Benchmarking the AS 2885 Safety Management Process

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What's the Problem?

- AS 2885 is a home-grown standard
  - The safety management study (SMS) process is not used anywhere else in the world
- We think it is world's best practice
  - A straightforward user-friendly method, minimal specialist input
  - Passes a sanity check - results look reasonable and are consistent
- But ... no-one knows how it compares to other risk assessment methods
  - Expect intense criticism if there is a pipeline disaster
  - Very serious for whole industry if our safety management was shown to be inadequate

What are the Alternatives?

Classical Quantitative Risk Assessment (**QRA**)

Modern Reliability Based Analysis (**RBA**)

If SMS compares unfavourably, need to improve SMS process

AS 2885 SMS

- Two phases
  - Design review to identify threats then eliminate them if possible by modifying the design or operating procedures
  - Risk assessment of residual threats that can't be fully eliminated
- Risk assessment is qualitative
  - Uses risk matrix, expresses risk as High, Intermediate, Low, etc
  - Frequency and severity of failure estimated on the basis of informed judgements (supported by calculations if necessary)
- Based on a cause-and-control model of risk management
  - Identify every cause of failure (threat)
  - Implement targeted measures to control each individual threat

Quantitative Risk Assessment

- Calculates and expresses risk levels numerically
  - Individual risk
    - Probability of fatality for a person at distance X from pipeline
    - Often expressed as graph of probability vs. distance
  - Societal risk
    - Probability that pipeline failure will result in N deaths (societal risk)
    - Often expressed as F-N curves (frequency vs. number of deaths)
- Estimating failure frequency requires valid historical data
  - Australian failure history very limited (good !)
- Limited capacity to address specific causes of failure, or effects of specific mitigation measures

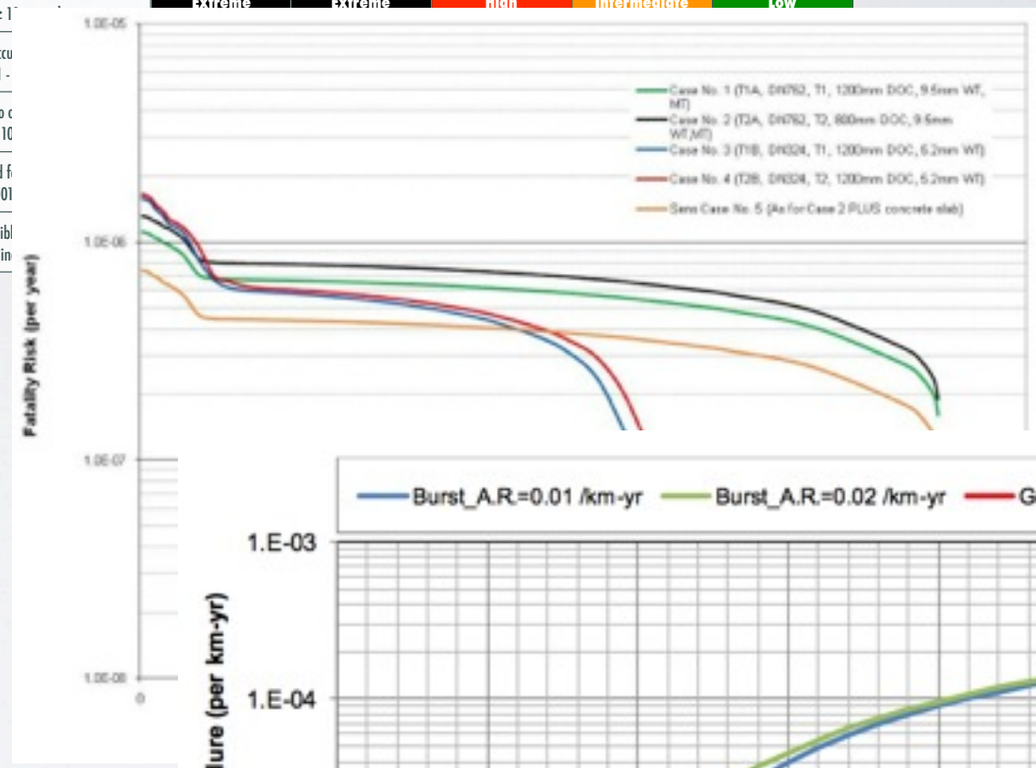
Reliability Based Analysis

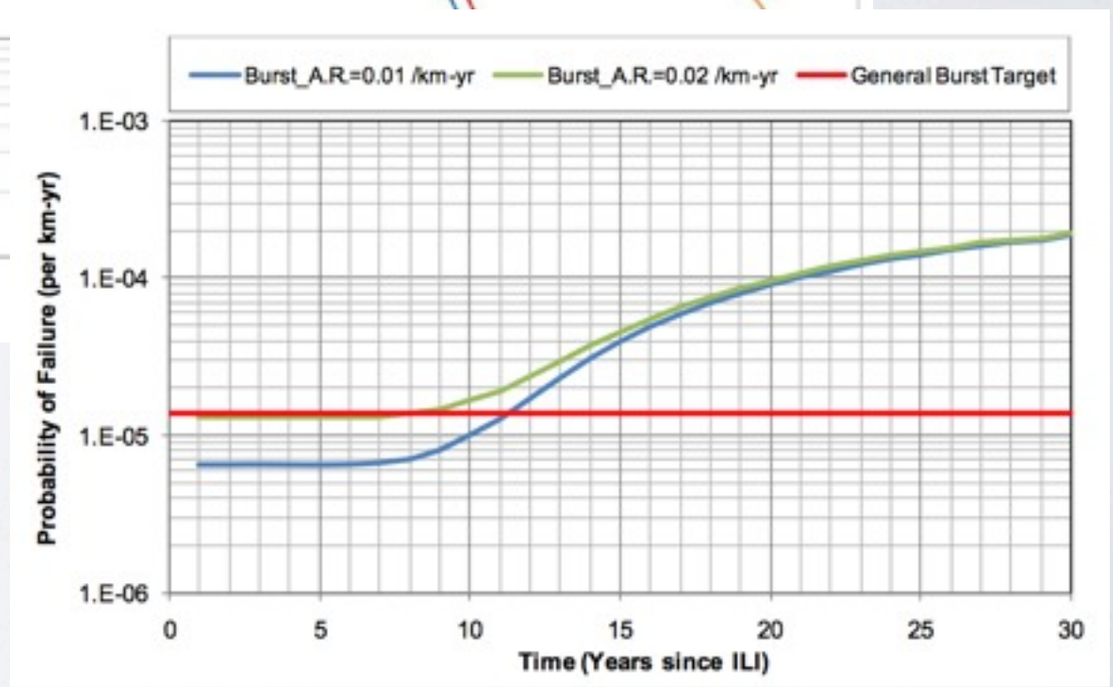
- Developed by C-FER in Canada, industry-sponsored project
  - Included as an option in Canadian Standard CS Z662
- Also numerical, but much less reliant on failure history
  - Starts with probability distributions for all factors that influence pipe failure (eg. WT, corrosion rates, level of third party activity, pipeline protection measures, etc)
  - Calculates probability of failure by Monte Carlo simulation
  - Compares against target reliability based on size of population affected by failure
- Should be more valid than QRA in situations where there is insufficient failure history (and perhaps generally)

But how to Compare?

- SMS, QRA and RBA are incommensurable
  - Each expresses risk in different terms and compares it against different criteria
  - Qualitative SMS vs quantitative risk (individual or societal) vs reliability

		CATASTROPHIC	MAJOR	SEVERE	MINOR	TRIVIAL
PEOPLE:		Multiple fatalities	Few fatalities, or several people with life-threatening injuries	Injury or illness requiring hospital treatment	Injuries requiring first aid treatment	Minimal impact on health
SUPPLY:		Long term interruption	Prolonged interruption or long-term restriction	Short term interruption or prolonged restriction	Short term interruption or restriction but shortfall met from other sources	No interruption or restriction
ENVIRONMENT:		Effects widespread, viability of ecosystems or species affected, permanent major changes	Major off-site impact or long-term severe effects or rectification difficult	Localised (<1 ha) & short-term (<2 yr) effects, easily rectified	Effect very localised (<0.1 ha) and very short term (weeks), minimal rectification	No effect, or minor on-site effects rectified immediately with negligible residual effect
FREQUENT	Expected to occur several times (≥ 1	Extreme	Extreme	High	Intermediate	Low
OCCASIONAL	May occu (0.1 -					
UNLIKELY	Unlikely to o (0.1% - 1					
REMOTE	Not anticipated f location (0.001					
HYPOTHETICAL	Theoretically possibl on a similar pipelin					





Basis for Comparison

Risk assessment methods are not absolute, just a decision aids:

Is the risk tolerable or not?

Key to comparison:

Compare borderline cases to see if all methods agree they are borderline tolerable

Only single-point calibration, but it's the most important point

Test Cases

- Basis for selection:
  - Already been through routine SMS
  - Risk level found to be Intermediate (ie. borderline in AS 2885 terms)
- Four cases, each segment 500 m long:

Location Class	T1 (Suburban)	T2 (High Density)
Pipeline A Urban Design, **thick**	T1 A	T2 A
Pipeline B Rural Design, **thin**	T1 B	T2 B

- Details confidential at request of pipeline owner

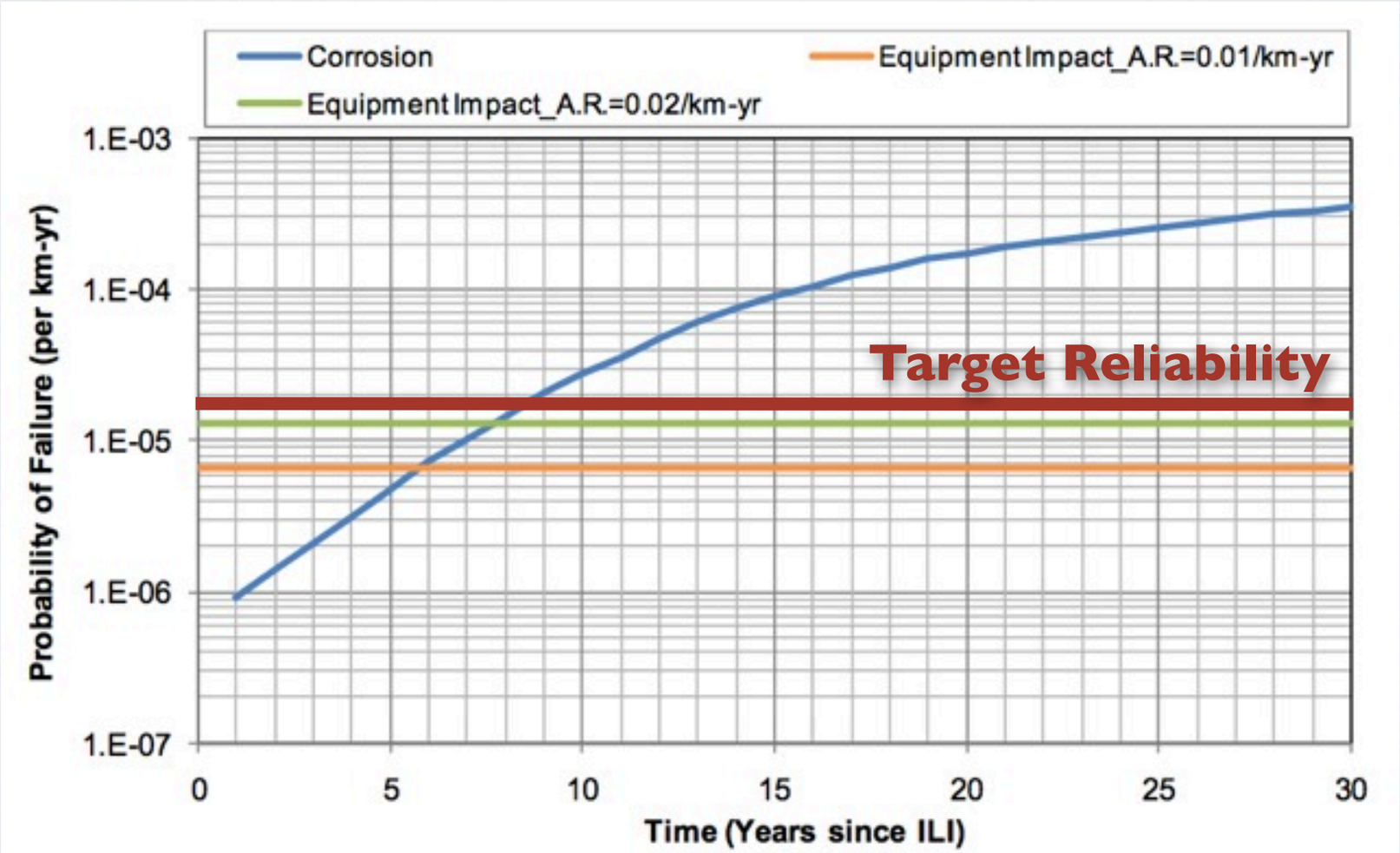
SMS Results

- SMS done as part of routine responsibilities of pipeline owner, not set up specifically for this study
  - Outcomes still useful for this study despite some differences in approach between Pipelines A and B
- Intermediate risk is borderline tolerable (and only if ALARP)

	Corrosion Risk	Puncture Risk	Rupture Risk
Pipeline A (thick)	Intermediate & ALARP	Low	"No Rupture"
Pipeline B (thin)	Intermediate & ALARP	Intermediate & ALARP	Intermediate & ALARP

RBA Results

- RBA results were calculated for two failure modes:
  - Corrosion leak
  - Mechanical damage rupture (including contribution from leak)
- Results presented as reliability vs. time, with target reliability also shown



This graph for illustration of concept only. Corrosion and impact risks have different target reliabilities but only impact target shown here.

RBA Summary

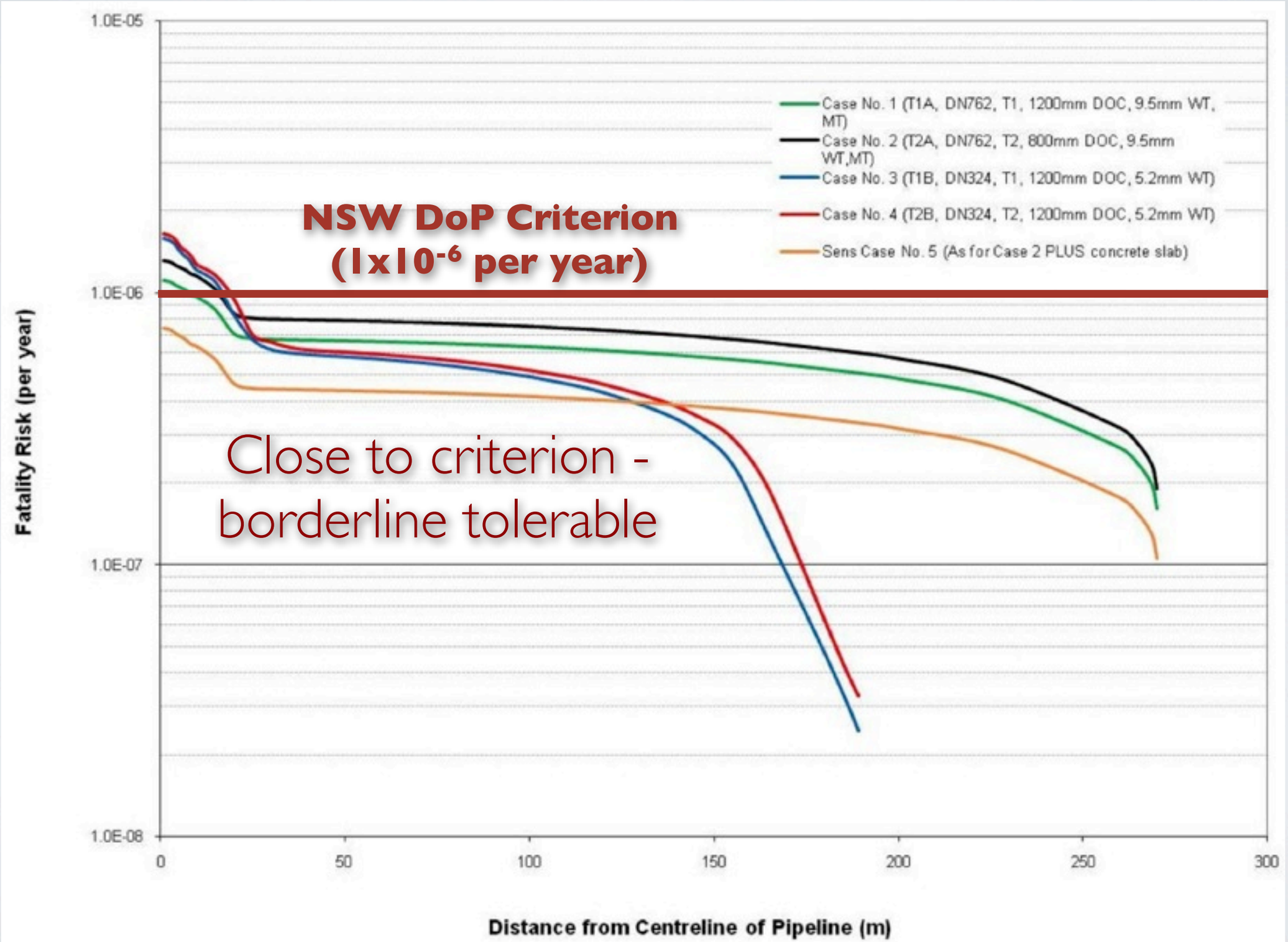
- Corrosion risk borderline if target reliability exceeded soon
- Burst risk borderline if failure rate roughly equals target rate (on an order of magnitude scale)
- **Red** cases are borderline tolerable

Segment	T1A	T2A	T1B	T2B
Years until corrosion target exceeded	25	17	**5**	**5**
Ratio of burst failure rate to target rate	**0.20**	**2.60**	**2.00**	**2.50**

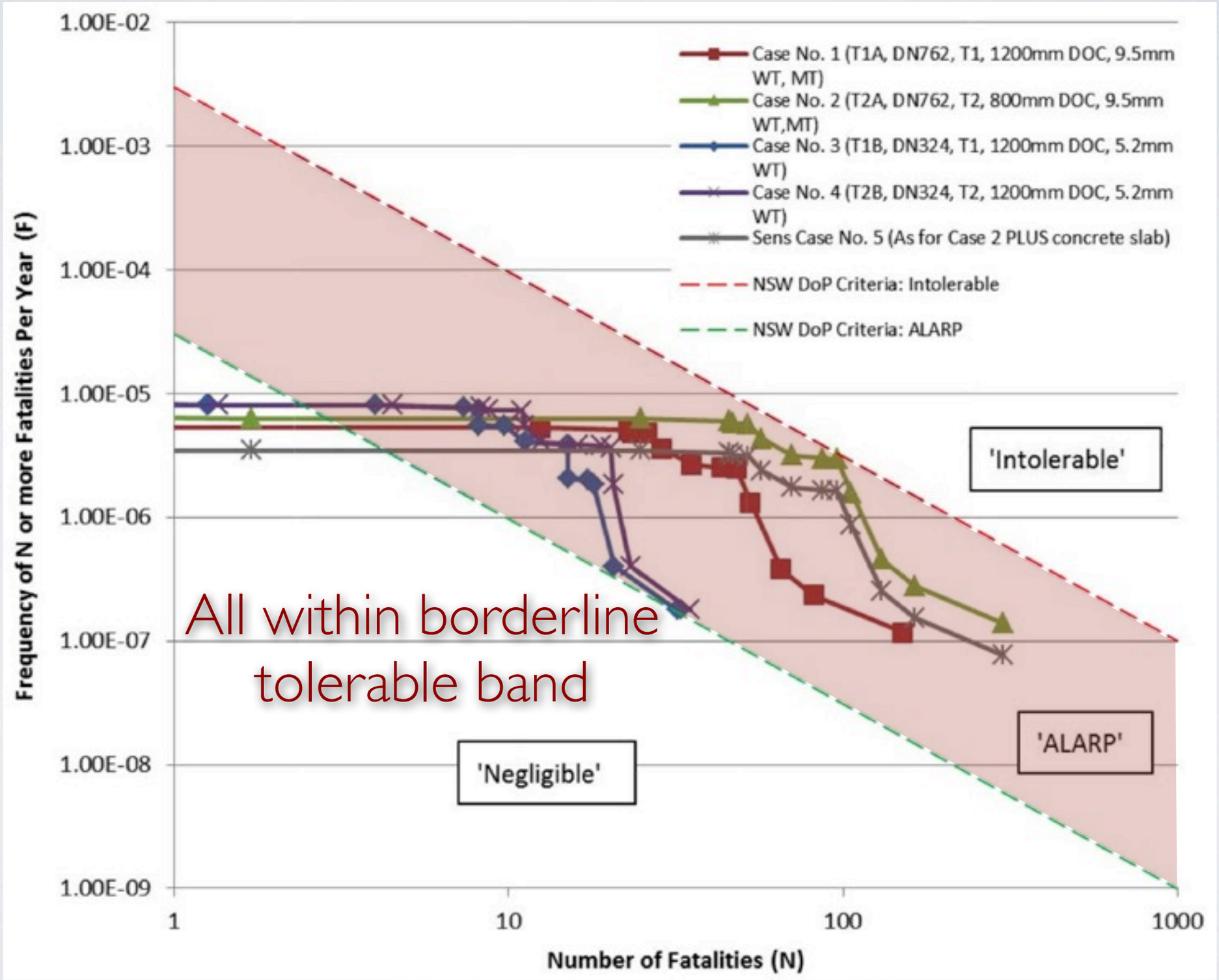
QRA Results

- QRA calculated combined risk from three failure scenarios (corrosion pinhole, mechanical puncture, rupture)
- Expressed as both individual risk and societal risk
- Compared against risk criteria from NSW Dept of Planning
  - Other criteria exist, and vary widely
- Incident frequencies based on European data, extremely conservative for Australia (about 15 times higher)

QRA Individual Risk



QRA Societal Risk



Comparison

Analysis Method	Pipeline	Corrosion leak	Puncture	Rupture
SMS	A	Borderline	Tolerable	n/a
	B	Borderline	Borderline	Borderline
RBA	A	Tolerable (~20 yr)	n/a	Borderline
	B	Borderline (~5 yr)	n/a	Borderline
QRA - individual	A	Borderline	Borderline (low)	Tolerable
	B	Borderline	Borderline (low)	Tolerable
QRA - societal	A	Borderline (low)	Borderline	Borderline
	B	Borderline (low)	Borderline	Borderline (low)

Observations

- Almost all cases are borderline - confirms that SMS results are consistent with other methods
- Differences between analysis methods greater than between pipelines, despite greater vulnerability of Pipeline B
  - Implies risk analyses are not absolute but at best indicative and an aid to decision making
- QRA known to be conservative by at least an order of magnitude, yet roughly same results as SMS
  - Implies SMS would be much more conservative than QRA if latter based on real Australian incident rates

Application

- RBA useful for quantifying increase in corrosion risk over time
- QRA remains of limited use for pipelines
  - Little or no guidance on how to reduce risk
  - Uncertain capacity to include effects of procedural protection
  - May have a role in satisfying authorities (and the public) that pipelines are safe, in terms familiar to them
- SMS is more than a risk analysis
  - Threat mitigation is an integral part of the process - takes place even before risk evaluation
  - Threats that present highest risk are obvious targets for risk reduction

Benchmarked Successfully

SMS confirmed as **consistent** with QRA and RBA

Industry can be confident that SMS estimates risk at least as reliably as other methods

No need for changes to SMS process to calibrate it

SMS has additional benefit of focus on risk reduction, regardless of formal risk evaluation

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The Australian pipeline industry can be confident in its home-grown process for effective pipeline risk management