to CATS in case linearity is assumed.

Since, therefore, the proposal at its extreme simplest form is reducible to a CATS notion, we are perplexed at its rejection by CATS proponents.

Greece’s concerns of CATS have been shared my enough delegations at MEPC to lead to the need for action by forming this Correspondence Group. Judging from the deliberations and positive comments received by various delegations during this round, and the voicing of serious concerns by so many delegations for the original CATS concept and its $60,000 figure, we think it is time to constructively move forward. In that respect, apart from Norway’s clarification of non-support, we feel the coordinator’s draft report accurately reflects the group’s deliberations.

As regards insurance factors, and other elements that should be allegedly included in the study by Japan (or in any other study for that matter), all these refer to the CATS methodology, which Norway gives the impression to dogmatically consider as the only correct approach, in spite of all the concerns that were voiced.

It may be that at the end of the day the 60,000 figure will be adopted by the IMO, while all other approaches are judged invalid. But certainly this delegation, for one, would be very concerned if this turns out to be the case. That is why we are waiting with interest to hear from Japan the figure that we have asked for in our latest comment.

United States
13 June 2008

Thank you for your hard work as this is certainly a challenging topic. The United States finds the report an accurate account of the discussions of the Correspondence Group and that it accurately summarizes the input from the United States during the second round of this Correspondence Group.

However, I must clarify, although the United States supports the intent of a more rigorous and deliberative policy making approach at the IMO level (with regards to the FSA and cost benefit analysis) the United States does not believe the necessary data is available to apply the proposal set forth in the proposed way forward. The United States believes there are too many uncertainties and regional differences for the proposal to determine if a specific RCO is cost effective globally.

Lastly, as stated during the first round of this Correspondence Group, the United States position of CATS is that it is not fully sufficient for use in the cost benefit step of FSA regarding environmental criteria. However, the United States feels it may be worthwhile if each administration explored to determine if there is variability within their own nation with regards to the costs associated with a response; and identifying quantitatively what those factors might be.

Thank you again for the work of the coordinator and all in the group.

Germany
13 June 2008

Thank you for the draft Correspondence Group report. Your effort is highly appreciated.

The report captures the essence of the group's considerations. We note, however, that little time has been spent discussing the severity index for use during hazids and the setting of an ALARP area.

Regarding the report, we suggest the following comments:

– one should aim to uniformly write "risk evaluation criteria" throughout the report.

– the 2nd sentence below the table of the summary on the contribution from Germany should read: "A paper on setting an ALARP area related to societal environmental risk acceptance is being published. An FSA on oil tankers is currently being finalized."

– paragraph 39:[17] it is noted that the proposal from Japan essentially suggests a functional dependence of CATS on spill size/weight. This has been discussed before and one conclusion to this could be to call for a study to look into this specifically.

We agree with the coordinator that more time and intensive debate are needed to further progress on the rather complex issue of determining a cost-effectiveness criterion related to environmental risk reduction.

Assuming that the Correspondence Group will continue on its path, Germanischer Lloyd is willing to contribute organizing a workshop to discuss related matters and to support progressing faster towards future environmental risk evaluation criteria.

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[17] Paragraph 34 of the draft report.