Catastrophe!

Why we should care about the possibility of rare but catastrophic transport incidents
Summary

1. The rail industry and the research project
2. What is our risk tolerance?
3. Discussion – The Value of Life
4. The SPACE Model
5. How safe do we need to be?
6. Discussion – Grossly Disproportionate
7. Wrap-up
Background – The New Zealand rail industry

98 operators

31mil passenger journeys

16mil tonnes of freight

4200 km network

6000 workers

Huge range of size and capability of rail operators doing a range of activities

Wellington & Auckland metro
Cablecars & Trams
Tourist & long distance service
Heritage

Critical infrastructure for NZ to move goods

3100 signals, 1600 bridges, 70km of tunnels, 3000 level crossings

Maintenance crews, train staff, corporate support, volunteers
Background – The Rail Safety Regulator

• The Rail Safety Regulator is part of the Transport Agency

• We **oversee** the safety of all rail operators in NZ
  • Rail operators remain **accountable** for safety & managing risk

• Licensing, auditing, education, investigation & compliance

- Tunnels
- SPAD
- Track workers
- Public in corridor
Background – Why the focus on risk?

• Risk management is a key activity in the rail sector
  • Trains are big and hard. People aren’t.
  • Potential for multi-fatality accidents

• Rail companies must manage their own risks
  • “Those creating the hazard are responsible for managing it”

• Risk management is evolving in New Zealand
  • Increasingly complicated activities
  • “Everyone comes home healthy and safe”
Background – The research project

Framework for review and prioritisation of rail safety risks

- Agency-funded research project to build risk capability across the sector
  - What is done well, what isn’t?
  - What risks should we focus on?

- Who was involved?
  - Carried out by Navigatus Consulting
  - Sector involvement – rail companies, TAIC, Worksafe, union

- How was it done?
  - Literature reviews
  - Observations of practices
  - Surveys of industry participants
  - Analysis of national & overseas data

- These are the findings of a research project – not the opinion or responsibility of the NZ Transport Agency.
What is our risk tolerance?

- Risk management is not risk elimination
- You can’t be absolutely “safe” – risk is a consequence of activity
Our tolerance – exposure

Who is exposed to the risk?

- Unauthorised on track
- Suicide
- Worker
- Level crossing
- Passengers
- Public

Increasing tolerance

Tolerance ∝ control the person has over it

Control over managing the risk

Control over exposure
Our tolerance – scale

Do we fear bigger accidents?

- Tolerance is proportional to consequence
- Tolerance is disproportionate to consequence

Considered:
- Public outrage in large disasters
- Countries that adjust risk standard for catastrophic accidents

Tolerance ∝ Consequence
Our tolerance – societal concerns

Does the type of harm matter?

**Lower tolerance**

- **Imposed Risks**
  - Man-made risks
    - eg. chemicals
  - Natural risks
    - eg. earthquake

- **Familiarity**
  - New or poorly understood
    - eg. nuclear
  - Familiar risks
    - eg. car accidents

- **Equity**
  - Localised risks
    - eg. regional safety standards
  - Universal risks
    - eg. asteroids

**Higher tolerance**
Time to chat

The Value of a Statistical Life

Break into groups of 5–6 and discuss for 10 minutes:

• Who uses VSL?
• How do you use it?
• How do you account for risk aversion in your use?
Value of Life Saved – Valuation Methods

Australian method

- Lost Earnings
- Medical Costs
- Societal Benefits

NZ method

- Context dependent
- 2017 Value $4.21 million
- Risk Aversion
- Pain and Suffering
- Societal Benefit
- Lost Earnings

- Willingness to Pay

Human Capital Method

Used to be the standard method

Hybrid

Derived from a road safety context
**Value of Life Saved**

**Examples:**

Edwards vs National Coal Board (1949)
- Compensation of £984 (1949)
  
  £32k (2016)  $70k (NZD 2016)

UK Court Compensation (1952–2002)
- Average compensation of £157k  $330k (NZD)
- All were less than £200k  $420k (NZD)
- HSE VSL at the time was £1m (≈ 2002)
- VSL was 5 times the compensation amount
Value of Life Saved

The current VSL is derived from a 1991 study by Miller and Guria asking approx. 600 people what they would be willing to pay for various improvements in road safety.

- This implicitly includes a degree of risk aversion
SPACE Model

Estimating fatality risks in New Zealand rail
Kevin Oldham, Navigatus
The Challenge

The problem of frequency:

- small rail industry
- relatively low incident counts
- very few higher consequence events.

Record keeping historically patchy.

- 5 years of recent improved record.

Source: NZ Ministry of Transport
The Challenge

- Under these circumstances how can we develop a best estimate of the safety risks across both common and rare event types?

Source: NZ Ministry of Transport
This required a hybrid approach, drawing on New Zealand and international data, resulting in the SPACE model.

Safety
Performance
And
Casualty
Estimates
Average expected fatalities not estimated for passenger tunnel fire risk. This is a priority risk due to the maximum credible number of fatalities.
Are events observed in RIS period of record?

Are fatalities observed in RIS events classified to risk?

Hazardous Event from UK Safety Risk Model applicable for risk?

Adopt NZ events/year and UK fatalities/event from category with similar outcome (if appropriate). Otherwise, examine TAIC reports or NZ railway accidents book for fatal events, adopt the observed rate as estimate of fatalities/year.

Develop estimates from similar activities, or if unavailable, from potential event scenarios*.

* Average expected fatalities not estimated for passenger tunnel fire risk. This is a priority risk due to the maximum credible number of fatalities.
Tangiwai Disaster 1953
Are events observed in period of data record?

Are fatalities observed in RIS events classified to risk?

Hazardous Event from UK Safety Risk Model applicable for risk?

Adopt NZ rate

Adopt NZ events/year and UK fatalities/event

Adopt NZ events/year and UK fatalities/event from category with similar outcome (if appropriate). Otherwise, examine TAIC reports or NZ railway accidents book for fatal events, adopt the observed rate as estimate of fatalities/year.

Adopt a portion of UK fatalities/year according to NZ track length compared to UK

Develop estimates from similar activities, or if unavailable, from potential event scenarios*.

* Average expected fatalities not estimated for passenger tunnel fire risk. This is a priority risk due to the maximum credible number of fatalities.
Are events observed in RIS period of record?

Yes (30)

Are fatalities observed in RIS events classified to risk?

Yes (4)

Adopt NZ rate

Hazardous Event from UK Safety Risk Model applicable for risk?

Yes (16)

Adopt NZ events/year and UK fatalities/event from category with similar outcome (if appropriate). Otherwise, examine TAIC reports or NZ railway accidents book for fatal events, adopt the observed rate as estimate of fatalities/year.

No (9)

Adopt a portion of UK fatalities/year according to NZ track length compared to UK

No (6)

Develop estimates from similar activities, or if unavailable, from potential event scenarios*.

Are hazardous events available for risk from UK Safety Risk Model?

Yes (4)

No (10)

No (26)

Base Confidence Class

A

B/C

C/D

D

Decreasing confidence

* Average expected fatalities not estimated for passenger tunnel fire risk. This is a priority risk due to the maximum credible number of fatalities.
## Sample of Raw results

<table>
<thead>
<tr>
<th>Type</th>
<th>Operations</th>
<th>Average Expected Fatalities (10-3 pa)</th>
<th>Max Credible Fatalities from Single Event</th>
<th>Confidence Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collision (level crossing)</td>
<td>All</td>
<td>1200</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>All</td>
<td>75</td>
<td>30</td>
<td>C</td>
</tr>
<tr>
<td>Bus</td>
<td>All</td>
<td>343</td>
<td>15</td>
<td>A</td>
</tr>
<tr>
<td>Heavy Vehicle</td>
<td>Mainline</td>
<td>76</td>
<td>15</td>
<td>D</td>
</tr>
<tr>
<td>Heritage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Risk Weighting

Method 1: treating every circumstance equally.

Method 2: weight assessment in an effort to reflect broad societal values on risk acceptance.
Example: Influence of Volition

- Research by Covey et al (2008) found that:

  Public would reduce willingness to spend on preventing a statistical fatality if victims are behaving irresponsibly: e.g.
  - adult trespassers engaged in acts of vandalism,
  - adult car drivers behaving irresponsibly at level crossings,
  - adult drunks falling from platforms
  - child trespassers engaged in acts of vandalism,
  - suicides.

  The Value of Preventing a Statistical Fatality (VPSF) ratios relative to the baseline case around 40% of the baseline figure.
Weighting: Party (Volition)

1. Unauthorised Member of Public (UMOP)
2. Level Crossing User
3. Railway Worker
4. Passenger
5. Member of Public (Bystander)
Weighting: Control

1. Unauthorised Access
2. Level Crossings
3. Natural Events
4. Technical risks
<table>
<thead>
<tr>
<th>Rank</th>
<th>Top risks ordered by Average Expected Fatalities / Year</th>
<th>Top risks in party weighted order</th>
<th>Top risks in party and outcome control weighted order</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Collision with unauthorised member of public</td>
<td>Collision with unauthorised member of public</td>
<td>Tsunami</td>
</tr>
<tr>
<td>2</td>
<td>Level crossing collision with light vehicle</td>
<td>Tsunami</td>
<td>Collision with unauthorised member of public</td>
</tr>
<tr>
<td>3</td>
<td>Level crossing collision with pedestrian</td>
<td>Level crossing collision with light vehicle</td>
<td>Level crossing collision with light vehicle</td>
</tr>
<tr>
<td>4</td>
<td>Tsunami</td>
<td>Level crossing collision with pedestrian</td>
<td>Level crossing collision with pedestrian</td>
</tr>
<tr>
<td>5</td>
<td>Mainline passenger level crossing collision with heavy vehicle</td>
<td>Passenger train collision with civil works failure</td>
<td>Passenger train collision with civil works failure</td>
</tr>
<tr>
<td>6</td>
<td>Passenger train collision with civil works failure</td>
<td>Mainline passenger derailment</td>
<td>Mainline passenger derailment</td>
</tr>
<tr>
<td>7</td>
<td>Collision with Infrastructure Maintenance Worker</td>
<td>Tourist and heritage derailment</td>
<td>Tourist and heritage derailment</td>
</tr>
<tr>
<td>8</td>
<td>Shunting incident</td>
<td>Mainline passenger level crossing collision with heavy vehicle</td>
<td>Collision with infrastructure maintenance worker</td>
</tr>
<tr>
<td>9</td>
<td>Mainline passenger derailment</td>
<td>Collision with infrastructure maintenance worker</td>
<td>Shunting incident</td>
</tr>
<tr>
<td>10</td>
<td>Tourist and heritage derailment</td>
<td>Shunting incident</td>
<td>Fire at station</td>
</tr>
<tr>
<td>11</td>
<td>UMOP electric shock</td>
<td>Fire at station</td>
<td>Freight derailment</td>
</tr>
<tr>
<td>12</td>
<td>Fire at station</td>
<td>Freight derailment</td>
<td>Mainline passenger level crossing collision with heavy vehicle</td>
</tr>
<tr>
<td>13</td>
<td>Freight derailment</td>
<td>Level crossing collision with bus</td>
<td>Collision between trains involving at least one passenger train</td>
</tr>
<tr>
<td>14</td>
<td>Tourist and heritage level crossing collision with heavy vehicle</td>
<td>Collision between trains involving at least one passenger train</td>
<td>Level crossing collision with bus</td>
</tr>
</tbody>
</table>
Interesting Outcome

- Tsunami risk was the highest ranked risk.
- Emerging understanding of tsunami risk in New Zealand and internationally.
- The biggest ever railway disaster arose in Sri Lanka during the Boxing Day tsunami of 2004.
- This wouldn’t have been assessed under conventional historical incident analysis, as no rail fatalities have been observed due to tsunamis in New Zealand history.
Consistency and Reliability

- How can you have consistent and reliable results when the method varies?
  - Researcher degrees of freedom
  - Researcher choices can greatly affect the outcomes
  - Judgement
  - Fit for purpose
  - Peer review

- Best available estimate of safety risk given current state of knowledge
Discussion

- Intent is to draw on best available data and apply most appropriate risk assessment approach.
- Builds a transparent and rational overview.
- Peer review and industry working group oversight.
- Building consensus on main risks.
Findings

- Hybrid approach is useful to build a system overview where incidents occur at widely different frequencies.

- Resarcher degrees of freedom – results may not be replicable.

- Needs to be used with care and with understanding of limitations.
How safe – What is the current standard?

Workers: 1 in 1000
Too high
- Industries in this range must reduce

Public: 1 in 10,000
Higher than in practice
- Less public pressure to reduce?
How safe – What should it be?

Ministerial Inquiry
Industry and public pressure reacting to fatalities and serious injuries

Research recommendation:
1 in 10,000 for workers

What impact does this have for other transport modes?

1 in 1,000
1 in 10,000
1 in 100,000
1 in 1,000,000
How safe – And where should we be heading?

The influence of SFAIRP

• Tolerance is the upper ceiling

SFAIRP – there is no longer an acceptable level of risk

• Continually strive to reduce risk
  • as better safety controls become available, risk will decrease
  • as catastrophic risks are better understood, improved focus
Time to chat

Q. What does “Grossly disproportionate” mean? How can it be assessed?

Break into groups of 5–6 and discuss for 10 minutes:

- Is it being applied – where?
- How disproportionate?
- Can it be used with the VSL?
Grossly disproportionate

Edwards vs National Coal Board, 1949
Reasonably practicable is a narrower term than ‘physically possible’ ...

...if it be shown that there is a great disproportion between [the quantum of risk and the sacrifice to avert it] — the risk being insignificant in relation to the sacrifice — the person upon whom the obligation is imposed discharges the onus which is upon him.
Wrap-up – Questions and Comments?