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Use of Risk Criteria in Decision Making

Martin Goose FIChemE

IChemE - ChemEnvoy

Formerly Head of Major Hazards Assessment Unit, HSE Hazardous Installations Directorate

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Synopsis

- Doing What Comes Naturally!
- Some Incidents (mainly Chemical Sector)
- Terminology
- Regulation, the Risk Assessment Process, Tolerability, and ALARP
- Cost Benefit Analysis
- Now the Bad News!
- Public Perception of Risk
- QRA/CBA pros and Cons
- Further Reading

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Doing What Comes Naturally!

- We do 'risk assessment' all the time!
  - Crossing the road and driving a car
  - National Lottery (or maybe not!)
- People are 'natural risk takers'
- Instinct or Trained?
- However, there is poor understanding of science (including statistics!) and engineering by the public so explaining risk concepts is difficult.

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Doing What Comes Naturally!

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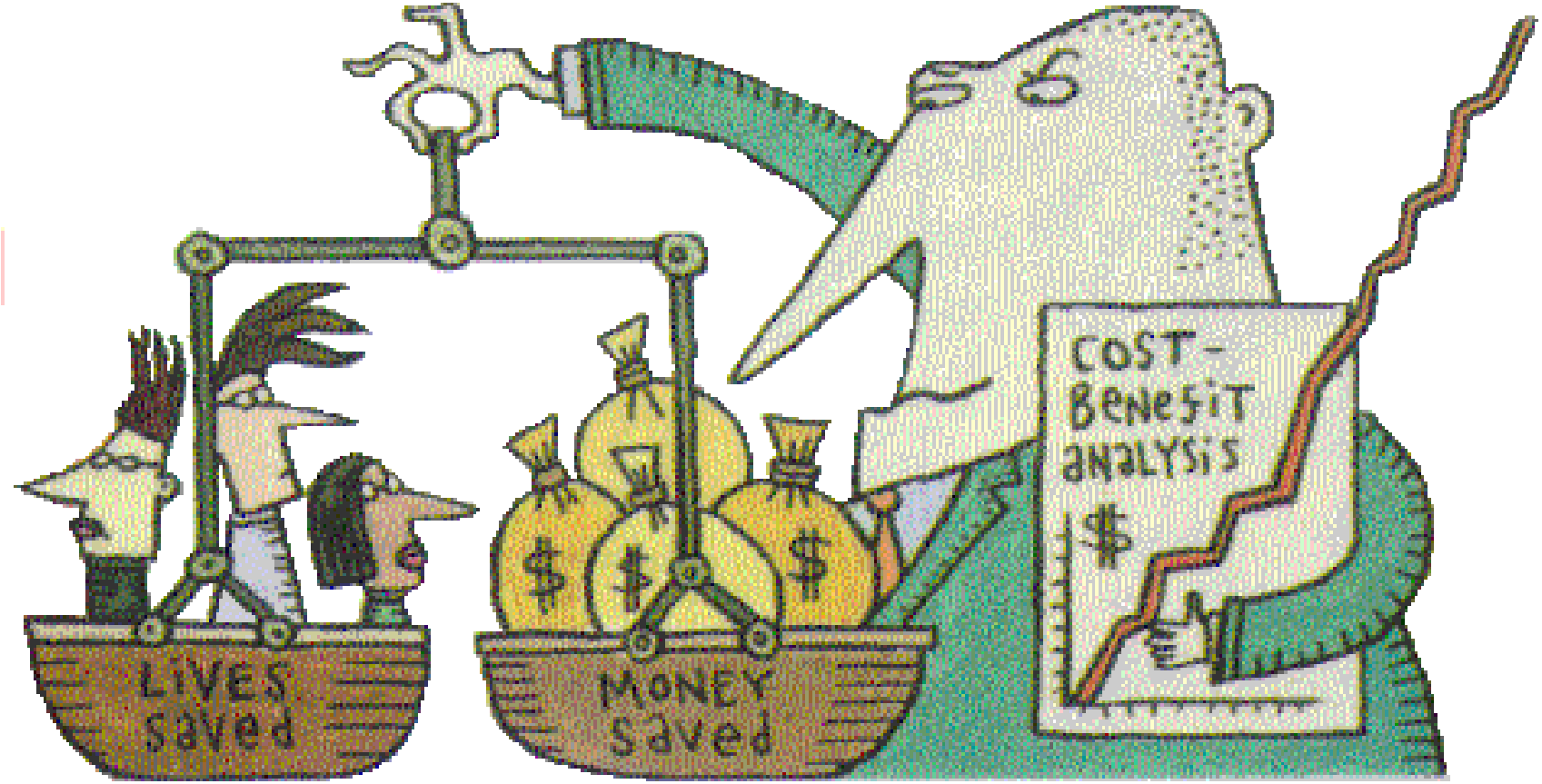
Doing What Comes Naturally!



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Some Incidents

- To show why major hazard risk must be managed
  - Crescent City 1970
  - Flixborough 1974
  - Mexico City 1984
  - Bhopal 1984
  - Kings Cross 1987
  - Piper Alpha 1988
  - BP Texas City 2005
  - Buncefield 2005

Crescent City, Illinois, 1970

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Flixborough
June 1974

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Flixborough June 1974

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Mexico City, 1984

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Mexico City, 1984

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Mexico City, 1984

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Bhopal, 1984 - 2500+ fatalities

Kings Cross, 1987

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Piper Alpha
1988

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BP Texas City, 2005

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Buncefield, 2005

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Terminology

- Hazard
  - A physical situation with a potential for human injury, damage to property, damage to the environment or some combination of these
- Risk
  - The likelihood of a specified undesired event occurring within a specified period or in specified circumstances

Terminology

- Hazard Identification
  - What if?
  - The process of recognising that hazards exist, defining what they are, and describing their characteristics
- Risk Analysis
  - What if? What then? Then what?
  - The process of identifying sources of potential harm, assessing the likelihood that harm will occur and the consequences if harm does occur

Terminology

- Risk Assessment
  - What if? What then? Then what? So what?
  - The process of *risk analysis* together with the value judgements made concerning the significance of the results

"Risk assessment data is like a captured spy. If you torture it long enough it will tell you anything you want to know"

W M Ruckelschaus Former Head of US EPA

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Terminology

- Risk Management
  - What if? What then? Then what?
    So what? Do what?
  - The assessment of risk followed by the making and implementation of decisions about what needs to be done to reduce risks to ALARP

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Terminology

- Individual Risk
  - The frequency at which an individual may be expected to sustain a specified level of harm from the realisation of specified hazards
  - Application: e.g. Machinery Guarding
- Societal Risk
  - The relationship between frequency and the number of people sustaining a specified level of harm in a given population from the realisation of specified hazards
  - Application: e.g. Major Hazards Sites

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Individual Risk Examples

Annual risk of death for various causes averaged over the entire population.

Cause of Death	Annual Risk	Annual Risk
Cancer	1 in 387	2.6×10^{-3}
Injury and Poisoning	1 in 3,137	3.2×10^{-4}
All Types of Accidents ...	1 in 4,064	2.5×10^{-4}
Road Accidents	1 in 16,800	6.0×10^{-5}
Lung Cancer Due to Radon	1 in 29,000	3.4×10^{-5}
Gas Incident (incl. poisoning)	1 in 1,510,000	6.6×10^{-7}
Lightning	1 in 18,700,000	5.3×10^{-8}

National Lottery - Match 6 of 6 main numbers with a single ticket - 1 in 14 000 000 or 7.1×10^{-8}

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Societal Risk Example

Canvey - Upper limits of estimated societal risks in units of chances in 10,000 a year

Number of Casualties Exceeding	10	1500	3000	4500	6000	12000	18000
Canvey Report 1978	47.5	29.0	17.5	9.3	4.4	2.7	1.8
Canvey Report 1978 (improvements)	11.8	6.4	4.2	2.7	1.4	0.8	0.5
1981 Reassessment	10.0	2.0	0.8	0.4	0.2	0.1	0.1

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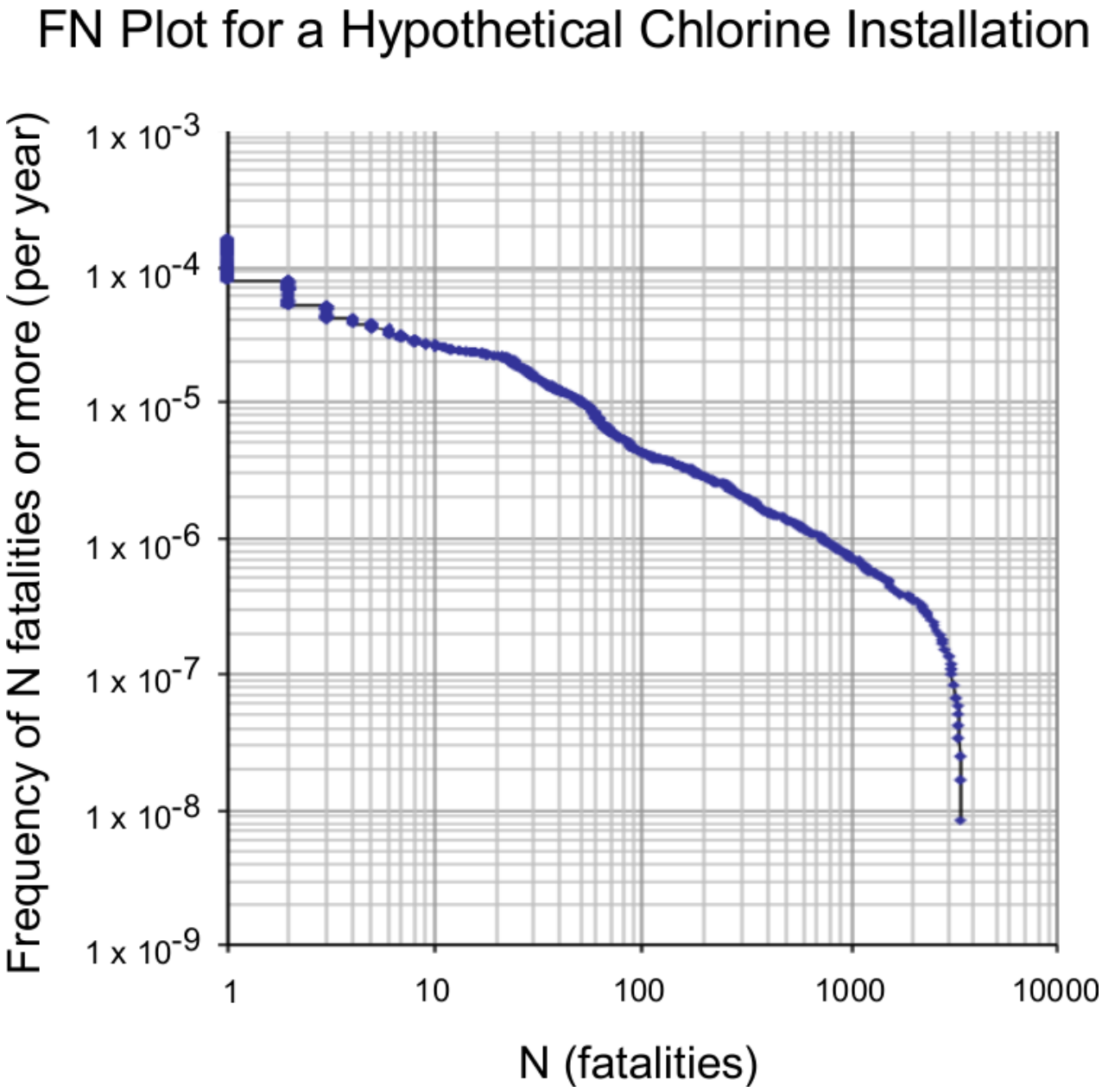
Chlorine Storage Societal Risks



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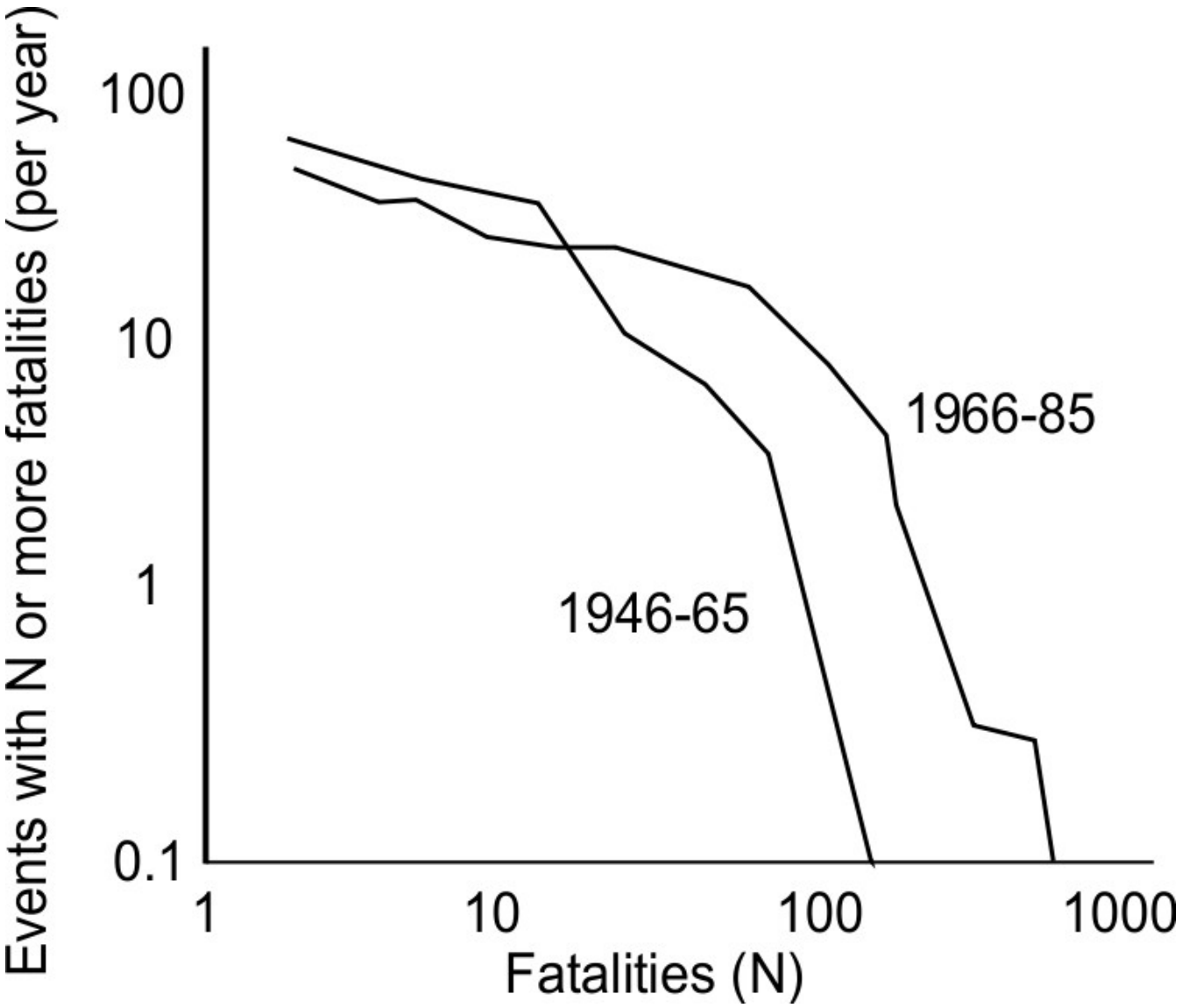
Aircraft Crash Societal Risks



Terminology

- Expectation Value
  - The predicted average number of deaths per year (from the process or system being analysed)
  - It is a numerical value representing the integral of the FN curve
  - It is sometimes referred to as potential loss of life, or rate of harm

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Expectation Value (EV)

- Making risk numbers useful?
- Difference in EV predicted before and after gives the predicted fatalities averted
- Must be converted to monetary value to be useful!
- Application: e.g. Cost Benefit Analysis

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The Compliance Process

- Apply all 'Relevant Good Practice Precautions'
  - Codes/Standards/Guidance
- Analyse 'What more can I do?'
  - Hazard ID/risk analysis to identify possible additional measures
- Demonstrate 'Why am I not doing it?'
  - Cost Benefit Analysis – Qualitative or quantitative according to initial assessed risk

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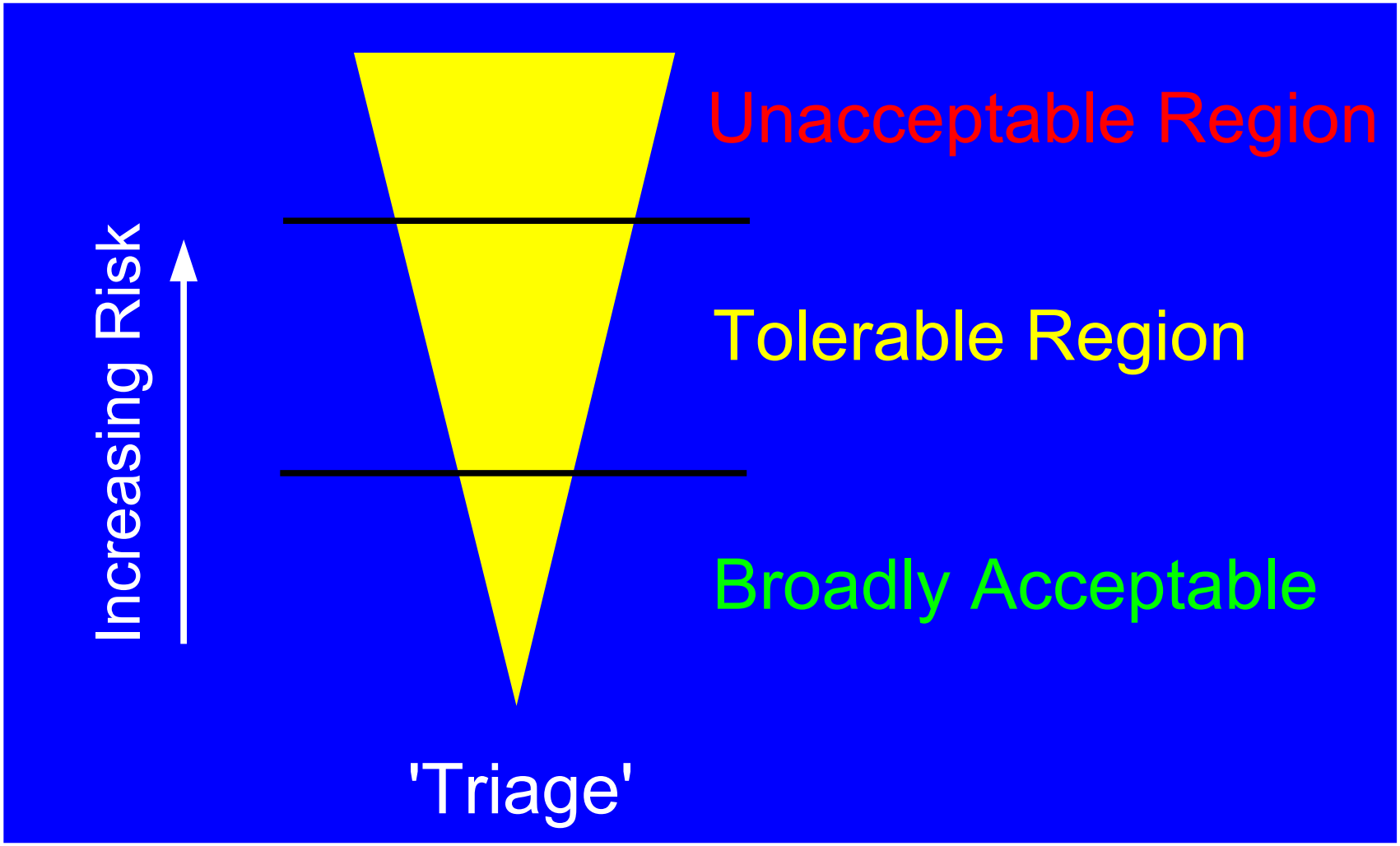
Tolerability (General Scheme)



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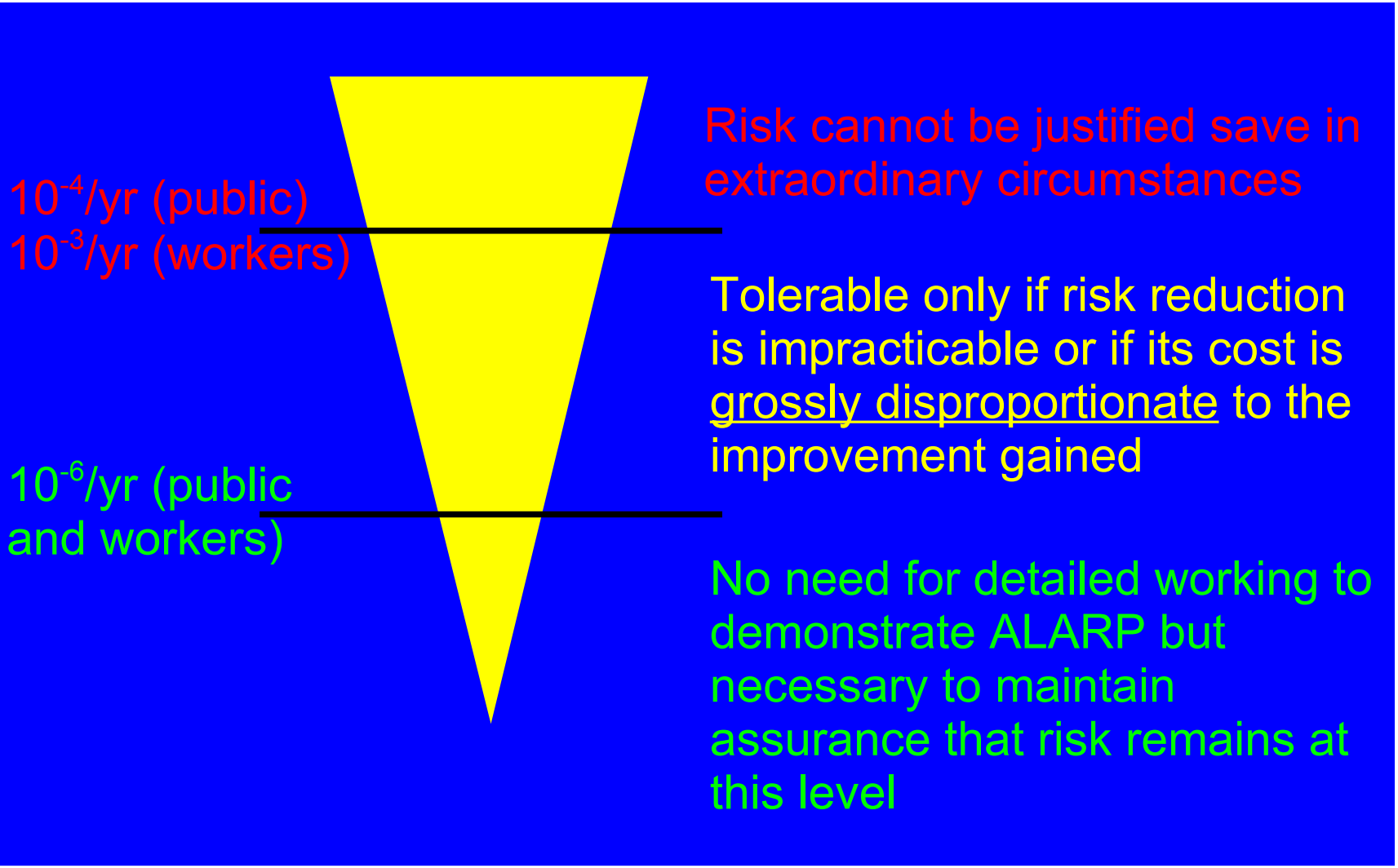
Tolerability (IR Death Criteria)



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Gross Disproportion

Edwards -v- National Coal Board

"Reasonably practicable" is a narrower term than "physically possible" and seems to me to imply that a computation must be made by the owner in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other, and that, if it be shown that there is a gross disproportion between them—the risk being insignificant in relation to the sacrifice—the defendants discharge the onus on them. Moreover, this computation falls to be made by the owner at a point of time anterior to the accident.

1949 Appeal re breach of s49 of the Coal Mines Act 1911

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Gross Disproportion

- Proportion Factor is

  Cost of the possible safety measure
  Value of all harms averted by it

  - Not just predicted fatalities averted
  - COMAH includes the Environment
  - What about disruption to activity of others during/after the accident, cost of emergency service response, etc., etc.?
- What is Gross Disproportion is uncertain
  - http://www.hse.gov.uk/risk/expert.htm

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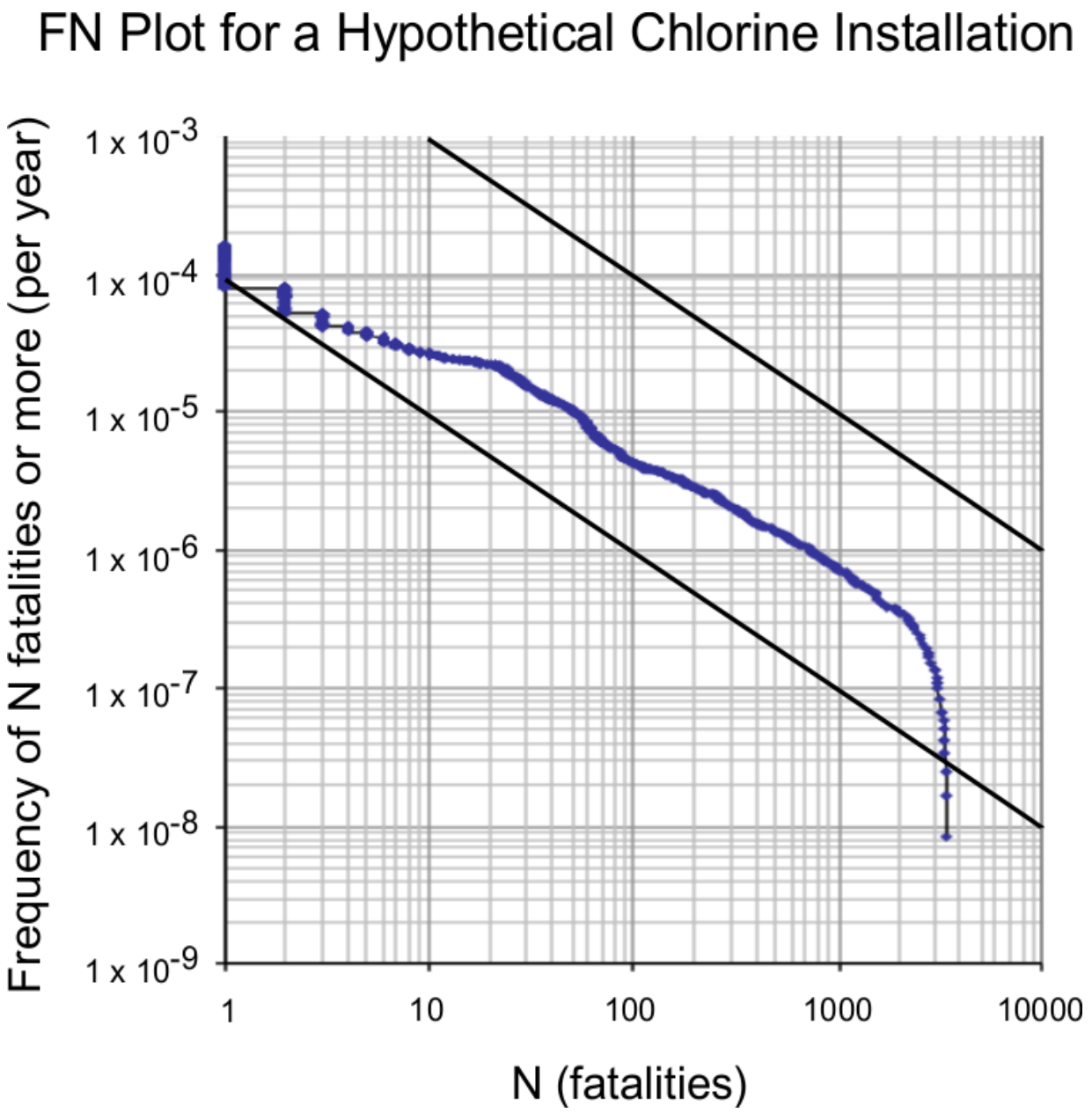
Societal Risk Criteria



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Cost Benefit Analysis

- Need clarity on:
  - Costs in scope (including incidental benefits)
  - Benefits in scope (including public costs)
  - Decision function (i.e. gross disproportion)
- Example
  - HSE – Reducing the risk of explosion
    - http://www.hse.gov.uk/risk/theory/alarpcheck.htm

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Costs (to the duty holder)

- Positive
  - Plant and equipment
  - Plant downtime → Lost production
- Negative
  - Improved efficiency
  - More valuable product
  - Asset value

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Benefits (to the public)

- Positive
  - Value of human harms averted
  - Value of damage to natural and built environment averted
  - Value of disruption averted (during and after incident)
- Negative
  - Disruption during change
  - Ongoing disruption

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Some Costs from Buncefield

Sector	*Cost (£ million)*
Site operators (compensation claims)	£625
Aviation	£245
Competent Authority and Government response	£15
Emergency response	£7
Environmental impact (drinking water)	£2
Total	£894

From Buncefield MIIB Final Report (Volume 1), Page 25

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Some Costs from Buncefield

Claimant type	*No. of claims*	*Estimate £ million*
Business		
inside site perimeter	5	£103
outside site perimeter	749	£488
Subtotal businesses	754	£591
Individuals	3 379	£30
Local authorities	7	£4
Totals	4 140	£625

From Buncefield MIIB Final Report (Volume 1), Page 25

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Valuing Human Harms Averted (HSE)

		Values (2003 Q3) [1]
FATALITY		£1,336,800 (times 2 for cancer)
INJURY		
Permanently incapacitating injury	Moderate to severe pain for 1-4 weeks. Thereafter some pain gradually reducing but may recur when taking part in some activities. Some permanent restrictions to leisure and possibly some work activities.	£207,2000
Serious	Slight to moderate pain for 2-7 days. Thereafter some pain/discomfort for several weeks. Some restrictions to work and/or leisure activities for several weeks/months. After 3-4 monthsreturn to normal health with no permanent disability.	£20,500
Slight	Injury involving minor cuts and bruises with a quick and complete recovery.	£300
ILLNESS		
Permanently incapacitating illness	Same as for injury.	£193,100
Other cases of ill health	Over one week absence. No permanent health consequences.	£2,300 + £180 per day of absence
Minor	Up to one-week absence. No permanent health consequences.	£530

http://www.hse.gov.uk/risk/expert.htm

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CBA - Other Issues

- Sensitivity analysis
  - A sensitivity analysis consists of varying one or more of the parameters/assumptions of the CBA to see how these variations affect the CBA outcomes
- Discounting
  - Discounting is a procedure that allows a comparison between costs and benefits arising in different time periods
  - More weight is given to earlier costs and benefits than later ones by applying a discount rate
  - Discount rates may be different (3.5% costs v 1.5% benefits)

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Risk Assessment/CBA Pitfalls

- HSE RR151 - Good practice and pitfalls in risk assessment
- 19 Identified types of pitfall including:
  - “Making decisions on the basis of individual risk estimates when societal risk is the appropriate measure;”
  - “Dividing the time spent on the hazardous activity between several individuals - the ‘salami slicing’ approach to risk estimation;”
  - “Inappropriate use of risk criteria;”
  - “No consideration of ALARP or further measures that could be taken;”
  - “Inappropriate use of cost benefit analysis;”

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Now the Bad News! (1)

- Uncertainty in the Predicted Risk Numbers
  - Consequence Modelling within Factor of 2?
  - Failure Rates within Factor of 10?
  - Risk within Factor of 20?
  - Range of Values - Factor of 400?
  - But Tolerable Band is only a Factor of 1000
  - Is QRA a 'blunt axe' rather than a 'surgeon's scalpel'?
- Many other modelling issues

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Now the Bad News! (2)

- Variability in the Risk Criteria
  - Risk tolerability, and justifiable spend on safety, are context dependant
  - Compare HSE policy on 'Safety Spend' with the National Institute for Clinical Excellence spend on medical treatments
  - Claimed to be the same across all of occupational safety but compare chemical sector with nuclear sector
  - 'Public perception of risk'

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How the Public Thinks? (1)

Experience suggests that:

- Acts of God or Nature are much more acceptable than acts caused directly by people
- Hazards, accidents and failures of public or community enterprises are much more acceptable than those of private, profit making enterprises
- Risks are accepted much more readily if we are in control or have participated in the decisions leading to the risk
- Risks are unacceptable if we cannot see the concomitant benefits either for some "deserving" group or ourselves
- Familiarity makes a hazard much more acceptable. Death in a road accident is more acceptable than death caused by radiation
- A large number of incidents spread over a wide area is much more acceptable than if the same effect took place at one time in one place (Consider the impact if all the annual deaths from lung cancer took place at one location on one day) *"Scale Aversion"*

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How the Public Thinks? (2)

Experience suggests that:

- We feel protective towards the innocent or vulnerable (children and the old)
- Recurrent incidents are much less acceptable than the first occurrence
- Even a modest systems failure in a mysterious, poorly understood operation like a chemical plant raises anxiety about what else is lurking within and is much less acceptable than a major incident in a better understood environment like a ship
- Response to an incident affects its acceptability
- Retreating into defensive denial can often be even less acceptable than the incident

From 'The Societal Aspects of Risk', The Royal Academy of Engineering,

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QRA Pros & Cons (Summary)

Pros

- Systematic Approach to Assess/Rank Risks and Make Decisions
- Prioritise Spend – How Safe is Safe Enough?

Cons

- Initial Assumptions can Determine Outcome
- Need Good Predictive Models (Hazards and Consequences)
- Need Good Failure Rate and Other Event Data
- Risk Modelling Does Not Come Close to Reality
- Need Consensus on Risk Tolerability and Cost/Benefit Parameters

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Further Reading (1)

- Reducing Risks – Protecting People “R2P2” <http://www.hse.gov.uk/risk/theory/r2p2.htm>
- HSE's ALARP Suite of Guidance <http://www.hse.gov.uk/risk/theory/alarp.htm>
- HID’s approach to ‘as low as reasonably practicable’ (ALARP) decisions (includes HID position on societal risk criteria) <http://www.hse.gov.uk/foi/internalops/hid/spc/spcperm09.pdf>
- 'Nomenclature for Hazard and Risk Assessment in the Process Industries, David Jones, ' IChemE, 1992

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Further Reading (2)

- Various publications by the Royal Academy of Engineering <http://www.raeng.org.uk/>
  - The Societal Aspects of Risk, January 2003
  - Common Methodologies for Risk Assessment and Management, January 2003
  - Risks Posed by Humans in the Control Loop, January 2003
  - The Risk Debate – Trust Me I'm an Engineer (a transcript of the debate), June 2004
  - Humans in Complex Engineering Systems (the proceedings of a workshop), January 2005