ENVIRONMENTAL RISK EVALUATION CRITERIA

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Some history

- My 1st time ever in Glasgow
- My 1st time in Scotland since 1980

What I will talk about

- Triggered by an unpredictable sequence of quasi-random events
- (much like a marine accident)

The 1st trigger

- Kontovas, C.A, " Formal Safety Assessment: Critical Review and Future Role", Diploma Thesis supervised by H.N. Psaraftis, National Technical University of Athens, July 2005.
- Kontovas,C.A. and Psaraftis, H.N, (2006) "Formal Safety Assessment: a critical review and ways to strengthen it and make it more transparent" Working Paper NTUA-MT-06-102, National Technical University of Athens.
- Annex to MSC 82/INF.3: submission of Greece to MSC 82 (Nov. – Dec. 2006)

Various FSA/GBS- related papers

- Psaraftis, H.N. and Kontovas, C.A., (2006), "Safety, Risk, Probability: or Playing with Lives", Lloyds List, 25 January.
- Psaraftis, H.N., (2006), "GBS vs. 'Safety-Level Approach': Contributing to the debate," informal presentation, MSC 81, May.
- Zachariadis, P., H.N. Psaraftis and C.A. Kontovas (2007), "Risk Based Rulemaking and Design: Proceed with caution", RINA Conference on Developments in Classification and International Regulations, London, January.
- Kontovas, C. A., H.N. Psaraftis, and P. Zachariadis (2007), "The Two C's of the Risk Based Approach to Goal-Based Standards: Challenges and Caveats," International Symposium on Maritime Safety, Security and Environmental Protection, Athens, Greece, September.
- Kontovas, C. A., H.N. Psaraftis, and P. Zachariadis (2007), "Improvements in FSA Necessary for Risk-Based GBS," PRADS 2007 Conference, Houston, USA, October.

The 2nd trigger

- Skjong, R., E. Vanem, Ø. Endresen (2005).”Risk Evaluation Criteria” SAFEDOR-D-4.5.2-2005-10-21-DNV; 21 October 2005.
- MEPC 55/18: Outcome of MSC 81 on FSA
  - Revised FSA guidelines
  - (Annex 3: Environmental Risk Acceptance Criteria)

Environmental-related papers

- Kontovas, C.A. and Psaraftis, H.N, (2006), "Assessing Environmental Risk: Is a Single Figure Realistic as an Estimate for the Cost of Averting one Tonne of Spilled Oil?," Working Paper NTUA-MT-06-101, National Technical University of Athens, February.

- MEPC 56/18/1: submission of Greece to MEPC 56 (July 2007)
- MEPC 57/17: report of CG on FSA: submitted by Greece to MEPC 57 (March-April 2008)

Basic topic of paper

- So far FSA guidelines do not account for environmental risk
- How do we cover it?

The CATS criterion

- "Cost to Avert one Tonne of Spilled Oil" (CATS) introduced by project SAFEDOR
- Concept similar to CAF (cost to avert a fatality)
- RCO cost effective if CATS < threshold
- Many assumptions used, .. →
- Estimate of threshold at ~$60,000/tonne

What can we say about CATS?

Cost of spill as a function of volume

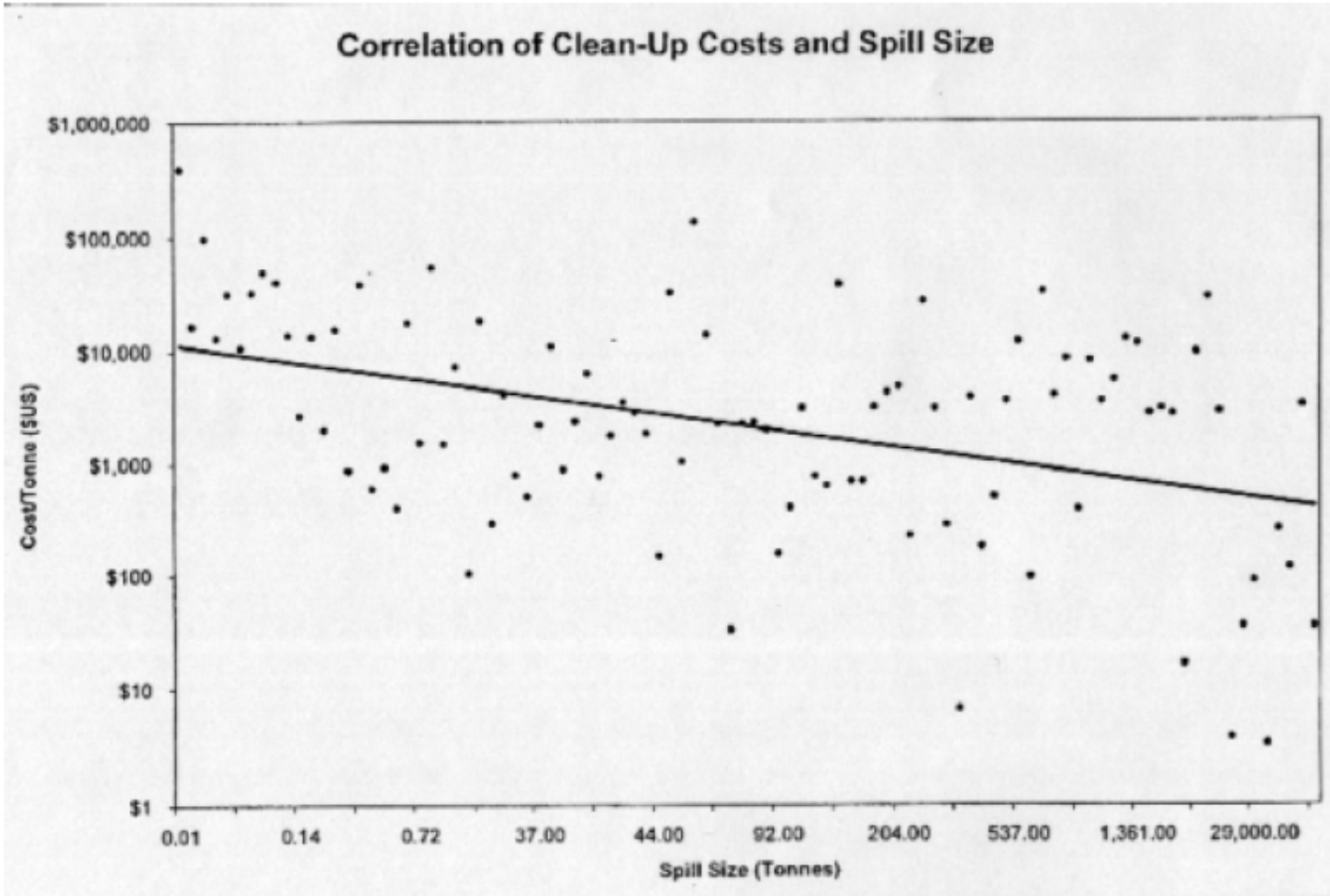
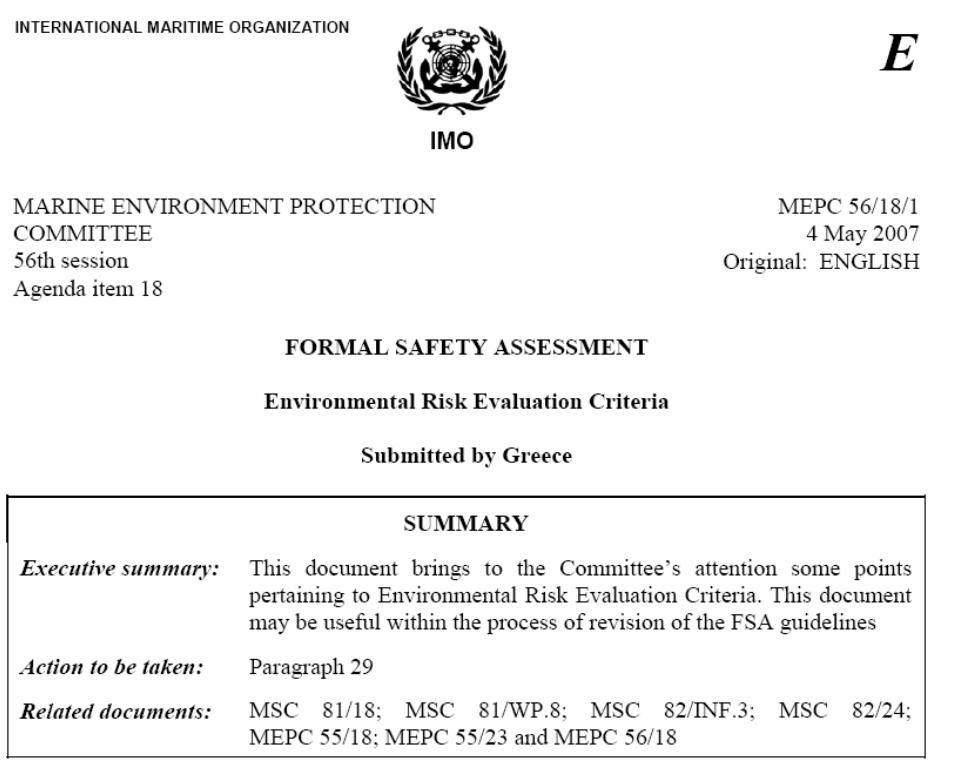


Figure 18: Correlation of per-tonne cleanup costs and spill size based on analysis of oil spill cost data in the OSIR International Oil spill data base [75].

The ball to MEPC

- MEPC 56/18/1: submission by Greece



INTERNATIONAL MARITIME ORGANIZATION

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MARINE ENVIRONMENT PROTECTION COMMITTEE
56th session
Agenda item 18

MEPC 56/18/1
4 May 2007
Original: ENGLISH

FORMAL SAFETY ASSESSMENT

Environmental Risk Evaluation Criteria

Submitted by Greece

SUMMARY

Executive summary:	This document brings to the Committee's attention some points pertaining to Environmental Risk Evaluation Criteria. This document may be useful within the process of revision of the FSA guidelines
Action to be taken:	Paragraph 29
Related documents:	MSC 81/18; MSC 81/WP.8; MSC 82/INF.3; MSC 82/24; MEPC 55/18; MEPC 55/23 and MEPC 56/18

MEPC 56/18/1 (Greece)

Argued, among other things, that:

- we need to develop a Severity Index appropriate for the environment.
- the ALARP region limits (what is intolerable and what is negligible) and the slope of -1 need to be discussed and debated.
- CATS is not an appropriate criterion.
- the way CBA is performed should be discussed.

MEPC 56 (July 2007): Formation of a Correspondence Group (CG)

18.7 The Committee, noting that further work, including more research, was needed on the subject, agreed to establish a correspondence group, under the co-ordination of Greece*, with the following terms of reference:

.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.

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CG workplan

- July- December 2007
- Two rounds of submissions
- Web site
- Synthesis by CG coordinator
- Report to MEPC 57

Report of CG to MEPC 57

INTERNATIONAL MARITIME ORGANIZATION

IMO

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MARINE ENVIRONMENT PROTECTION COMMITTEE
57th session
Agenda item 17

MEPC 57/17
17 December 2007
Original: ENGLISH

FORMAL SAFETY ASSESSMENT

Report of the Correspondence Group on Environmental Risk Evaluation Criteria

Submitted by Greece

SUMMARY

Executive summary:	This document reports on the outcome of the work of the correspondence group on environmental risk evaluation criteria
Action to be taken:	Paragraph 39
Related documents:	MEPC 55/18, MEPC 56/18, MEPC 56/18/1, MSC 83/INF.2

Approach

- Basic question: How can FSA be extended to account for environmental criteria?

- Terms of reference of CG limited to oil pollution
  - From cargo of tankers
  - From bunker spills of any ship

Extended scope (not of this CG)

- Residues
- Recycling
- Paints
- Garbage
- Air emissions
- Noise
- Water ballast
- Radioactive and dangerous cargoes
- etc

CG members

Canada, Denmark, France, Ghana, Germany, Greece, Japan, Malaysia, Netherlands, Norway, United Kingdom and United States; the International Oil Pollution Compensation Funds (IOPC Funds); the International Association of Classification Societies (IACS), the International Association of Independent Tanker Owners (INTERTANKO), and the International Tanker Owners Pollution Federation Limited (ITOPF).

- Most active:
  Germany,
  Greece,
  Intertanko,
  ITOPF,
  Norway,
  UK,
  USA.

Discussion

- Biggest discussion: CATS
- Some for (Germany, Norway)
- Some against (Greece, USA, Intertanko, ITOPF)
- USA tried something like CATS years ago and abandoned it
- No alternative to CATS was proposed

Discussion cont'd

- UK approach

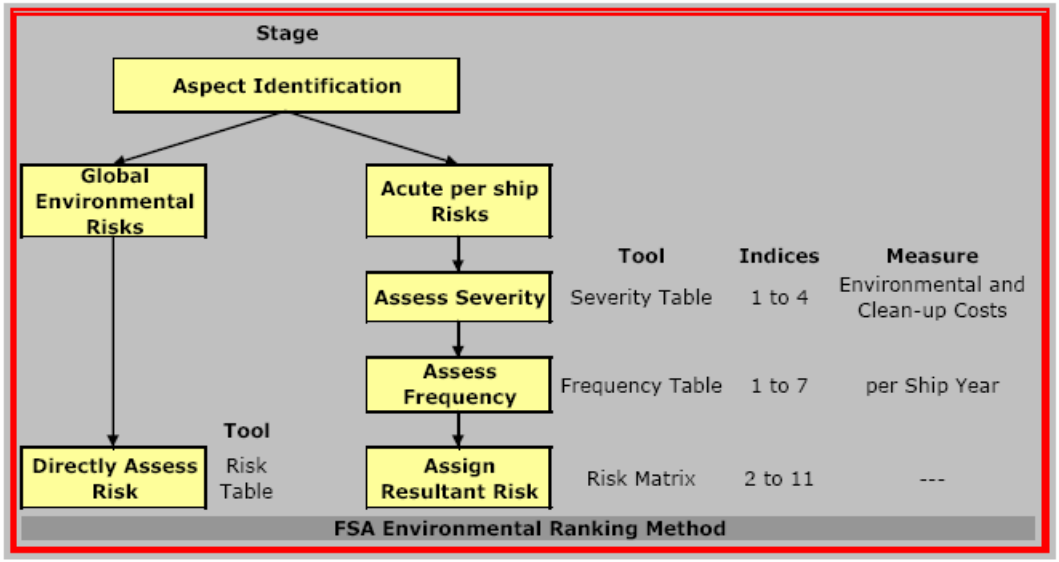


Figure 4 Proposed Environmental Ranking Method

Status before MEPC 57

Summary

34 The following table attempts to summarize the main issues discussed by the correspondence group which are currently open and merit further discussion.

Issue	Comment
Decide on appropriate Severity Index (SI) in Hazid step.	No consensus was reached on what should be the consequence variable.
Decide on CATS versus alternative criteria.	No consensus was reached whether CATS or an alternative criterion would offer the needed decision-making quality.
Decide on boundaries of ALARP region, slope of F-N diagram and what is the variable of horizontal axis.	Slope of -1 questioned by two correspondence group members, but no consensus was reached on alternative proposals.

At MEPC 57 (March 31-April 4):

- CG report well received
- Extend terms of reference of CG to MEPC 58 (October 2008)
- Deadline for bulky docs: July 4, 2008!

The way forward

- THIS PAPER: STEPS 3 and 4 of FSA
- (2 more issues open)

RCOs to reduce oil pollution risk

- Any RCO that reduces oil 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.
  - Although incidents that lead to fatalities may not necessarily lead to oil pollution, or vice versa.
- A specific methodology already exists in FSA for looking at fatalities and injuries.
- Attention is due when combining the benefits of fatality risk reduction to those due to oil pollution risk reduction.

Assume two scenarios:

- (A) the status quo
- (B) 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.
- Need a way to decide if this RCO is cost-effective and hence should be recommended for adoption

Reduce oil pollution risk: how?

BASICALLY 2 WAYS:

- Reduce probability of spillage
- Mitigate consequences of spillage, if it happens

- (risk= probability X consequences)

Typical RCOs

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

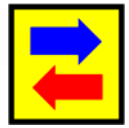
STATUS QUO (without RCO):

Define E(TOT) as the expected annual total cost of all spills worldwide.

TWO COMPONENTS:

- (A) Expected annual **total damage cost** of these spills, taking into account
  - economic consequences to the ship owner,
  - the cargo owner,
  - fisheries,
  - tourism,
  - other industries that may be impacted negatively by the spill,
  - quantifiable damages to the environment,
  - etc

- (B) Expected annual **total cleanup 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.



Assume that

- We know how to calculate E(TOT)
- (method how to do it, later)

How can E(TOT) be reduced?

- Introduce a specific RCO
  - choose from list
- Apply RCO:
  - Globally (to all ships, everywhere)
  - Or locally (to some ships or to a certain geographical area)
- Cost of RCO application = ΔK (known)
  (annualized basis)

Effects of RCO = 2

- Spill frequency may change because of it
  - Presumably it will be reduced
- Probability distribution of spill volume may change because of it
  - Presumably less oil will be spilled, and expected spill volume will be reduced

WITH this RCO applied:

- $E_{RCO}(TOT)$ = New expected annual total cost of all spills worldwide
- Presumably $E_{RCO}(TOT) < E(TOT)$
- $E_{RCO}(TOT)$ can be computed same way as E(TOT)- more later

Cost Benefit Assessment

- Define $\Delta E(TOT) = E(TOT) - E_{RCO}(TOT)$
- $\Delta E(TOT)$ = Expected benefit from RCO
- RCO is cost-effective globally if

$$\Delta K < \Delta E(TOT)$$

Comparison among RCOs

- Among alternative RCOs for which $\Delta K < \Delta E(TOT)$, pick the one that achieves the highest positive difference $\{\Delta E(TOT)-\Delta K\}$

- NOTE: **NOT** the one that achieves the highest ratio $\Delta E(TOT)/\Delta K$!

Beware of ratio tests?

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

(in $billion/yr)

- Highest difference: RCO3
- Highest ratio: RCO1
- If RCO1 is chosen, $1 billion/yr less expected benefits

Important note

- The stakeholders who will receive the expected benefits ΔE(TOT) can be many.
- But they may not be the same with those who will incur cost ΔK to adopt RCO!

- 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.

Combining environmental and safety risk

- RCOs that reduce pollution risk may also improve safety, i.e. reduce the risk of fatalities.
- How can this be incorporated into the CBA?

Currently in FSA

- Cost to Avert a Fatality (CAF)
- GCAF and NCAF

GCAF

- If GCAF = $\Delta C/\Delta R <$ VHL, then RCO is cost-effective, otherwise not
  - ΔC: Cost of introducing RCO
  - ΔR: Expected reduction of fatalities
- Among alternatives that pass this test, choose the one with the minimum GCAF.
- VHL = $3million

[NCAF

- If NCAF = (ΔC-ΔB)/ΔR < VHL, then RCO is cost-effective, otherwise not.
  - ΔB: Benefit of introducing RCO

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

Note 1: CAF is another ratio test

- $\Delta C/\Delta R <$ VHL

- But can also be written as a difference

  $VHL^* \Delta R - \Delta C > 0$

(see MSC82/INF.3 on possible pitfalls on the use of ratio tests in CBA)

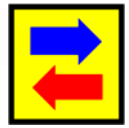
Combining the criteria

- The specific RCO under consideration is cost-effective globally if its cost

  $\Delta K < \Delta E(TOT)+VHL*\Delta R$, otherwise it is not.

- Among alternative RCOs that pass this test, choose the one that achieves the highest positive difference

  $\{\Delta E(TOT) +VHL*\Delta R -\Delta K\}$.



Note 2

- Unclear if or how this can be expressed as a ratio test
- Unclear why it should be expressed as a ratio test!

Note 3 (NCAF)

- The specific RCO under consideration is cost-effective globally if its cost

  $\Delta K < \Delta E(TOT)+VHL*\Delta R +\Delta B$, otherwise it is not.

- Among alternative RCOs that pass this test, choose the one that achieves the highest positive difference

  $\{\Delta E(TOT) +VHL*\Delta R +\Delta B -\Delta K\}.]$

Other environmental consequences

- These 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.

Approach can still be applied!

FOR A SPECIFIC CASE, DEFINE:

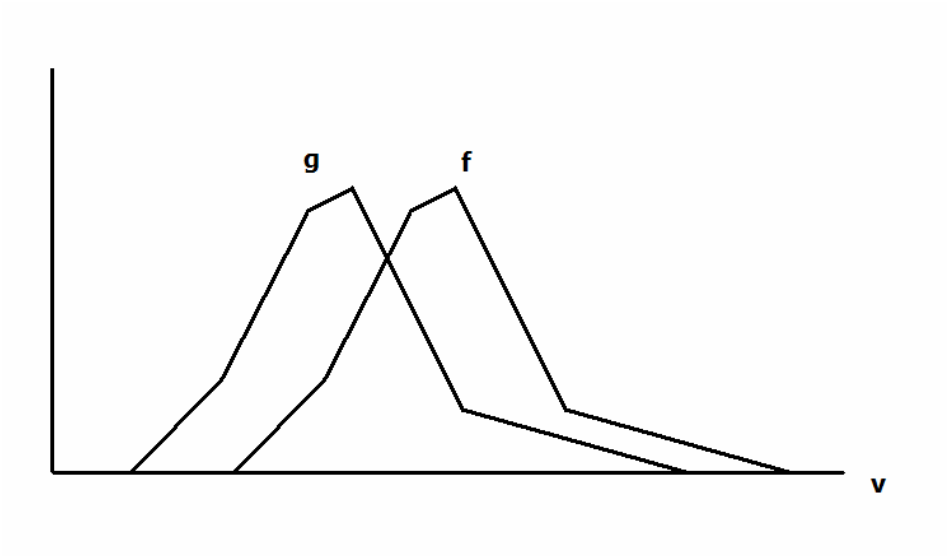
- E(TOT) and E_{RCO}(TOT): Expected annual total costs associated with environmental consequences, before and after the application of a specific RCO (respectively).
- For instance, one may contemplate a measure to mitigate SOx emissions, a measure to reduce recycling residues, and so on.

HOW TO COMPUTE E(TOT)

- SEE **ANNEX A** OF PAPER
- Assumes spills are generated according to a Poisson process of known frequency λ
- Assumes known spill volume distribution f(v)
- Assumes various other known probabilities and damage & cleanup cost functions (generally non-linear with spill volume)
- Accounts for different spill locations and oil types

What an RCO may do

- It may reduce spill frequency to $\mu<\lambda$
- It may change spill volume distribution from f(v) to g(v)
- both μ and g(v) known
  - use of probabilistic modelling, Bayesian analysis and/or the help of expert opinion



Special cases

- Special case μ=λ
  - RCO concerns only measures to mitigate damage once pollution occurs
  - Many “ship-design” measures are in this category
- Total cost function assumed linear in spill volume v (or linear approximation is used)

Then, criterion reduces to

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

- Numerator = per ship cost of implementing the RCO (on an annual basis)
- Denominator = per ship reduction of expected total volume spilled in one year
- B: a constant (function of input data)
- B ↔ CATS threshold! (but computed differently)

Optimizing RCO resources

- Adress a different, but related problem:
- 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 ΔE(TOT) for a given budget of C that cannot be exceeded.

‘Knapsack’ problem

Maximize $\sum \Delta E(TOT)_n x_n$

subject to $\sum c_n x_n \leq C$

$x_n \in \{0,1\}$

Inputs:

c_n =cost of applying RCO to all ships of type n

$\Delta E(TOT)_n$ = equivalent expected benefit

Decision variables:

x_n= 1 if ship type n is chosen, 0 otherwise

‘Greedy algorithm’ (approximate)

- Rank-order all ship categories by descending order of $\{\Delta E(TOT)_n/c_n\}$ ratios (expected benefit per unit cost).
- First apply RCO to ship category that has the highest ratio of $\{\Delta E(TOT)_n/c_n\}$.
- 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.
- Repeat until overall budget is exhausted.

Example (N=4, available budget=5)

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

- Greedy solution: Pick types 3 and 4 (exp. benefit = 34)
- Optimal solution: Pick types 1 and 2 (exp. benefit = 36)

Current plan

- This approach sent to CG members
- Wait for feedback & contributions
- Synthesize
- Submit to MEPC (by July 4!)
- Discuss at MEPC 58 (October)

Final outcome?

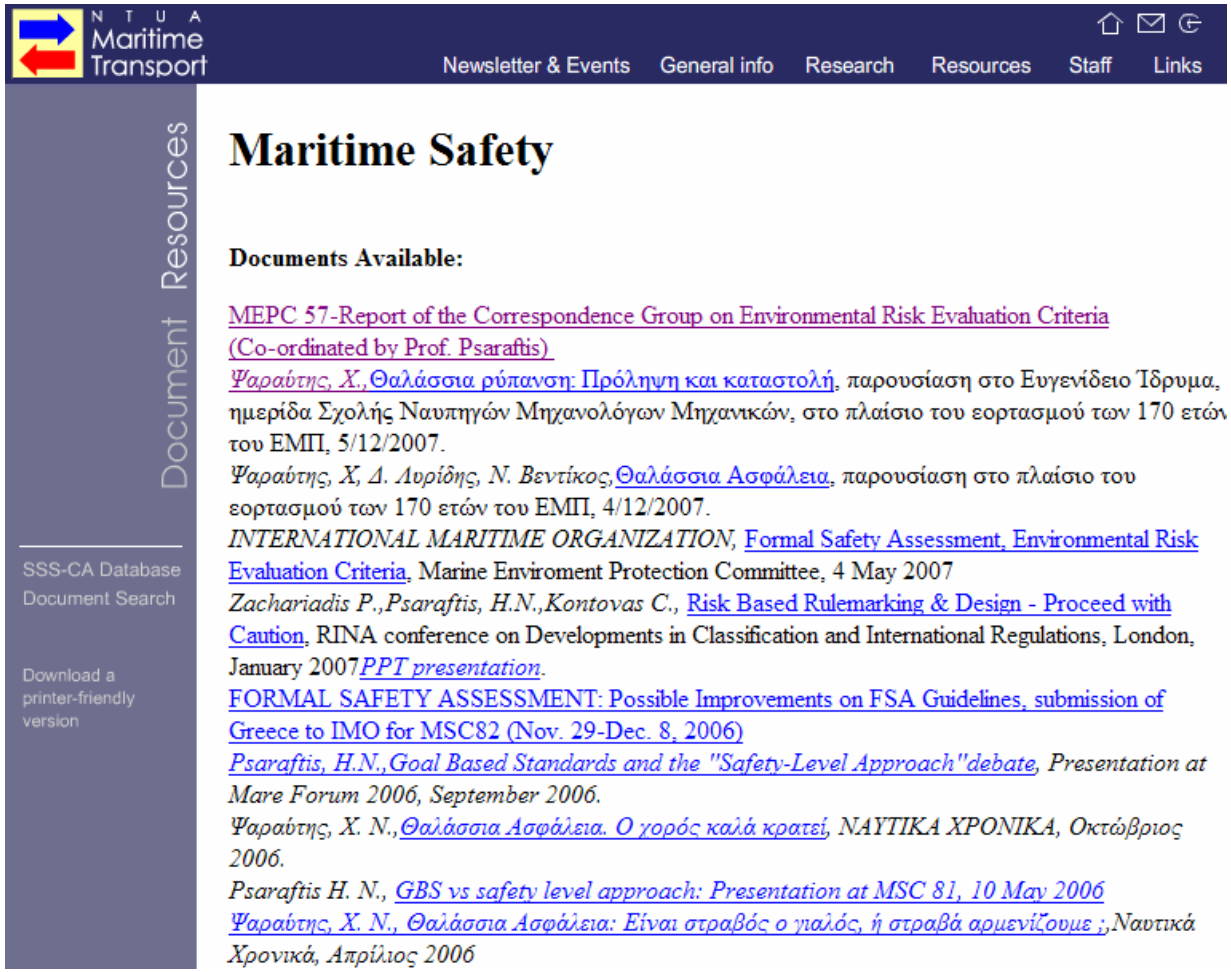
Long-run picture

BEYOND OIL POLLUTION:

- Residues
- Recycling
- Paints
- Garbage
- Air emissions
- Noise
- Water ballast
- Radioactive and dangerous cargoes
- Etc

- MY OPINION: Not a simple extension of FSA!

http://www.martrans.org/resources/render1.asp?doc=/documents/browse/sft.xml



THANK YOU!

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