Risk Acceptance Criteria by Rolf Skjong, DNV

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Contents

Introduction

- Risk Acceptance Criterion is the standard term in the literature
  - But risk is not accepted, activities involving risks are accepted because of the benefit
- At IMO, the term used is Risk Evaluation Criterion
  - indicating that a yes/no decision is not prescribed by the criterion
- Risk acceptance criteria is set by the regulator
- Any risk model will reveal the regulators 'implicit' risk acceptance criteria
- This is one of the methods to decide: Make implicit criteria explicit

Introduction - Status of criteria

Industrial Self Regulation Regime

- Criteria Defined by Operator

Safety Case Regime

- Criteria Defined by Regulator

FSA: For use by the regulator in own decisions

- With acceptance criteria given, IMO may still decide not to adhere strictly to criteria (will lead to "inconsistency")

Risk Based Design:

- Based on same as FSA – Specific interpretation agreed with regulator

Introduction – A Guideline to IMO doc

The decisions at MSC81 on the amendments of the FSA Guidelines are not implemented in a consolidated new FSA Guideline

- **Risk acceptance criteria -> messy**
- **Recommended reading MSC81/18/Annex1**
  - **Contains new Appendix 5 and Appendix 7 of FSA Guidelines**
  - **Measures and Tolerability of Risks**
  - **Example of calculation of risk indices for cost effectiveness**

Introduction

- **Basic assumption is that Risk Acceptance Criteria as used in Step 5 of Formal Safety Assessment, can be used in Risk Based Design and Approval**
- **With some additional considerations**

Steps in Formal Safety Assessment

Steps of FSA	*In laymen Terminology*	**The Professional Language**
Step 1	*What might go wrong?*	Hazard Identification
Step 2, a	*How often or how likely?*	Frequencies or probabilities
Step 2, b	*How bad?*	Consequences
Step 2, c		Risk = Probability x Consequence
Step 3	*Can matters be improved?*	Identify risk management options
Step 4	*What would it cost and how much better would it be?*	Cost Benefit Evaluation
Step 5	*What actions are worthwhile to take?*	Recommendation
IMO	*What actions to take?*	Decision

Introduction - Why criteria

- Help FSA team knowing what to report
- Committees will learn what to expect and ask for
- May compare to previous decisions
- More predictable decisions, motivate FSA
- Compare with alternative decisions
- Find balance between e.g. preventive and mitigating measures
- Basis for acceptance of “Safety Equivalency
- Transparency, consistency, systematic, scientific

Approach - High level implicit criteria

- Ships should be as safe a workplace as land based industries, e.g. manufacturing and process industries,
- Passenger ships should be as safe transport as e.g. aeroplanes
- Risks in shipping activities should not be disproportionate to benefits
- Ships should not pose risks that could be reasonable avoided
- Risks should not unduly concentrate on particular individuals
- Risks from catastrophic accidents should be a small portion of the total risk

Not as in Goal Based Standard:

Ships are to be designed and constructed for a specified design life to be safe and environmentally friendly, when properly operated and maintained under the specified operating and environmental conditions, in intact and specified damage conditions, throughout their life.

Approach: High level implicit criteria:

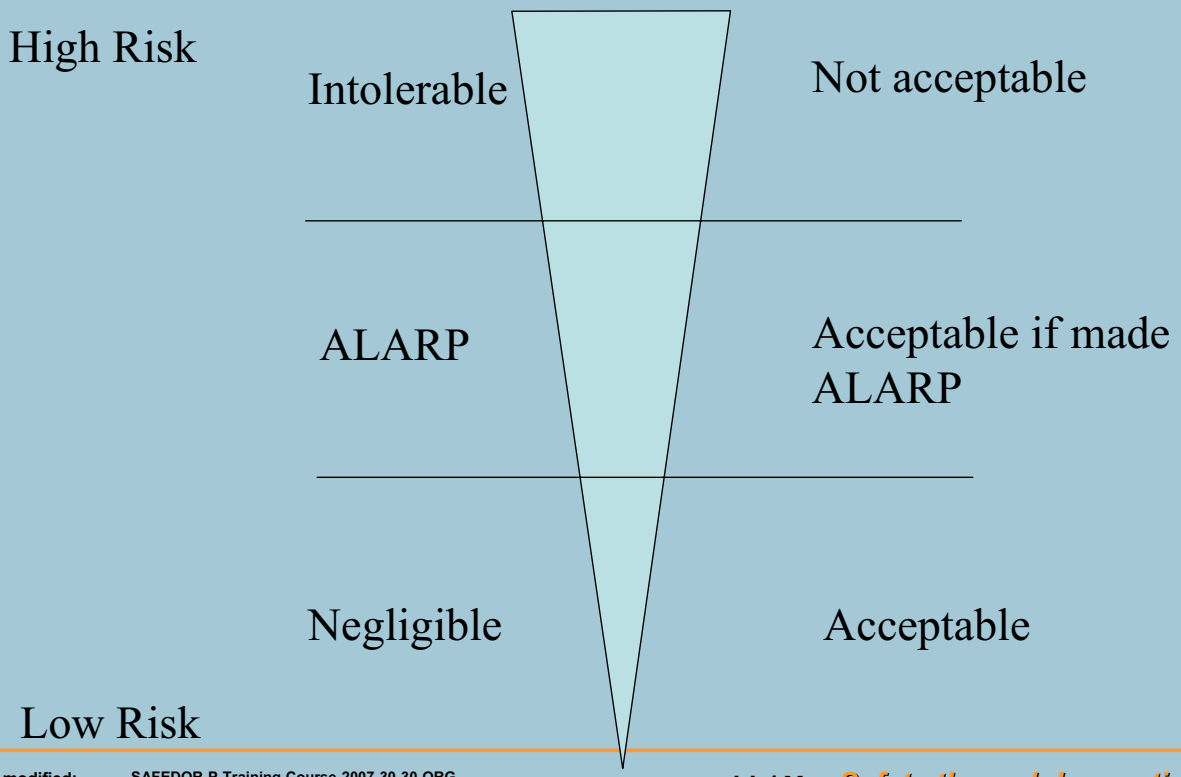
- Will be easily interpreted by risk analysts
- Different interpretation
- FSA not consistently applied
- FSA not transparent

Recommend: More explicit criteria

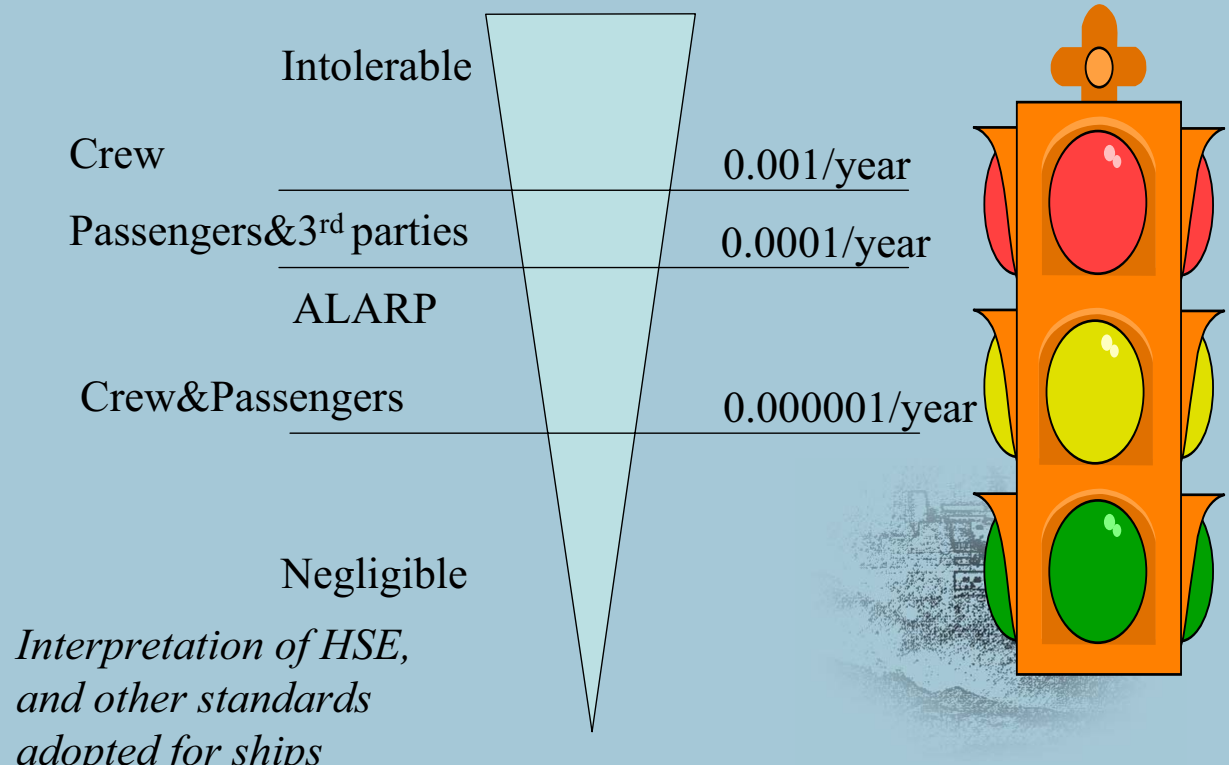
Approach: Criteria referenced in FSA Guidelines

- Individual Risk
- Societal Risk
- Environmental Risk
- ALARP

Format of Risk Acceptance Criteria



Risk Acceptability - Individual Risk



Interpretation of HSE, and other standards adopted for ships

Approach Individual Risk

- Crew, Passenger, Third Parties (Not necessarily IMO)
- Fatalities, ill health and injuries (separately)
- Fatalities, ill health and injuries (aggregated, QALY)
- Distinguish fatalities from fatalities as indicator (implicit/explicit)

Approach: Individual Risk

10^{-0}	Probability of dieing for some reason sometime
10^{-1}	Death from Russian roulette, if tried in Russia or elsewhere
	Annual probability of dying as king of Norway 1000 AD
	Annual probability of being fired as president of large company
10^{-2}	Annual probability of dying of any cause
10^{-3}	Annual probability of dying of any cause for children in the age of 5-15 years
	Historic. Now down to about 2 10^{-4} (OECD)
10^{-4}	Mother's probability of dying giving birth (per birth, OECD average,
	If no-one took such a risk, civilisation would end)
10^{-5}	Extra risk of cancer from eating a peanut butter sandwich every day
10^{-6}	Women killed by husband or lover (US)
10^{-7}	Annual probability of being killed by lightening (in Norway)
10^{-8}	Annual probability of being killed in an event killing everyone else on earth
	(Gamma burst from collapsing Hypernova, or collision with Near Earth Object)
10^{-9}	Happened once in the lifetime of the earth
10^{-10}	Happened once in the lifetime of the universe

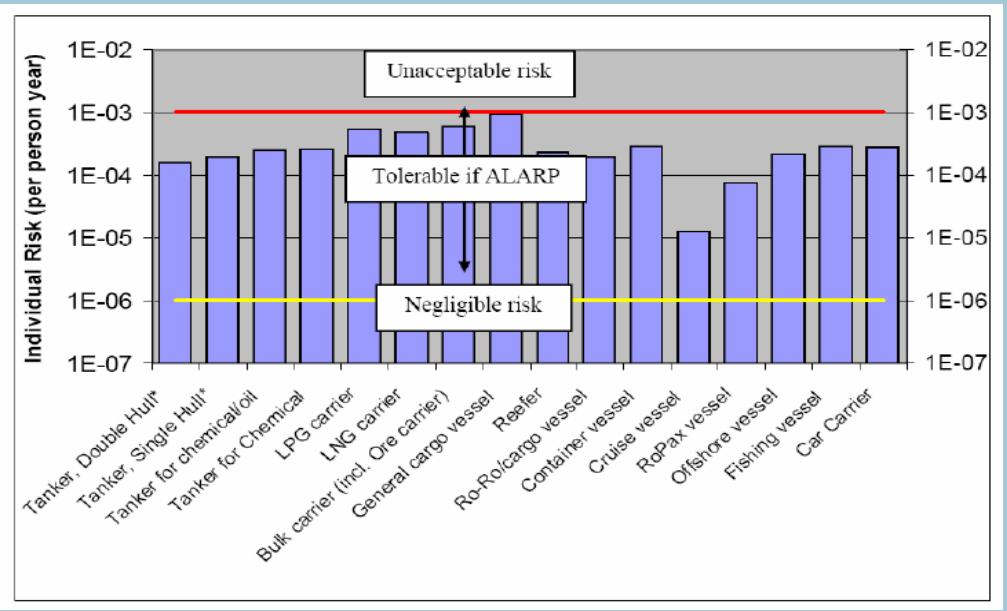
Individual Risk Acceptance Criteria

Maximum tolerable risk for crew members	10^{-3} annually
Maximum tolerable risk for passengers	10^{-4} annually
Maximum tolerable risk for public ashore	10^{-4} annually
Negligible risk	10^{-6} annually

Comprehensive FSA for new ships:

Target individual risk for crew members	10^{-4} annually
Target individual risk for passengers	10^{-5} annually
Target individual risk for public ashore	10^{-5} annually

Application: Individual Risk & Acceptance Criteria



Source: MSC82/5/1 (Input from IACS)

FN Criteria

- FN diagrams should not be copied between industries and activities
- Suggest to use unique FN diagrams for each ship type
- Suggest to scale FN diagrams to importance of activity
- Scaling factors from aggregated information
- Ships are
  - Work Place
  - Transport
- Two scaling factors needed
  - Work related accidents: 1.0 fatality per billion $ GDP
  - Transport related accidents: 44 fatalities per billion $ GDP
- Note: Statistics only from US and Norway

FN Criteria

- Suggest to use economic information, because
  - Good statistics on ship and societal level (GDP)
  - Collection of statistics should be improved
  - Wish to avoid debating “purpose of activity”
  - Passenger kilometres (air traffic look good, ships bad)
  - Passenger hours (ships look good, air traffic bad)
- Suggest to compare to air traffic, because
  - High Standard
  - Good Statistics

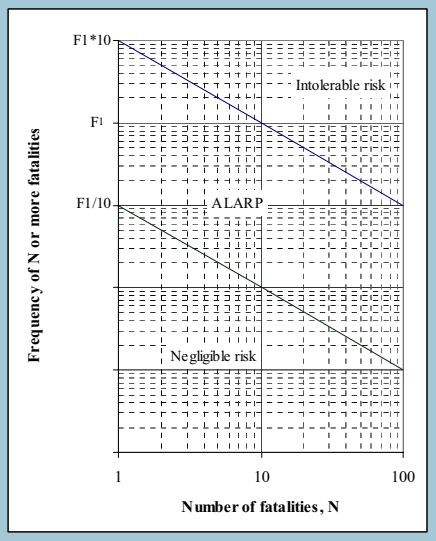
FN Criteria

- Other assumptions

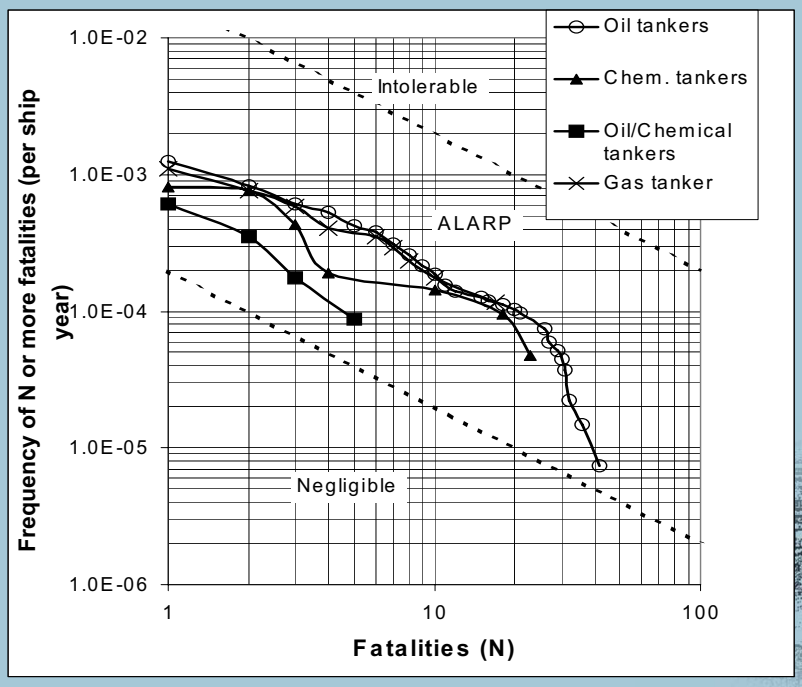
  - ALARP area covers two orders of magnitude
  - FN line inclination -1
  - These are the most common format used by regulators

Format Societal Risk as FN diagrams

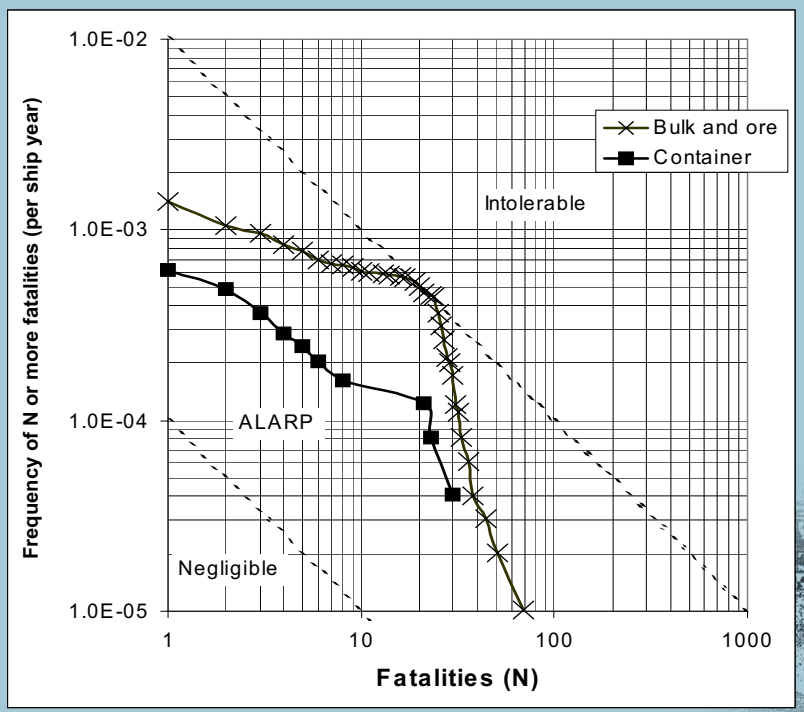
- **Crew, Passenger,**
- **Third Parties (not necessarily IMO)**
- **Only fatalities in this format**



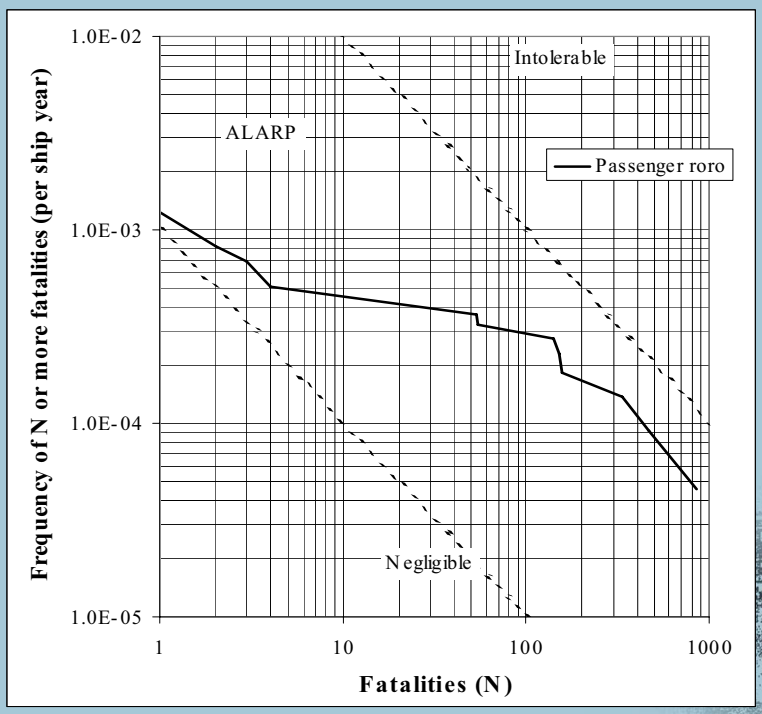
FN Criteria



FN Criteria



FN Criteria



For Individual and Societal Risk

- Individual and Societal risks are in ALARP area
- Individual and societal risks are not ALARP
- Cost Effectiveness Assessment (CEA) must me carried out to arrive at recommendations
- Societal risks for Bulk Carriers were recently close to intolerable or intolerable
- Note: Not all ship types included

Cost Effectiveness

- Could get much more safety for same budget

Table 2: Results from Tengs et al. (1995)	
"Five Hundred Life-Saving Interventions and their Cost Effectiveness"	
Number of measures studied	587
Range of cost effectiveness	Negative to $10 billion/life year saved
Median Value	$ 42.000/life year
Median for Medical Interventions	$ 19.000/life year
Median for Injury Prevention	$ 48.000/life year
Median for toxic control	$2.8 million/life year

Cost Effectiveness

- Could get much more safety for same budget

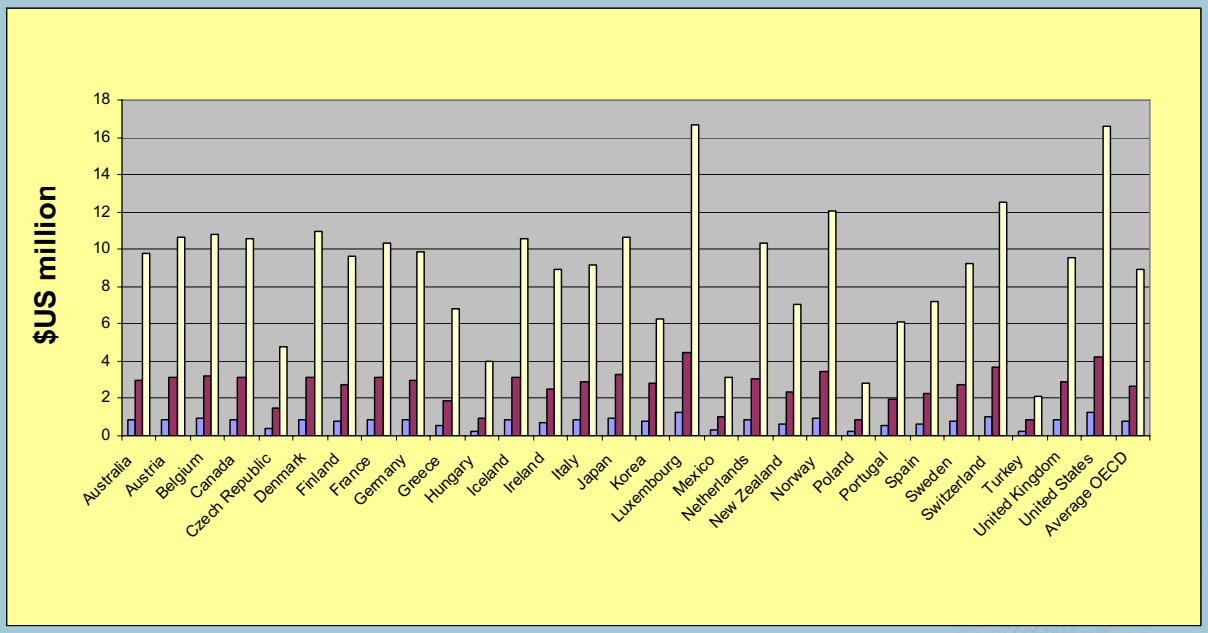
Table 1:Values of statistical fatalities averted in actual decisions		
Decision	Decision Maker	Value
Strengthening Bulkheads on existing Bulk Carriers	IACS(1)	> 1.5 million $
Helicopter Landing Areas on Non Ro/Ro passenger ships	IMO(2)	> 37 million $ (12 million $ to 73.000 million $)
3 bulkheads on car deck	IMO(3)	< 5 million $
3 bulkheads on car deck	NMD(3)	> 5 million $
3 bulkheads + sponsons	IMO (3)	< 7.8 million $
Extended sponsons only	IMO(3)	< 11.8 million $
Collision avoidance training	Owner(3)	> 0.7 million $
Extra deck officer	IMO(3)	< 5.5 million $
Re: (1) Mathiesen et al.(1997),(2)Skjong et al.(1997) MSC 70 WP.12,(3) DNV(1966)		

Cost Effectiveness

Table 1: Published ICAFs in use as acceptance criteria			
ORGANISATION	SUBJECT	ICAF	SOURCE
US Federal Highway Administration	Road Transport	$2.5m (£1.6m)	FHWA (1994)
UK Department of Transport	Road transport	£1.0 m (1998, uprated with GDP per capita)	DETR (1998)
UK Health & Safety Executive	Industrial safety	As above or higher	HSE (1999)
Railtrack (UK rail infrastructure controller)	Overground railways	As above to £2.65m	Railtrack (1998)
London Underground Ltd	Underground railways	£2m	Rose (1994)
EU	Road Transport	ECU 1 million (£0.667m)	from Evans (1998)
Norway	All hazards	NOK 10m (£0.8m)	Norway (1996)

Cost Effectiveness Criteria

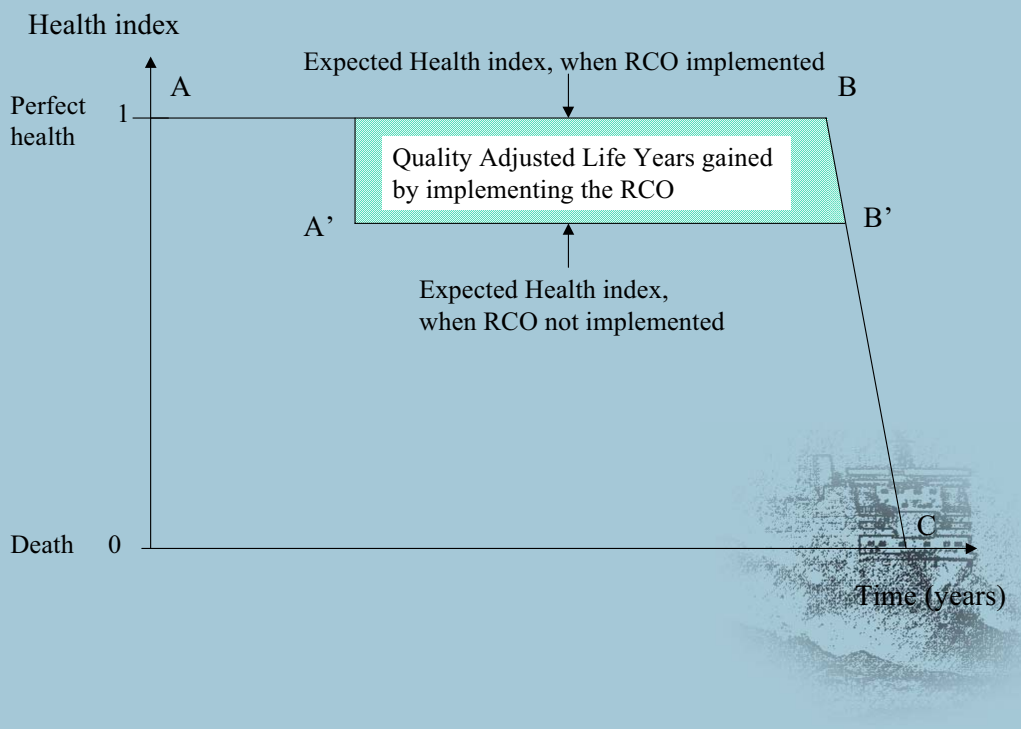
- Assume that all safety measures that improve rating on social indicator are implemented



Cost Effectiveness

- Distinguish between fatalities and equivalent fatalities (implicit or explicit health/injury)
- Suggest implicit: $3 million [1,5]
- Suggest explicit: $1.5 million
- Note: Need for better statistics for relation fatalities/injuries/health

Health and Injuries by QALY



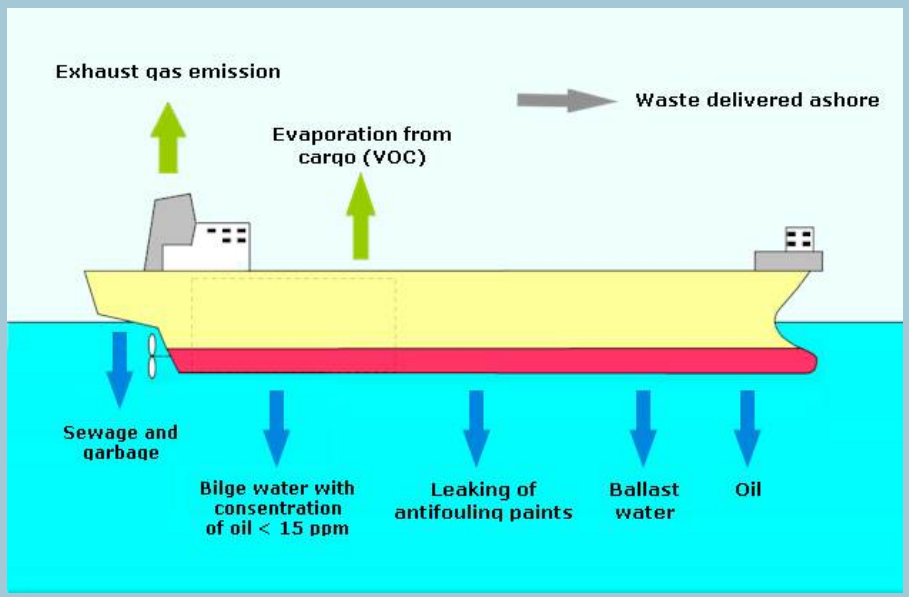
QALY

- Assume 1 fatality=35 QALY lost : $42.000
- Tengs average value: $ 42.000

Maritime environmental risk

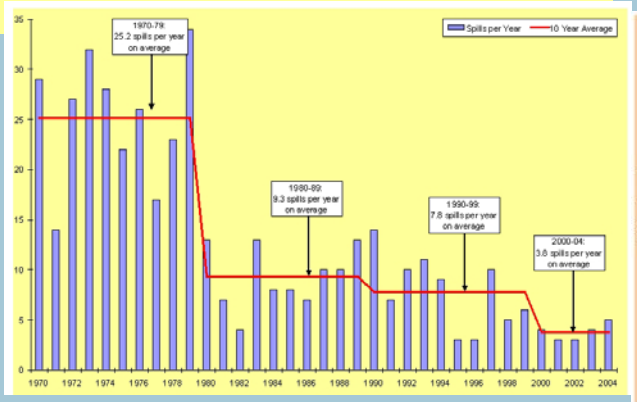
Regular discharges, illegal dumping and accidental release of hazardous material into the sea

Risk assessment only needed for accidental releases

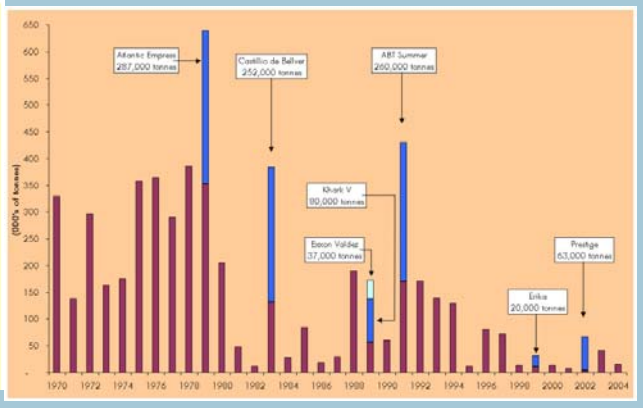


Oil tanker accidents

Number of oil spills > 700 tonnes



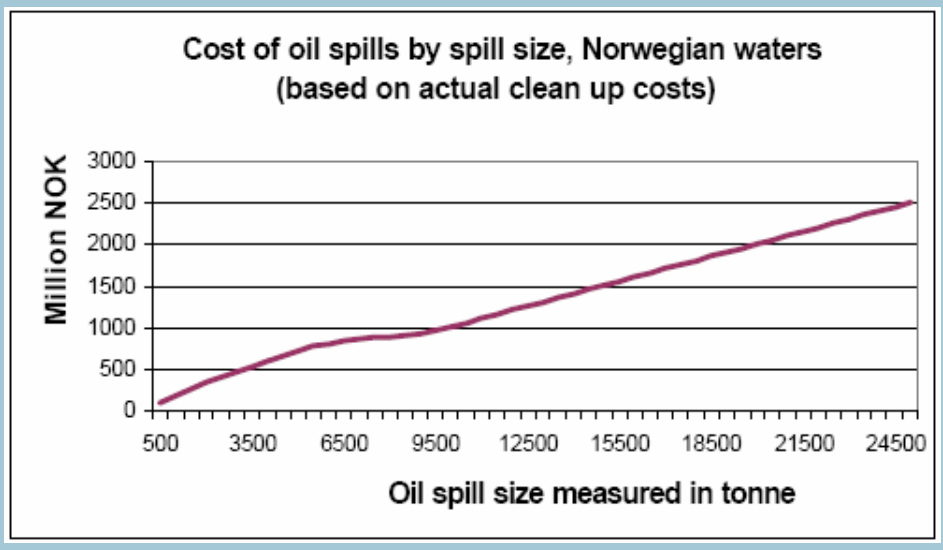
Quantities of oil spilt (in 1000 tonnes)



Some observations

- The majority of oil spills are small (85 % are < 7 tonnes)
- A few very large spill accounts for a high percentage of the total oil spilt
- Decreasing trend in the number and size of oil spills
- Collision and grounding account for > 60% of all oil spills > 700 tonnes

Cleanup cost of oil spills by spill size

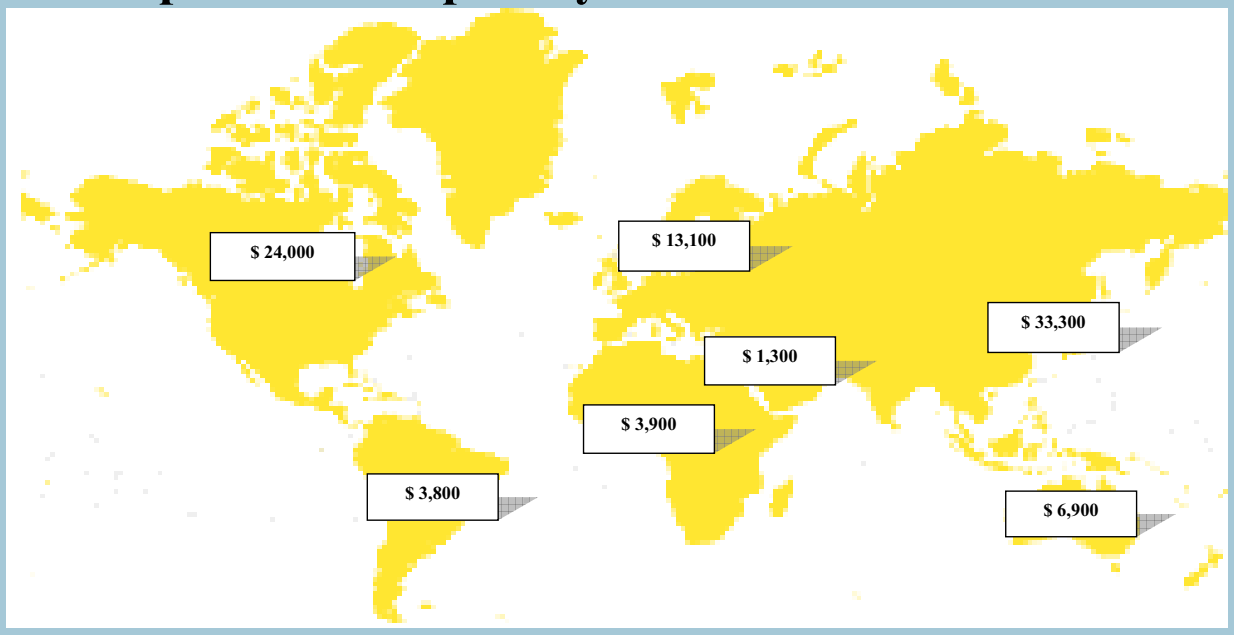


In reality: Per-tonne cleanup cost decreases with spill size

But, cleanup costs assumed proportional to spill size

In European waters approx. USD 13,000/tonne spilt

Cleanup cost of oil spills by location



Minimum: USD 1,300/tonne spilled (Middle East)

Maximum: USD 33,000/tonne spilled (Asia)

Weighted global average: USD 16,000/tonne spilled (based on ship traffic density distributions)

Criteria for implementation of RCOs

Basic idea:

Cost of averting an accident < F x Cost of an occurred accident

- **F > 1, insurance factor**

Separate cost elements

- **Environmental, i.e. costs per tonne oil spilt**
- **Safety, i.e. costs per life lost**
- **Monetary, i.e. property damage, downtime, etc.**

Criteria for implementation of oil spill RCOs

Assuming RCO do not enhance safety

- I.e. LL = 0

Cost of averting an oil spill < F_{env} x (RC + ED)

- RC = Rescue and cleanup costs
- ED = Environmental damage
- Assuming global average: RC = 16,000 USD/tonnes spilt
- Assuming ED = 24,000 USD/tonnes spilt

Cost effectiveness criteria for oil spill RCOs:

CATS < F x USD 40,000

- CATS: Cost of Averting a Tonne of oil Spilt
- F, insurance factor between 1 and F_{max}

This is global average. May be justifiable to use higher values for areas associated with higher costs, e.g. USA

Cost effectiveness of existing regulations (OPA 90)

Core group of 11 rules used as proxy for the OPA 90 rules

Both individual and marginal cost effectiveness assessed

Implicit insurance factors associated with OPA 90 rules		
OPA 90 rule	$F_{marginal}$	$F_{individual}$
Overall	**1.6**	
Double hulls	**12**	**5.4**
Deck spill control	**5.7**	**1.6**
Spill source control and containment	**0.7**	**0.2**
Lightering of single hull vessels	**0.2**	**< 0.08**
Overfill devices	**5.3**	**1.6**
Operational measures for single hull vessels	**0.7**	**0.2**
Licences, certificates and mariner's documents	**0.8**	**0.2**
Financial responsibility	**0.03**	**0.03**
Vessel response plans	**12**	**4.6**
Facility response plans	**0.6**	**0.3**
PWS equipment & personnel requirements	**20**	**7.4**

Concepts introduced consistent with IPCC

Concept used in IPCC 4th assessment report (released Friday, May 4, 2007)

Cost per unit CO_2-eq emission avoided

Table SPM 1: Global economic mitigation potential in 2030 estimated from bottom-up studies.

Carbon price (US/tCO_2$-eq)	Economic mitigation potential ($GtCO$_2$-eq/yr)	Reduction relative to SRES A1 B (68 $GtCO_2$- eq/yr) %	Reduction relative to SRES B2 (49 $GtCO_2$- eq/yr) %
0	5-7	7-10	10-14
20	9-17	14-25	19-35
50	13-26	20-38	27-52
100	16-31	23-46	32-63

Conclusion

- Individual risk criteria may be taken from HSE
- FN diagrams developed for each ship type
  - All necessary data are available
  - Better statistics will change result, but probably not much
- Most “generic”ship types in ALARP area
- Similar cost effectiveness criteria from many different sources
- Inclusion of ill health and injuries possible by QALY criterion
- Oil spills by CATS
- **Specifics for RBD**
- Equivalent or better on all criteria
- For Radically new Designs: Proof of ALARP & Equivalence
- Agree with Regulator in advance

References

- IMO FSA Guidelines
- MSC81/18
- MSC72/16
- SADEDOR D4.5.2 on www.safedor.org
- Skjong & Ronold (2002) ‘So Much For Safety’