GBS vs “Safety Level Approach”: contributing to the debate

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The debate

- Should a “safety level approach” be used in GBS?
- Should GBS be “risk based”?
- Should FSA be used in GBS?
- Should SRA be used in GBS?
- What are the linkages?
- Etc, etc

The debate

- Should a “safety level approach” be used in GBS? **YES**
- Should GBS be “risk based”? **YES**
- Should FSA be used in GBS? **YES**
- Should SRA be used in GBS? **YES**
- What are the linkages? **MANY**

- THE REAL QUESTION: **HOW, and WHEN ?**

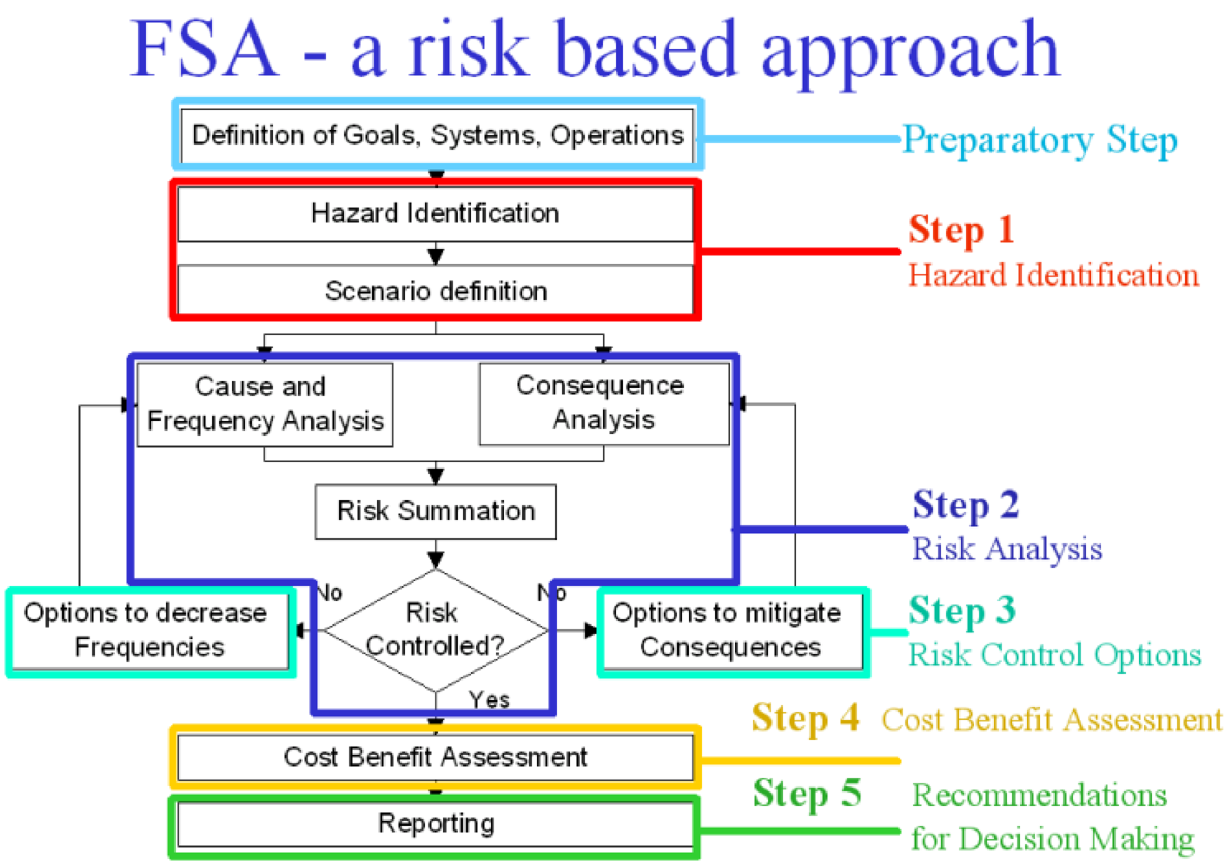
The need to be proactive

- **Proactive** safety regulations should be based on advance identification of risks and sound scientific justification **before** the policies are adopted.
- Much of the story thus far is quite the opposite, as many regulations have been adopted ad hoc in the aftermath of a catastrophic accident (e.g. after *Exxon Valdez, Estonia, Erika, Prestige* and so on).
- **The road from reactive to proactive: FSA & GBS**

FSA

- No doubt: FSA has been the premier scientific method to support proactive maritime safety regulation, at IMO and elsewhere
- BUT: Are there areas where FSA exhibits deficiencies (or glitches), which should be rectified?
- Answer: **Of course!**
- in what follows, only a sample will be presented

FSA steps (IACS – MSC 75)



FSA Step 1 (HAZID)

OBJECTIVES

- to identify all potential hazardous scenarios which could lead to significant consequences, and
- to prioritize them by risk level

Possible "glitches"

- Use of frequency instead of probability breaks down if little or no data is available

- Risk index approach has "glitches"

In FSA, “frequency” is used instead of “probability”

BUT:

- Frequency ≠ Probability!
- Frequency = Probability only if historical data sample is large
- Basing analysis on historical data is not proactive
- What if there is no data?
- Eg, what is the probability of structural failure of a tanker built according to IACS’s new CSR?

Frequency and severity indices

(MSC Circ. 1023)

Frequency Index			
FI	FREQUENCY	DEFINITION	F (per ship year)
7	Frequent	Likely to occur once per month on one ship	10
5	Reasonably probable	Likely to occur once per year in a fleet of 10 ships, i.e. likely to occur a few times during the ship's life	0.1
3	Remote	Likely to occur once per year in a fleet of 1000 ships, i.e. likely to occur in the total life of several similar ships	10^{-3}
1	Extremely remote	Likely to occur once in the lifetime (20 years) of a world fleet of 5000 ships.	10^{-5}

Severity Index				
SI	SEVERITY	EFFECTS ON HUMAN SAFETY	EFFECTS ON SHIP	S (Equivalent fatalities)
1	Minor	Single or minor injuries	Local equipment damage	0.01
2	Significant	Multiple or severe injuries	Non-severe ship damage	0.1
3	Severe	Single fatality or multiple severe injuries	Severe damage	1
4	Catastrophic	Multiple fatalities	Total loss	10

Possible deficiencies

- 10 severe injuries equivalent to 1 fatality?
- No distinction for > 10 fatalities
- This means that 50, 100, 1000, 3000, or more fatalities are somehow equivalent to 10?

Risk index RI= FI+SI
(MSC Circ. 1023)

- Risk = frequency X severity

Risk Index (RI)					
		SEVERITY (SI)			
		1	2	3	4
FI	FREQUENCY	Minor	Significant	Severe	Catastrophic
7	Frequent	**8**	**9**	**10**	**11**
6		**7**	**8**	**9**	**10**
5	Reasonably probable	**6**	**7**	**8**	**9**
4		**5**	**6**	**7**	**8**
3	Remote	**4**	**5**	**6**	**7**
2		**3**	**4**	**5**	**6**
1	Extremely remote	**2**	**3**	**4**	**5**

Risk Index problematic

- Once a month (FI=7), an accident leads to an injury (SI=1). This means that **RI=8.**
- Within a year in a 1,000–ship fleet (FI=3), an accident leads to more than 10 deaths (SI=4) . This means that **RI=7.**

- Why is 2nd scenario less serious than 1st?

Diagnosis

- Concept of risk is inherently 2-dimensional (probability, consequence)
- But Risk Index is 1-dimensional
- Collapsing to 1 dimension loses much of relevant information
- **Risk matrix assigns more importance to high-frequency, low-consequence events, and less to low-frequency, truly catastrophic events**

The “Political risk”..

- .. is that regulations that are promulgated may be more tailored to high-frequency, low-consequence scenarios than to low-frequency, truly catastrophic scenarios.
- One would need a way to cover both cases.

Suggestions for FSA Step 1

- Use probability instead of frequency
- Use probabilistic modelling (from 1st principles) for cases with little or no historical data
- Use Bayesian approaches to update probabilities as data becomes available
- Maintain two-dimensional aspect of risk, or
- Revise/refine risk matrices (esp. for environmental consequences-see later)

FSA Step 4 (Cost benefit assessment)

- Most crucial and vulnerable step in FSA
- If one wants to manipulate FSA's results, this is the usual step to do it

- ΔC = cost per ship of the RCO under consideration.
- ΔB = economic benefit per ship resulting from the implementation of the RCO.
- ΔR = risk reduction per ship, in terms of fatalities averted, implied by the RCO.
- GCAF = $\Delta C/\Delta R$
- NCAF = $(\Delta C-\Delta B)/\Delta R$

The $3M yardstick

An RCO is acceptable if

- GCAF < $3M
- NCAF < $3M

- Among alternative RCOs that pass this test, the RCO with the lower CAF is preferable

Use caution!

- Hypothetical example

	ΔR	ΔC ($)	ΔB($)	GCAF ($m)	NCAF ($m)
RCO1	0.10	100 000	90 000	1.0	0.10
RCO2	0.01	9 000	8 500	0.9	0.05

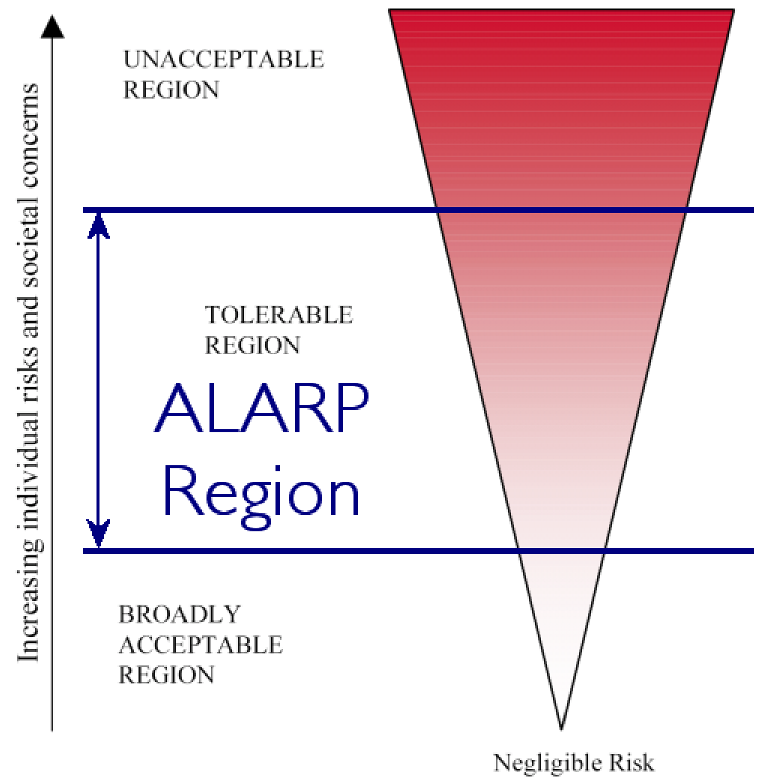
- both RCOs are acceptable, since GCAF<$3m and NCAF<$3m.
- RCO2 is superior to RCO1 in terms of both criteria.
- However, RCO1 reduces fatality risk ten times more than RCO2!
- **The RCO that is selected as best is 10 times more risky than the one that is rejected!**

Suggestions for FSA Step 4

- Extreme caution in calculating ΔR, ΔB, ΔC!
- GCAF should have a hierarchically higher priority than NCAF.
- Examine NCAF, only if GCAF satisfies criterion.
- Caution with NCAF, especially if <0.
- Interaction among RCOs needs re-calculation of CAFs.
- Utmost caution in calculating environmental consequences! (more on this later)

FSA Step 5 (recommendations for decision making)

- What is a desired risk level?
- ALARP principle



Individual risk acceptance criteria

MSC 81/18
ANNEX 1
Page 7

5.3 Recommended risk acceptance criteria

The following criteria are broadly used in other industries and have been also published in HSE (1999).

Decision Parameter		Acceptance Criteria	
		Lower bound for ALARP region	Upper bound for ALARP region
		Negligible (broadly acceptable) fatality risk per year	Maximum tolerable fatality risk per year
Individual Risk	to crew member	10^{-6}	10^{-3}
	to passenger	10^{-6}	10^{-4}
	to third parties, member of public ashore	10^{-6}	10^{-4}
	target values for new ships *)	10^{-6}	Above values to be reduced by one order of magnitude
Societal Risk	to groups of above persons	To be derived by using economic parameters as per MSC 72/16	

Table 1: Quantitative risk evaluation upper and lower bounds

Comparison to air transport

- Chance of being involved in a fatal air crash: 1 in 8 million per flight on 1st world airlines (Barnett, 2006)
- Take a flight every day: expected time until death is 22,000 years
- Take 8 flights a year: annual risk of death is 10^{-6}
- A ship passenger is allowed an annual risk 100 times higher? (10^{-4})

- **Are maritime transport travellers second class citizens?**

FSA Steps 2 &3 (Risk analysis and RCOs)

- Much of the same problems if based on frequency
- F = No. of casualties/ Shipyears
- PLL = No. of fatalities/ Shipyears

MSC 81/INF.6 by IACS

- Example on how to link SRA and GBS
- Failure mode: Longitudinal bending, hull girder failure, sagging (not a full ultimate strength assessment)
- Analysis extensive

In fact..

- There is no “standard” SRA technique for ships yet
- Ships are not stationary. Their load variations are many
- Even though the example examines a very limited scope problem, the uncertainties and complications are many, requiring a large number of assumptions to arrive at some results

Risk analysis on ships

- Much more difficult problem than for stationary structures
- Calculating probabilities and consequences is not an easy task
- Same is true for translating these into risk acceptance criteria for all failure modes

MSC 81/6/3 by Japan

- Annex: Risk assessment committee, ISSC 2000
- Difficulty to model and quantify ship risk exposures (page 9)
- Inadequacy of data (page 12)
- Difficulty to quantify impact of human element (page 19 – Perhaps THE most important element for Safety)
- Similar observations from ISSC 2003

Linking Risk Analysis with GBS
(for ship design & construction)

- GBS deals with individual failure modes
- A total "safety level" number as the goal must be developed and agreed.
- To do that we need to develop "safety levels" (risk acceptance criteria) for the individual failure modes.
- As stated this is not an easy task. It will involve a large project (much "simpler" RAC turn out not so simple and tricky – see the $ 60,000 for CATS)

Linking Risk Analysis with GBS cont'd

- Without risk acceptance criteria for individual failure modes there can be no real link with GBS.
- The results must be compared/calibrated with present knowledge (which is large for Tankers and Bulkers)
- To set the total goal "safety level", the current "safety level" must be calculated first (not a small or easy task).
- The human element must be incorporated in the analysis in quantifiable terms

To be meaningful and verifiable

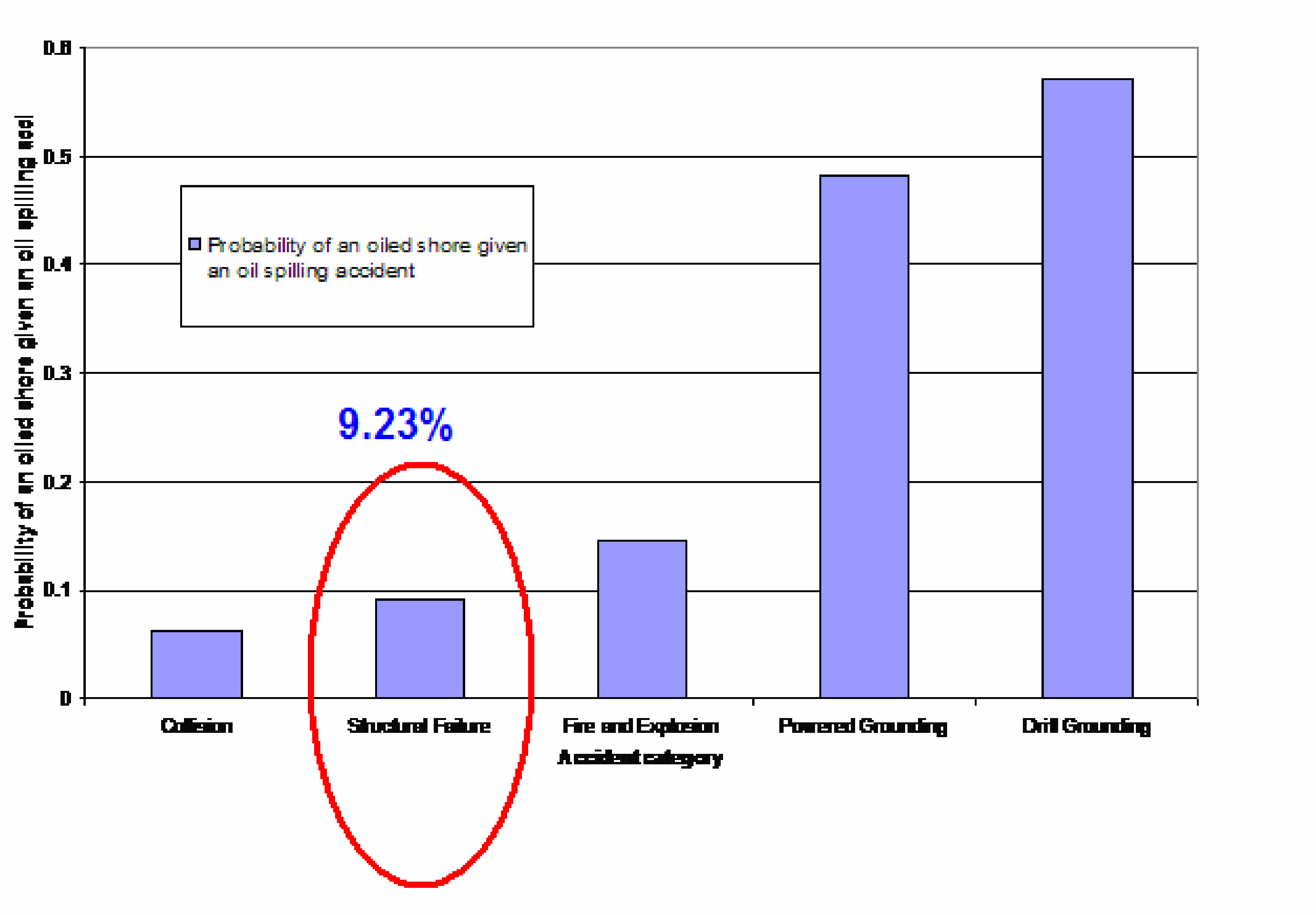
- Any safety level number placed at the top of the pyramid as a goal has to be linked through a clear and transparent process all the way down to ship level
- Thus, the safety requirements have to be linked clearly to the technology requirements for the design and construction of the ship

MSC 81/INF.6, Section 7.5 “Cost Benefit and Cost Effectiveness Evaluation”, Para. 81, point (b) (pages 21-22)

- According to Sørgård et al (1999)*, the likelihood of polluting the shores, in cases of structural failure, is **9.23%.**
- The failure mode subjected to analysis is failure in sagging condition, which corresponds to loaded condition of the ship.
- The Cost of Averting a Tonne of oil Spilled (CATS), is taken to be **$60,000.**

- *Sørgård et al (1999) was a joint DNV-NTUA report from EU project SAFECO II.

Environmental impacts as a function of accident type (1960 – 1997) (SAFECO II report, Fig. 38, page 61)



What is 9.23%?

- It is the probability of shore pollution given
  - **a structural failure AND**
  - **an oil spillage**
- Structural failure can be in hull girder, side shell, bottom plate, etc, and mode can be bending, shear, torsional, etc

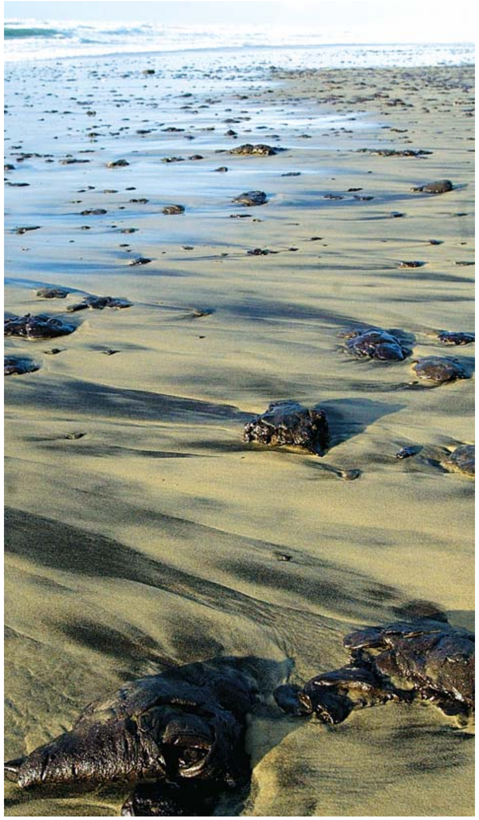
- It is NOT the probability of shore pollution given
  - **a hull girder failure due to sagging**

(as per MSC/81.INF6)

- We actually expect the latter probability to be <9.23%.

The $60,000/tonne figure

- Cost to Avert one Tonne of Spilled Oil (CATS)
- A project SAFEDOR report estimates CATS at $60,000/tonne
- Lots of assumptions are used, and an extensive analysis is reported
- But the $60,000 figure stands out
- $60,000 is used in the Cost-Benefit Analysis of MSC 81/INF.6



Examples of assumptions used to arrive at $60,000 (SAFEDOR report page 55)

Per tonne cleanup costs assumed:

- constant with spill size
- independent of oil type, ie, a generic oil type is assumed
- constant within certain locations
- independent of all other factors!

None of these assumptions can really be justified

What $60,000/tonne means

- Prestige 4.9 billion dollars (1,633)*
- Braer 6 billion dollars (2,000)*
- Torrey Canyon 8.5 billion dollars (2,833)*
- Haven 9.9 billion dollars (3,300)*
- Amoco Cadiz 16 billion dollars (5,333)*
- Castillo de Bellver 17.8 billion dollars (5,933)*
- Atlantic Empress **19.7 billion dollars!** (6,567)*

*equivalent fatalities

Suggestion

- The $60,000/tonne figure for CATS is totally unrealistic (or any other single figure for that matter)
- Additional work is required to develop environmental risk assessment criteria

Greece's position

- GBS and "Safety Level Approach" should continue to run in parallel until
  - GBS for Tankers and Bulkers is finalized, so it can be used as the "testing ground" for the developed risk based approach
  - Issues on possible FSA deficiencies are dealt with satisfactorily
  - Risk analysis techniques for ship design (or its rulemaking) are further developed, tested and calibrated with present experience.

- Doing the opposite now runs the risk that progress on both GBS and FSA / Risk approach is delayed

References (selected)

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- www.martrans.org
- Section ‘document search’
- Page ‘maritime safety’

Thank you very much!