RISK-BASED RULEMAKING AND DESIGN: PROCEED WITH CAUTION

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The drive for greener shipping

- Focus on safety
- Focus on environment
- Focus on prevention
- Be proactive

The need for ‘proactive’ regulation

- Early stage identification of main factors that affect safety
- Development of regulatory action to prevent undesirable events
- Formulation of regulation BEFORE event
- Formulation of regulation AFTER careful analysis of all of its implications

[Parenthesis:

- Much of the story thus far is quite the opposite
- Many regulations have been adopted ad hoc in the aftermath of catastrophic accidents
- *Exxon Valdez, Estonia, Erika, Prestige,* and so on.]

The long road from reactive to proactive regulation

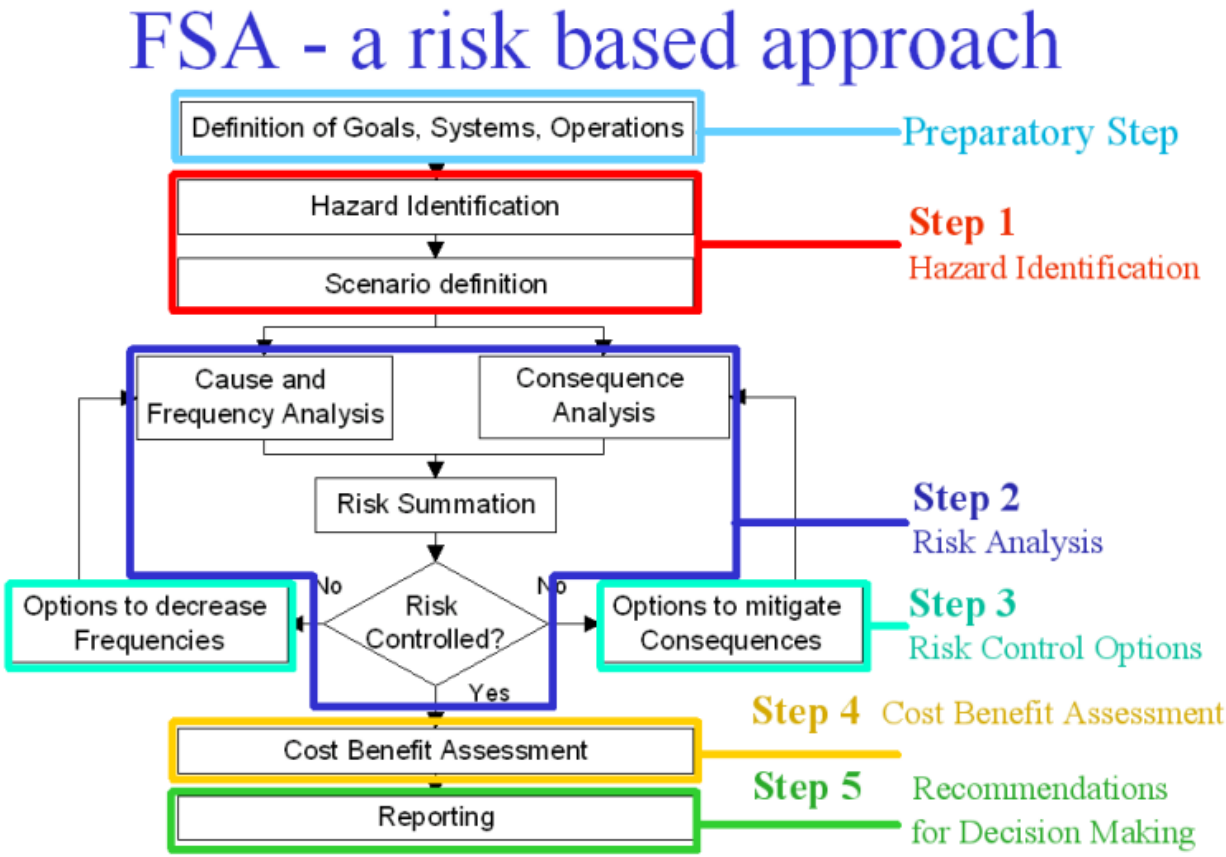
- Formal Safety Assessment (some time now)
- Goal Based Standards (quite recently)

Formal Safety Assessment (FSA)

FSA was introduced by the IMO as

- "a rational and systematic process for accessing the risk related to maritime safety and the protection of the marine environment and for evaluating the costs and benefits of IMO's options for reducing these risks" (FSA Guidelines in MSC circ. 1023, MEPC circ. 392)

FSA steps (IACS – MSC 75)



Highest profile example (2004)

- Use of FSA within IMO, to decide not to mandate double hulls on bulk carriers
- FSA was critical in IMO's reversal of prior position on this issue

Goal Based Standards (GBS)

- Proposed to IMO by Greece, Bahamas and IACS (2004)
- Main objective: Introduce a system of standards, as measures against which the safety of a ship could be assessed during its design and construction, as well as later on during its operation
- Basic premise: Standards should be broad, over-arching goals against which ship safety should be verified
- They are NOT intended to set prescriptive requirements or to give specific solutions.
- But also they must be Clear, Demonstrable, Verifiable, and Specific Enough in order not to be open to differing interpretations. (this suggests a certain degree of prescription…)
- For the moment, work on GBS focuses on SHIP CONSTRUCTION

Prescriptive vs GBS rule making

- Hull bottom plate for tankers

- Prescriptive:

  Plate thickness ≥ X mm

- Goal based:

  Plate should not fail during tanker's life of Y years if operated in a specific environment (eg, North Atlantic)

GBS: A five-tier approach

- Tier I: Goals
- Tier II: Functional requirements
- Tier III: Verification of compliance
- Tier IV: Technical procedures and guidelines, classification rules and industry standards
- Tier V: Codes of practice and safety and quality systems for shipbuilding, ship operation, maintenance, training, manning, etc.

The GBS “safety level approach” debate

- Should the “safety-level approach” be used within GBS?
- Should GBS be “risk based”?
- Should GBS use FSA and other risk techniques?
- If yes, how?
- Etc, etc

Why the debate?

- No question that risk-based principles are central for modern maritime safety regulation
- FSA and GBS have developed thus far in parallel
- But many linkages between FSA and GBS exist
- It is only natural that the “safety-level” arsenal be eventually used in GBS
- The real question: HOW, and WHEN?

Possible GBS-FSA linkages

(to augment but not totally replace all elements of the traditional-prescriptive approach)

GBS	FSA
Tier I (Goals)	Step 1 (HAZID) Step 2 (Risk Analysis)
Tier II (Functional requirements)	Step 2 (Risk Analysis) Step 3 (RCOs)
Tier III (Verification of compliance)	Step 4 (Cost benefit assessment) Step 5 (Recommendations)
Tier IV (Technical procedures and guidelines, classification rules and industry standards)	Step 3 (RCOs) Step 4 (Cost benefit assessment) Step 5 (Recommendations)
Tier V (Codes of practice and safety and quality systems for shipbuilding, ship operation, maintenance, training, manning, etc)	Step 3 (RCOs) Step 4 (Cost benefit assessment) Step 5 (Recommendations)

“Safety-level approach” glitches

- Are there areas where SLA exhibits deficiencies (or glitches), which should be rectified before use in GBS?

- Answer: **Of course!**

The “individual risk” glitch

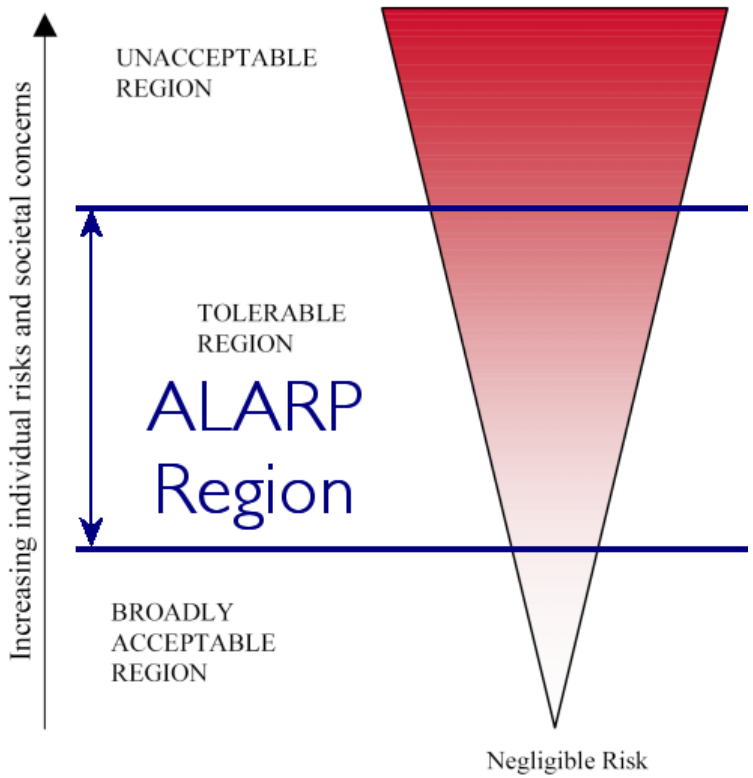
§ Individual risk acceptance criteria

- BASIC QUESTION: what is the tolerable level of risk for an individual?
- Answer (incredible as it may seem):

  Neither the IMO, nor any other body has yet a definite position on this issue!
- Whatever exists today is only indicative

FSA Step 5 (recommendations for decision making)

- What is a desired risk level?
- ALARP principle



From IMO's FSA guidelines

(adopted in 2002, amended in 2006):

Maximum annual tolerable risk of death (INDICATIVE FIGURES ONLY):

- For crew members: 1/1,000
- For passengers: 1/10,000
- For third parties or public ashore: 1/10,000

Negligible risk: 1/1,000,000

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 1/1,000,000
- Why is a ship passenger allowed an annual risk 100 times higher? (1/10,000)

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

The “risk index” glitch

From FSA guidelines (MSC circ. 1023, MEPC circ. 392):

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

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?

Risk index RI= FI+SI

- 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

[Parenthesis:

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

Paradox

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 Index 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 = ΔC/ΔR
- NCAF = (ΔC-ΔB)/ΔR

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)

The “Common Structural Rules” glitch

- Do new rules increase safety?
- IACS: Of course!
- UGS: No! (serious reservations)

- My opinion: We don’t really know, as the level of safety of old rules is still not known (let alone safety level of the new rules)
- Also: Legislating without environmental impact assessment?

The “environmental” glitch

- Very important issue
- So far no FSA study has tried to assess environmental risk
- Cost to Avert one Tonne of Spilled Oil (CATS)
- Project SAFEDOR estimates CATS at $60,000/tonne
- Lots of assumptions used
- Issue just under discussion at IMO

To arrive at $60,000:

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 (assuming $3M/fatality - IMO)

Suggestion

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

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

More issues to be looked at?

- YES!
- Full agenda at IMO
- Correspondence group on GBS for Tankers and Bulk Carriers
- Correspondence group on GBS-Safety Level Approach
- Submission by Greece on revision of FSA guidelines
- To be followed at next MSC (and MEPC for FSA environmental criteria)

Conclusions

- Caution is necessary before the Safety Level Approach is fully integrated within the rule making process for maritime transport safety
- It would be a mistake to rush through the GBS process if potential deficiencies in FSA and other Risk Based methodologies such as those identified here are not dealt with successfully

References (some)

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For more info:

- www.martrans.org
- Section ‘library’
- Page ‘maritime safety’

Thank you very much!