ALARP: when is enough, enough?
Overview

- ALARP in GB rail
- Level of detail, time & effort in safety decision making process
- Qualitative or quantitative approach?
- Real world examples

SFAIRP and ALARP generally interchangeable
ALARP concept in GB rail

‘...a computation must be made...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 on the other’.

Hence the ‘sacrifice’ is taken to be the cost of a potential measure and the ‘quantum of risk’ the safety benefit associated with it. The quantum of risk is a collective risk estimate. The VPF is used to translate the safety benefit to a financial value.

Case law establishes that a safety measure is reasonably practicable unless the cost is ‘grossly disproportionate’ to the safety benefit. This is determined by professional judgment, paying particular attention to the degree of uncertainty in the assessment of costs and safety benefits. See Taking Safe Decisions for more on ‘gross disproportion’.

Source: RSSB, CBA guidance
ALARP level

No need to implement

Sacrifice grossly disproportionate

Implement

Risk Reduction

£

Risk Reduction

£

Risk Reduction

£

Risk Reduction

£
Rail industry standards & guidance

Guidance on the use of cost-benefit analysis when determining whether a measure is necessary to ensure safety so far as is reasonably practicable

Internal guidance on cost benefit analysis (CBA) in support of safety-related investment decisions
February 2016

Category 1 Standard
S1521 Safety Decision Making

Taking Safe Decisions - How Britain’s railways take decisions that affect safety
Reverse burden of proof

Gross disproportion acknowledges that accidents & their consequences difficult to predict – estimation of risk is an inherently uncertain process

Degree of uncertainty in risk estimates considered in judgment they are used to inform

Source: RSSB, TSD

Section 40 of HSWA says that “it shall be for the accused to prove… that it was not practicable or not reasonably practicable to do more than what was in fact done…” sometimes referred to as ‘reverse burden of proof’ – anyone taking decision not to introduce a safety measure needs to be confident that it is not reasonably practicable
Timing is key

Design and concept well defined: integration of safety measures becomes increasingly expensive

High level of flexibility for building safety measures into the design

Addition of new safety measures is still possible but is likely to lead to substantial cost or delays to the project

Source: RSSB, TSD
Delay not an excuse

It is not acceptable to argue that a measure is not necessary to ensure safety SFAIRP on the basis of excessive cost if that measure could and should have been identified at an earlier point in the project when its implementation would have been required.

Source: RSSB, TSD
Demonstrating ALARP is a process

1. Identify & assess hazards
2. Confirm minimum acceptance criteria met
3. Identify all possible risk reduction measures
4. Implement unless proven not reasonably practicable
5. Document process & justify decisions

Risk reduced ALARP once every measure identified either implemented or proven to be not reasonably practicable
When is enough, enough?

<table>
<thead>
<tr>
<th>Factors to consider</th>
<th>Nature of the decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk owner</td>
<td>Owned by one organisation</td>
</tr>
<tr>
<td>Worst credible case consequences</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Operational experience</td>
<td>Extensive</td>
</tr>
<tr>
<td>Technology</td>
<td>Mature</td>
</tr>
<tr>
<td>Complexity</td>
<td>Very simple</td>
</tr>
<tr>
<td>Ability to monitor and act post change</td>
<td>Can identify problems and resolve quickly</td>
</tr>
</tbody>
</table>

Approach for making the decision:

- More likely to be categorised as significant
- More senior level decision taking
- More consultation
- More extensive and detailed analysis
- More time to agree and implement the decision

Source: RSSB, TSD
Qualitative ALARP

- Allows for transparent decision making
- How to calibrate the axes?

Expert judgement & structured workshops may be useful

Qualitative Matrix for Implementation of SM based on Benefit vs. Cost

<table>
<thead>
<tr>
<th>Effort (time and/or cost)</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Benefit</td>
<td>Consider</td>
<td>Consider, if risk high</td>
<td>Do not implement</td>
</tr>
<tr>
<td>Medium Benefit</td>
<td>Implement</td>
<td>Consider</td>
<td>Consider, if risk high</td>
</tr>
<tr>
<td>High Benefit</td>
<td>Implement</td>
<td>Implement</td>
<td>Consider</td>
</tr>
</tbody>
</table>

ALARP assessment should *start* with a qualitative approach before considering quantitative.
Kirkstall Forge station

- New station near Leeds (opened June 2016)
- Independent safety review raised concern of potential vehicle incursion onto station and track
Vehicle incursion data

Number of Road Vehicle Incursions at Stations (2007 – 2015)

- 2007: 27
- 2008: 31
- 2009: 35
- 2010: 24
- 2011: 31
- 2012: 21
- 2013: 26
- 2014: 27
- 2015: 33

Vehicle Incursion Outcome by Final Resting Place (2005 – 2015)

- Collision with train: 5%
- Not foul of the line: 42%
- Foul of the line (not struck): 53%

Source: RSSB, SMIS & ASPR
Vehicle incursion scenarios
### ALARP review: example site

<table>
<thead>
<tr>
<th>Mitigation Measure</th>
<th>Benefit</th>
<th>Effort</th>
<th>ALARP Review</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Droppable bollards between two substations (front line of substations)</td>
<td>High</td>
<td>High</td>
<td>Consider</td>
<td></td>
</tr>
<tr>
<td>Droppable bollards between two substations (back line of substations)</td>
<td>High</td>
<td>High</td>
<td>Consider</td>
<td></td>
</tr>
<tr>
<td>Concrete lane guard barrier between two substations (back line of substations)</td>
<td>Medium</td>
<td>Medium</td>
<td>Consider</td>
<td>Barrier will bend/shift on impact and may not be a permanent solution</td>
</tr>
<tr>
<td>Large planters between two substations (back line of substations)</td>
<td>High</td>
<td>Low</td>
<td>Implement</td>
<td></td>
</tr>
</tbody>
</table>
Outcome: example site

- Concrete planters with rebar
- PAS 68 rated – stop a 2.5 tonne vehicle at 40 mph
- Shallow foundations – limitations due to buried services
- [http://www.securiscape.co.uk/compare-our-products/planter](http://www.securiscape.co.uk/compare-our-products/planter)
Quantitative ALARP

- NPV: net present value
- DF: disproportion factor (1 – 10)
- VPF: value of preventing (statistical) fatality e.g. using published RSSB figure (£1,826,000)
- Risk difference = base risk – option risk
- t: time from 0th to Tth year
- r: discount rate (%)
  - Safety benefit @ 1.5% (1% for > 30 years)
  - Costs @ 3.5% (3% for > 30 years)
Derailment containment in the Connaught tunnel

- Twin track, single bore tunnel → secondary collision
- Reduced clearances
- Evacuation walkways in 4 foot only
- Alignment – tight radius of curvature on entry/exit
Standards & requirements

CPFR: Derailment containment shall be included in the design of the subsurface sections

RGS: The track should provide for the safe guidance and support of trains. The factors for consideration should include…the provision of adequate containment arrangements where the effects of derailment would be severe
History of ALARP studies

<table>
<thead>
<tr>
<th>Date</th>
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<tbody>
<tr>
<td>November 2012</td>
</tr>
<tr>
<td>July 2013</td>
</tr>
<tr>
<td>June 2014</td>
</tr>
<tr>
<td>October 2014</td>
</tr>
<tr>
<td>April 2015</td>
</tr>
<tr>
<td>May 2016</td>
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</tbody>
</table>
Fault & event trees

SCSC – ALARP: when is enough, enough?
If 50 year NPV CAPEX + OPEX of designing, installing & maintaining chosen DC option is equal to or less than the safety benefit, then it *should* be implemented on grounds of reasonable practicability.

QRA shows DC *risk reduction* of 0.00581 FWI/year

50 year *safety benefit* calculated using 2015 VPF

Gross disproportion factor of 3 applied by project in this case

50 year cost of DC options to be compared with safety benefit
Summary

- ALARP as used in GB rail
- Qualitative or quantitative approaches possible depending on application
- Real world approaches to ALARP & safety decision making
Thank you for your attention