Application of Cost Benefit Analysis to Demonstrate ALARP

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Good Practice Guides
Societal Risk / CBA / ALARP

- Suite of Good Practice Guides & Technical Briefing Notes:
  - Elements of Risk Assessment Methodology for different fluids
    - Natural Gas / Gasoline / Ethylene
  - Calculation of Land Use Planning zones
    - History of discussions with HSE on ethylene / gasoline
  - Managing Societal Risk
    - When to use QRA
    - Risk reduction/mitigation
  - Use of Cost Benefit Analysis to Demonstrate ALARP

GPG – Use of Cost Benefit Analysis to Demonstrate ALARP

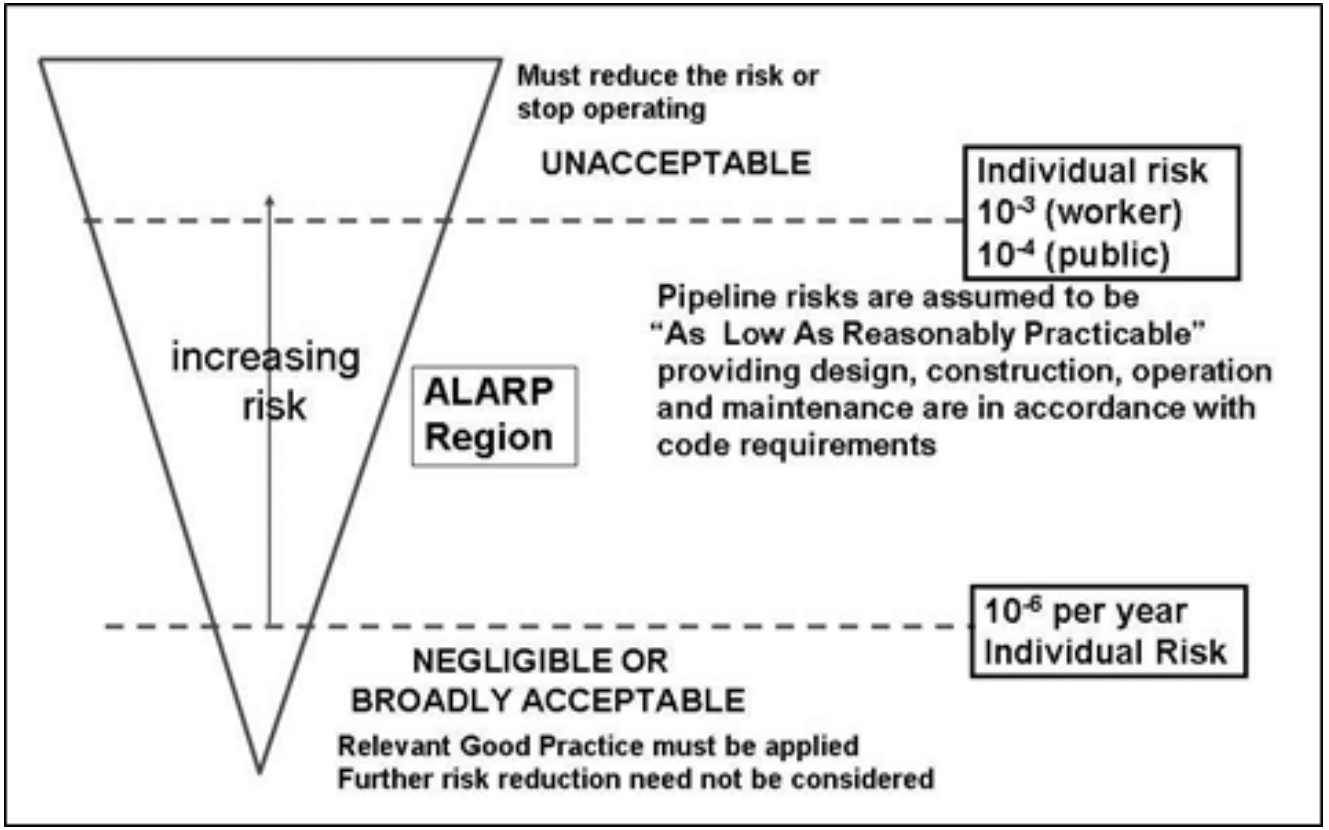
- 1st Draft developed by Rod McConnell
  - Issued to FARWG for comment on 1st September 2017
- 2nd Draft currently in preparation
  - Mike Acton & Karen Warhurst (DNV GL)
- Deadline for 2nd Draft – end of Q2 2018
- Expect to issue by end Q3 / start Q4 2018
  - i.e. approved at Autumn Board Meeting

Background – ALARP Principle

- Concept of ALARP introduced in Appeal Court judgement from Edwards vs National Coal Board [1949] 1 All ER 743

"'Reasonably practicable' is a narrower term than 'physically possible' … 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."

ALARP Principle – UK HSE



- Residual risk should be reduced so far as is reasonably practicable

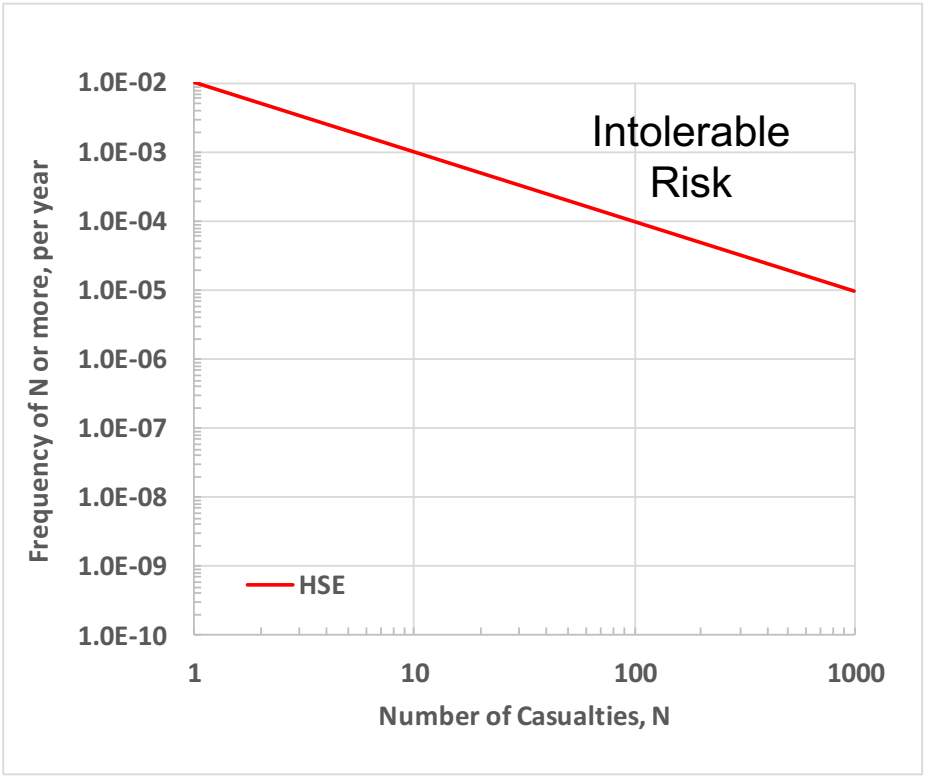
Tolerability Limits – Individual Risk

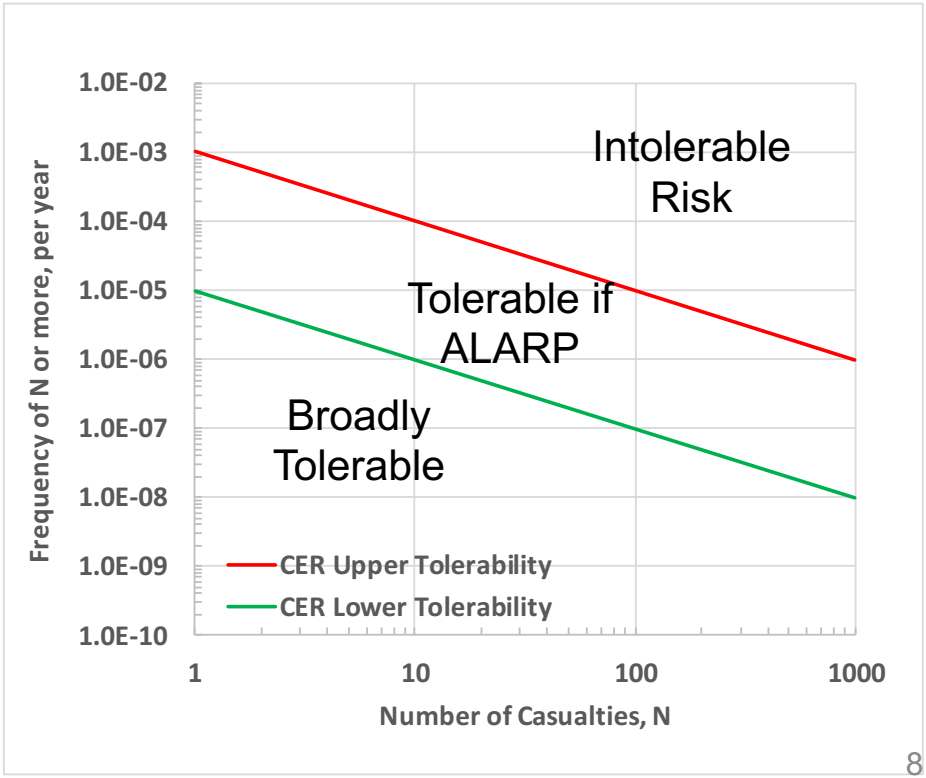
- UK HSE
  - Upper Tolerability Limit (Worker) – 1×10^{-3} per year
  - Upper Tolerability Limit (Public) – 1×10^{-4} per year
  - Lower Tolerability Limit – 1×10^{-6} per year

- Average risk of death from all causes is approximately 1×10^{-2} per year
  - i.e. Risks at lower tolerability limit add 0.01% to overall individual risk for average person

Tolerability Limits – Societal Risk

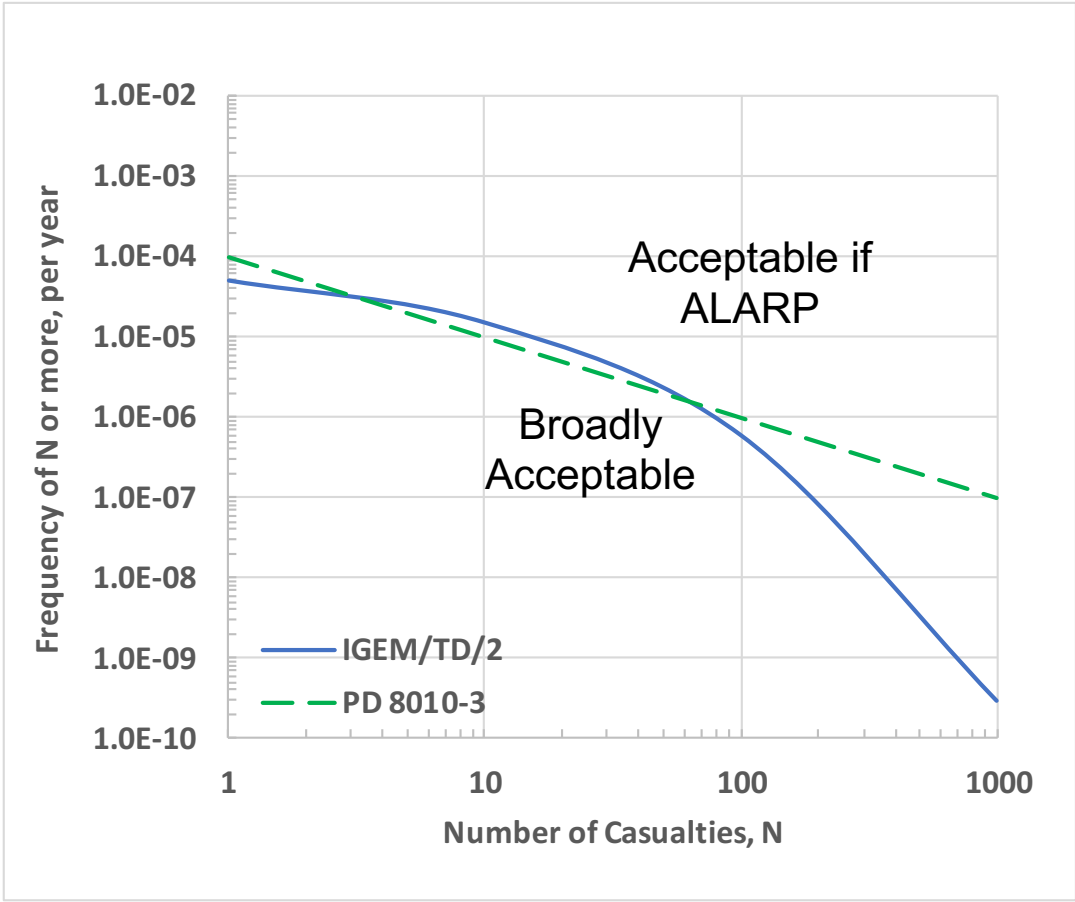
- UK HSE
  - Intolerable region defined as 50 people at more than 2 x 10^{-4} per year
  - Slope of -1 (no aversion)
- ROI CER
  - One order lower & Tolerable if ALARP Region defined





Tolerability Limits – Societal Risk

- IGEM/TD/1 & IGEM/TD/2
  - 1.6 km of pipeline
- PD8010-3
  - 1 km of pipeline



Legislative Requirements (UK)

- Health & Safety at Work etc. Act 1974 (HASWA)
  - "It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his/her employees"

- Management of Health & Safety at Work Regulations 1999
  - "Every employer shall make a suitable and sufficient assessment of-

    (a) the risks to the health and safety of his employees to which they are exposed whilst they are at work; and

    (b) the risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking"

- Pipelines Safety Regulations (PSR) 1996
  - Goal-setting
  - Design, construction and safety systems
    - Limited by reasonable practicability clauses
  - MAPD (MAHPs only)
    - All hazards identified and risks arising from those hazards evaluated

Code Requirements (UK)

- IGEM/TD/1 Edition 5
  - Affirmation of MOP including infrastructure survey – every 4 years
    - 'TD/1 Survey'
  - QRA allowed to justify proximity & population density infringements as part of a safety evaluation
  - Cost benefit analysis to demonstrate ALARP required when
    - Individual Risk is in the tolerable region, or
    - Societal Risk is outside the broadly acceptable region

- PD 8010-1:2015
  - Currently lighter on O&M details but does now require Affirmation of MAOP in accordance with requirements of IGEM/TD/1
    - UK HSE does expect operators of pipelines designed to earlier versions of PD 8010 to complete this

Good Practice & ALARP Demonstration

- 1st step in an ALARP assessment is to determine if relevant good practice risk reduction measures have been adopted
  - Defined by recognised codes / standards / ACOPs / etc.

- Design, construction, operation and maintenance to IGEM/TD/1 or PD 8010-1 considered to be good practice by UK HSE
  - Implicit assumption that risk levels of pipelines to code are ALARP
    - QRA of the residual risk used where code is infringed
  - Be careful with cherry-picking!

Cost Benefit Analysis Process

- Calculate the Cost of Preventing a Fatality (CPF)
  - Sometimes called Cost per Life Saved (CPLS) or Cost per Casualty Averted (CPCA)
- Compare with Value of Preventing a Fatality (VPF)
  - £1,336,800 in 2003
  - Approximately £2 million today (adjusted for inflation)
- Determine the Disproportion Factor (DF)
  - UK guidance not totally clear on what is gross disproportion but robust justification required, e.g. if DF less than 10
    - i.e. CPF or should be greater than ≈£20 million (2018 figures)
    - QRAs typically use a larger value to account for uncertainty in frequency and consequence predictions
- NB Reverse ALARP not allowed
  - i.e. can't use ALARP to argue against implementation of recognised good practice

Cost of Preventing a Fatality

$$CPF = \frac{Cost\ of\ Risk\ Reduction\ Measure}{Reduction\ in\ Potential\ Loss\ of\ Life}$$

$$= \frac{Annualised\ Cost}{\Delta EV} = \frac{Cost}{\Delta EV \times Remaining\ Life}$$

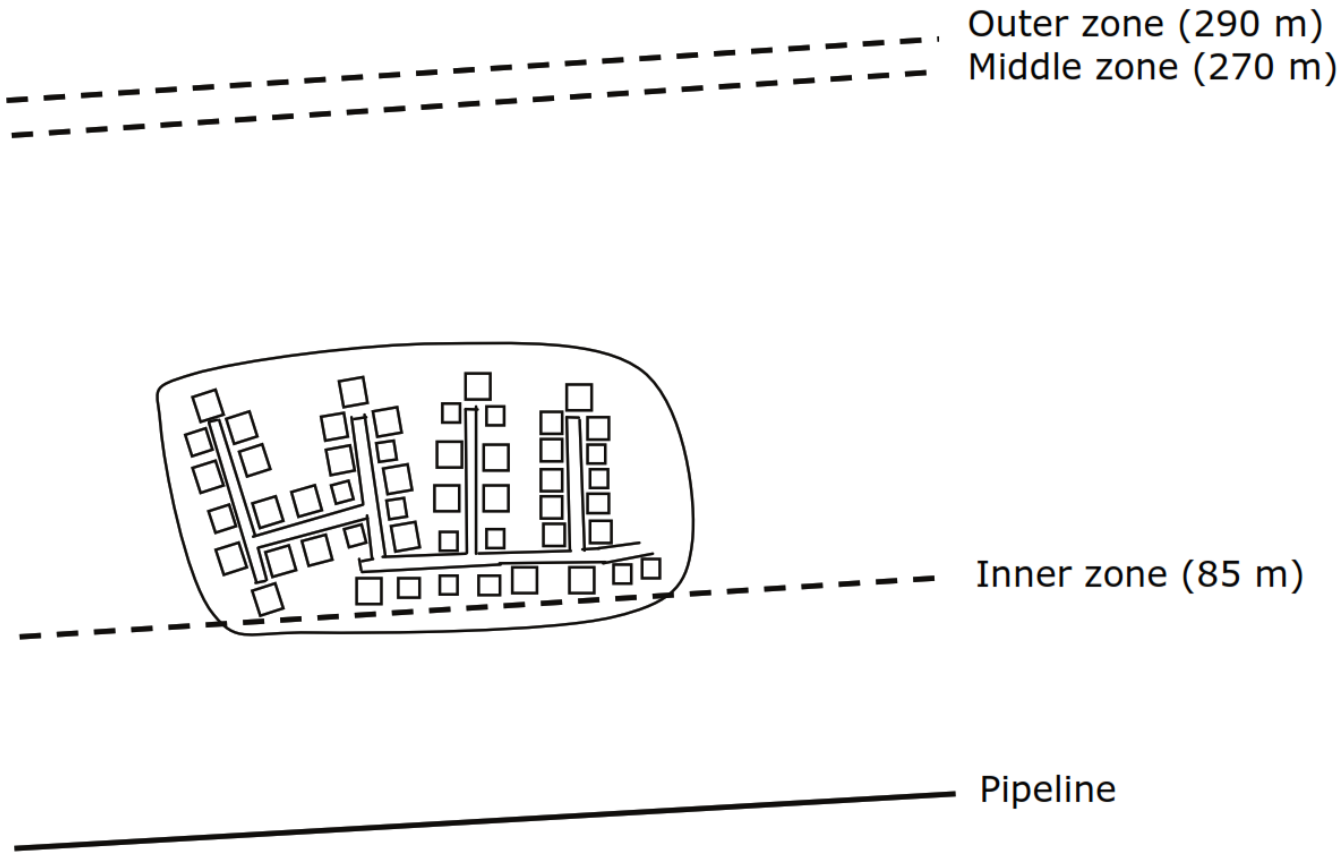
- EV = Expectation Value
  - Statistical expression for average number of casualties per year
  - Also known as Potential Loss of Life (PLL)

$$EV = \sum f.n$$

- Equivalent to area under FN curve

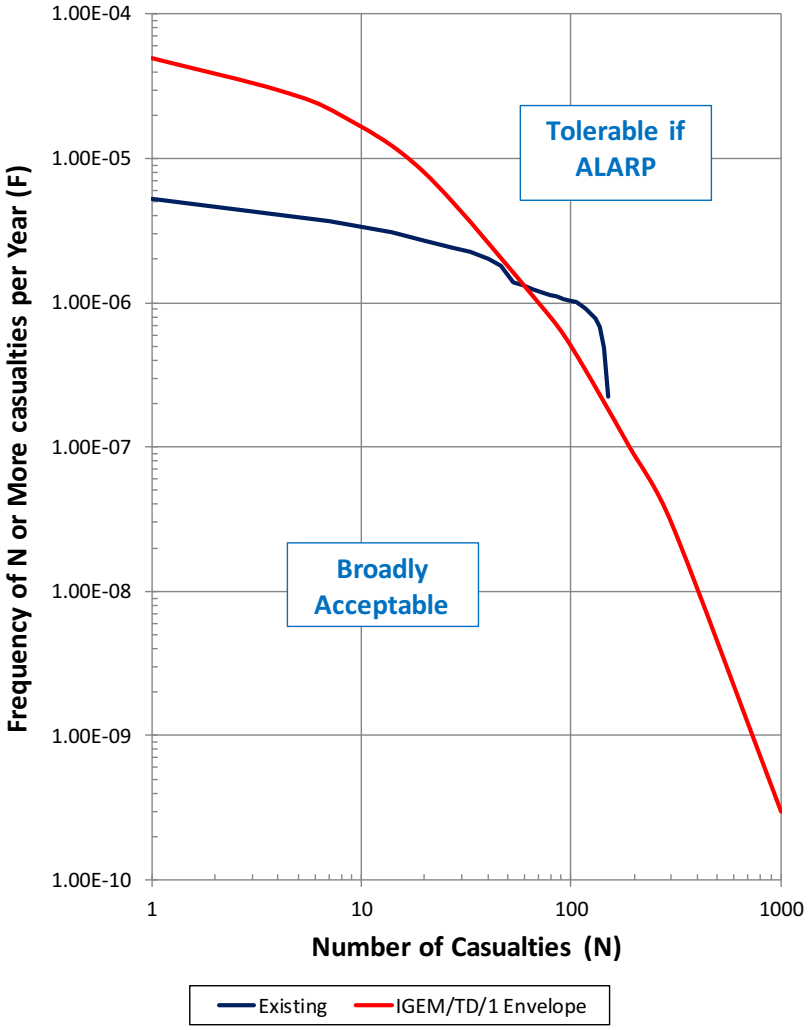
CBA Example – IGEM/TD/2

- S-area cluster of 50 houses



CBA Example

- Initial QRA
  - Societal Risk in Tolerable if ALARP region
- Consider additional risk mitigation measures
  - Assess using CBA

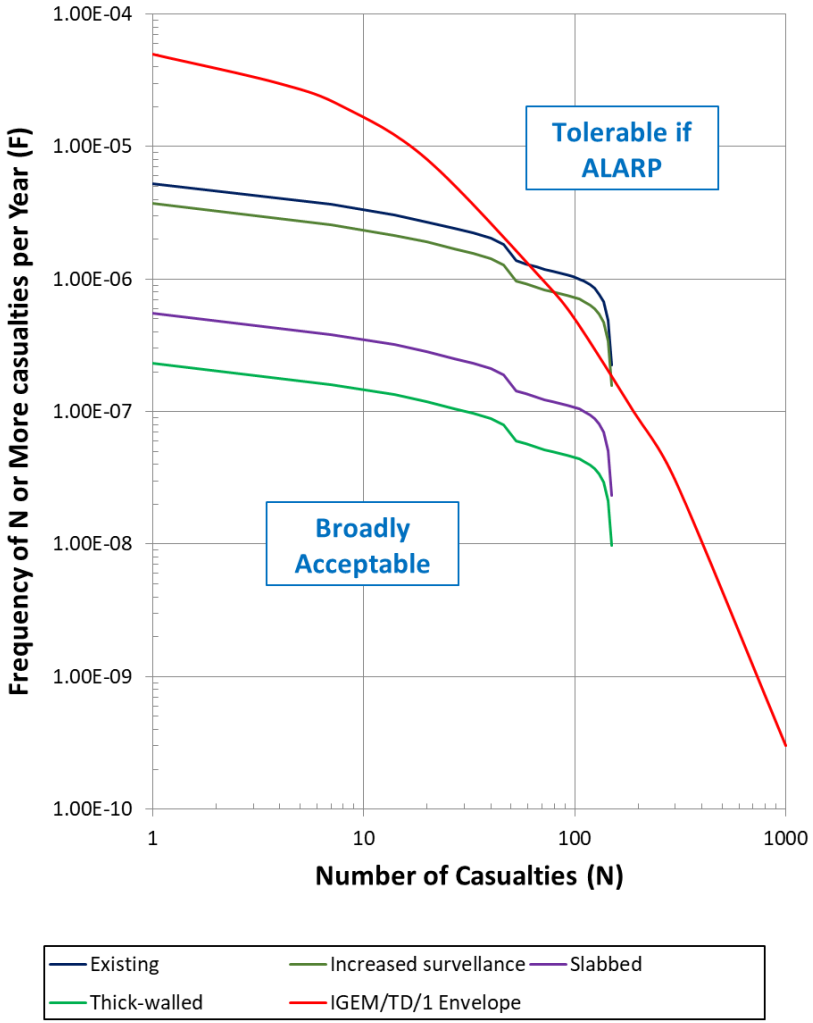


CBA Example – Possible Risk Reduction

- Daily Surveillance
  - Additional vehicle use and technician time = £1,500 per year
- Concrete Slabbing for length of infringement
  - 200 m of slabbing @ £1500 / meter = £300,000 or £7,500 per year
- Relay in thick-wall for length of infringement
  - 200 m including hot tap and stopple = £875,000 or £21,875 per year
- Typical to assume remaining life is always 40 years for gas networks
  - May not always be true!

CBA Example – QRA Results

- Risk reduction due to increased surveillance is small
- Risk reductions due to slabbing and thick-wall are broadly similar



CBA Example – Results

Risk Reduction Measure	Original Expectation Value	Reduced Expectation Value	Annualised Cost	VPF	DF
Surveillance	2.32×10^{-4}	1.63×10^{-4}	£1,500	£21.7 million	10.9
Slabbing		2.42×10^{-5}	£7,500	£36.0 million	18.0
Relaying		1.01×10^{-5}	£21,875	£98.6 million	49.3

- Physical mitigation options are grossly disproportionate
- Additional surveillance is just grossly disproportionate
  - But relatively low cost…
- Existing risk levels are ALARP?
  - Could anything else be considered?

Things to think about…

- Risk reduction models and factors exist in IGEM/TD/2 for
  - Thicker-wall / Deeper cover / Concrete slabs / Increased surveillance
  - But what is the effect of increased land-owner liaison, improved marker posts or other management procedures?
- Managerial or procedural risk reduction measures need to be maintained for life of pipeline
  - Given changes in industry over last 40 years UK HSE may struggle to accept this!
- Would a shorter length of slabbing or thick-wall be better?
  - May depend on the location of the majority of the affected population…
  - Complete sensitivity study if DF is close to 10? Or less than x?
- Use of discounting / inflation?
  - Costs/benefits more than ≈10 years in the future are worthless…

Questions?