Road/rail vehicle safety

Follow-up workshops
May/June 2013
Brisbane-Sydney-Adelaide
WELCOME - LESSONS FROM THE PREVIOUS WORKSHOP
Previous workshop

- October 2012 – Sydney
- 48 participants from a variety of organisations
- Briefings providing a variety of perspectives
  - Understanding the RRV landscape
    Kirsty Baxter, Transport Safety Victoria
  - Management of RRVs – experiences, strengths and weaknesses
    Lindsay Holt and Andrew Shore, Laing O’Rourke
  - Management of RRVs – experiences, strengths and weaknesses
    Alan Ross and Mike Rogers, John Holland Rail
  - Management of RRVs – experiences, strengths and weaknesses
    V/Line Hi-Rail Project, Allen Fleckner

- Preliminary Hazard Analysis using structured what if technique (SWIFT)
- Forward actions identified – Strategic/Organisational/Team & individual.
Rail guidance fitted to light vehicles (“track inspector vehicles”)

The Fleet includes 29 light road rail vehicles used for track inspection. The rail gear requires regular inspection and adjustment (4 month cycle).
The RM Track maintenance group operates 18 ‘mobile gangs’ throughout the state each equipped with a set of engine powered tools.

Night shift is becoming more common requiring better lighting and accessories.
Rail guidance fitted to wheeled excavator

CAT M315 Excavator with rail guidance wheels rotating hitch and multi function grab
A Komatsu 4 tonne excavator fitted with driven rail wheels and a Harsco Scarifier Head.

Concept and design by V/Line Plant in co-operation with Harrybilt.
A Komatsu 4 tonne excavator fitted with driven rail wheels and a Harsco Tie Grip.

Concept and design by V/Line Plant in co-operation with Harrybilt
Rail guidance fitted to loader back hoe
Vehicle types – Type 9A

- Type 9A: braking and traction forces transmitted directly to the rail wheels (i.e. the rail wheels are self-powered)

*Figure 1: Example Type 9A RRV with self-powered rail wheels*
Vehicle types – Type 9B

- Type 9B: traction forces indirectly transmitted from the road wheels to the rail wheels and the braking force either indirectly from the road wheels to the rail wheels or direct on the rail wheels, with the load entirely on the rail wheels. These are often known as ‘high ride’ RRVs.
Type 9B variation

Figure 4: Type 9B high ride RRV with extensions fitted to the rail wheels (spigots)
Vehicle types – Type 9C

- Type 9C: braking and traction forces transmitted to the road wheels with the load shared between the road and the rail wheels. These are often known as ‘low ride’ RRVs.
Risks associated with Hi-Rail vehicles on the rail network

Kirsty Baxter
Manager, Compliance Strategy & Planning
Contributing factors framework analysis

All three types have similar problems of runaway risks
• Forgetting handbrake
• Judgment errors
• Poor maintenance

• Type 9B has significant other risks
• Although all three Hi-rail configurations are at risk of runaways, examination of incident data and a detailed risk assessment from UK’s Network Rail, determined that type 9B (high-ride) Hi-Rail vehicles posed the highest risk in terms of runaways.

• All three configurations share common runaway risks such forgetting the handbrake, errors of judgment and poor maintenance. However, type 9B Hi-rails have additional risks not shared by the other two configurations.
On review of various investigation reports, the biggest proportion of previous runaways has arisen during the on- or off-tracking process where the operator placed the Hi-rail, with no brakes fitted to the rail wheels, into a free wheel, unbraked, condition.

An engineering means to prevent this occurring is progressively being fitted on some Hi-rails both in the UK and Australia. In the meantime, the prevention of a freewheel condition occurring depends on the operator correctly following the on/off-tracking.

Other runaways have occurred during braking where the rails were wet and/or contaminated and gradient has also been a factor in other incidents.
Twelve of the 18 runaways resulted from uncontrolled movement occurring from rest, usually during the on- or off-tracking process.

The remaining six incidents involved the vehicle not being able to stop in time, often due to the conditions of the track and site (e.g. gradient and rail contamination), travelling at excessive speed, as well as a combination of both.
The vast majority of the incidents (16) involved some kind of human error while operating the road-rail vehicle, such as the operator:
- putting the vehicle in an unbraked condition; or
- adopting an inappropriate technique when operating the vehicle.

Some errors (2) occurred during preparation, such as:
- the conditions of the track/site were not taking into account into the risk assessment; and
- poor choice of on-off tracking location.

A few (4) errors also occurred due to a lack of communication between the operator and other track maintenance personnel (i.e. not communicating safety-critical information). There was one potential violation identified where the operator was using the vehicle in a manner contrary to procedures.
Out of the 18 incidents, only three incidents were found to result from technical failure. These were due to:

- inadequate maintenance of the vehicle (i.e. tyre pressure not maintained);
- the design of the park brake (which was unable to be applied due to uncoupling of the hydraulic brake and oil being trapped in the system); and
- sub-optimal load sharing between the road wheels and the rail wheels of the vehicle.

Lack of functionality of the road-rail vehicle and equipment was found to contribute to two incidents.
Bow-tie analysis

**CAUSES**
- Rain, moisture, ice
- Debris
- Weather/ season
- Gradient
- Personal factors (fitness, fatigue, workload, distraction, time pressure)
- Training/ knowledge (operating under normal, abnormal, emergency conditions, "what to do", local conditions, route)
- Compliance with rules, procedures, etc
- Communication
- Lack of standards and procedures specific to Hi-Rails
- Lack of training

**PREVENTATIVE CONTROLS**
- Site assessment/ planning
- Protocols for adverse conditions
- On-off tracking pads
- JSEA, toolbox meetings
- Briefings/ Inductions

**PATHWAY**

**ORGANISATIONAL FACTORS**
- Standards/ policies / procedures
- Safety Culture
- JSEAs being completed
- Risk Management
- Competence and Capacity of resources
- Fatigue Management framework
- National Law
- Regulation
- Communication and consultation

**CAUSES**
- Competition for business advantage
- Culture
- Risk acceptance
- Resourcing
- Budget/ finance
- Time constraints
- Multi-jurisdictional operation

**PREVENTATIVE CONTROLS**
- On-off tracking pads
- Scheduling
- Fitness assessment
- Training/ awareness
- Briefings/ inductions
- Procedures
- Track protection
- JSEA, toolbox meetings
- Competencies/ qualifications
- Safety Alerts / communication
- Regulation

**PATHWAY**

**OPERATOR OPERATING THE VEHICLE**

**MITIGATING CONTROLS**
- Emergency brake application
- Audible Warning device
- Remote application of brakes

**PATHWAY**

**CONSEQUENCES**
- Fatalities, injuries, property & environmental damage, inefficiency & delay
- Fatalities, Injuries Property damage delays
- Fatalities, Injuries Property damage delays
- Fatalities, Injuries Property damage delays

**CAUSES**
- Design
- Lack of design standards and specifications
- Lack of compliance

**PREVENTATIVE CONTROLS**
- Design Standards
- Modification Standards and processes
- Competence
- Consultation
- Risk Management
- Change management processes
- Acceptance processes
- Safety Alerts

**PATHWAY**

**MAINTENANCE**

**CAUSES**
- Maintenance Standards and processes
- Competence of workers
- Consultation, Information instruction and training
- Risk Management
- Change management processes
- Safety Alerts

**PREVENTATIVE CONTROLS**
- Maintenance Standards and processes
- Competence of workers
- Consultation, Information instruction and training
- Risk Management
- Change management processes
- Safety Alerts

**PATHWAY**

**CONSEQUENCES**
- Fatalities, Injuries Property damage delays
- Fatalities, Injuries Property damage delays
- Fatalities, Injuries Property damage delays
Hi-Rail – a John Holland Perspective

Road/rail vehicle workshop – 30 October 2012

Michael Rogers
Fatality Perth City Link – 30/12/2011

The vehicle involved in the runaway
What are the expectations?

What would eliminating or reducing risks SFAIRP look like?
RRV types have proliferated

What Standards apply?
Where do the figures come from?

Arrow (Rail and Plant Equipment) is a rail industry approved RRV certifier
Other incidents

This type of vehicle has been involved in 2 ‘uncontrolled’ movements, one due to a mechanical fault and the other due to poor traction between road wheels and the ‘spiggots’
Other incidents

The same type of vehicle was involved in a ‘tipping’ incident due to instability.
Incidents

So what are the solutions?
LAING O'ROURKE PRESENTATION

ROAD RAIL VEHICLES FROM THEN TILL NOW

SYDNEY 30 & 31 OCTOBER 2012
HOWEVER DURING THE PERIOD ALERTS WERE ISSUED AND DOCUMENTS DEVELOPED

### Daily Road-Rail vehicle checks by End User

<table>
<thead>
<tr>
<th>Item</th>
<th>Ref#</th>
<th>Vehicle Check</th>
<th>M</th>
<th>T</th>
<th>W</th>
<th>T</th>
<th>F</th>
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<tr>
<td>29</td>
<td></td>
<td>Engine oil check for correct levels</td>
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<td>30</td>
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<td>Radiator coolant check for correct levels</td>
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<tr>
<td>31,32,13</td>
<td></td>
<td>Fluids and fuel check for correct levels</td>
<td></td>
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<td></td>
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<tr>
<td>58</td>
<td></td>
<td>Tyre pressures correct</td>
<td></td>
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<td></td>
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<tr>
<td>57</td>
<td></td>
<td>Tyres, check for damage, tread and wear pattern</td>
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<tr>
<td>59,55</td>
<td></td>
<td>Tyres, rims wheels check for security, cracks, signs of fatigue</td>
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<td>56</td>
<td></td>
<td>Wheel studs and nuts, check for security or damage</td>
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<td>51</td>
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<td>Rail wheel bearings check for play or noise</td>
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<td>46</td>
<td></td>
<td>Rail wheel studs and nuts check for security or damage</td>
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<td>73,74,75</td>
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<td>Mechanical safety locks, rail kits, locks, front axle lockout (where fitted), check for correct function, damage and wear</td>
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<td>76</td>
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<td>Anti derail frame, check for condition</td>
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<td>78</td>
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<td>Over centre condition check it is maintained</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>83</td>
<td></td>
<td>Rail guidance frame assemblies check for wear, cracks, structural damage and lubrication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>44</td>
<td></td>
<td>Rail wheels flange-off check are in place and correctly adjusted</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>34</td>
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<td>Hydraulic, check for correct function or damage</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>36</td>
<td></td>
<td>Emergency hand pump, check for pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>17</td>
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<td>Electrical control, check for correct function, South Australia, UK</td>
<td></td>
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<td>21</td>
<td></td>
<td>Warning devices, horns and sirens check for correct function</td>
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</tr>
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**Guideline for the Safe Operation of Road-Rail Vehicles**

**AUSTRALIAN CODE OF PRACTICE**

**Roll 41-1**

**Version 1.0**

**Subject:** Rail Safety Alert to all Operators of Road / Rail Vehicles

The following information is presented in the interest of improving rail/railway safety awareness, and is based on local industry standards. It is considered a recommendation that all operators follow to ensure the safety of personnel and the general public.

#### Background

On 23 October 2000, a Taunton Land Rover welfare vehicle was involved in an incident with a passing road vehicle. There were no injuries, however, the vehicle was damaged and required repair. The driver of the road vehicle was subsequently charged with careless driving. This incident highlights the importance of regular checks and maintenance of the vehicle, whether on the rail or on the road, to prevent potential accidents.

#### Investigation

While the formal investigation process into all aspects of the incident is yet to be fully completed, a significant finding to date is that a primary cause of the incident was the driver of the road vehicle's failure to check the vehicle's electrical system before the incident. The vehicle's electrical system was not operational at the time of the accident, which is a requirement of the rail vehicle's operational condition.

The investigation confirms that the vehicle suffered a failure of the electrical system, which led to the vehicle's inability to function correctly. This highlights the importance of regular checks and maintenance to prevent potential accidents.

#### Suggested Actions

Operators are encouraged to inspect all vehicles and ensure the inspection form's instructions have been followed. The guidelines recommend that all operators follow these guidelines to prevent potential accidents.

In particular, operators are advised to ensure the vehicle's electrical system, including the charging system, is checked before each journey. This includes checking the battery, alternator, and any other electrical components. It is also recommended to check the vehicle's mechanical systems, including the brakes and suspension, to ensure they are in good condition.

Operators are also encouraged to ensure that all components of the vehicle are properly maintained and that any issues are addressed immediately. This includes checking the vehicle's electrical system, mechanical systems, and any other components to ensure they are in good condition.

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**CMC COC MANAGMENT COMPANY**

**Date:** 23 January 2001

**Sign:** [Signature]

**End User (please print):** [Name]

**Description:** [Details]

**Week Ending:** [Date]

**Last serviced:** [Date]

**Next service due:** [Date]
THE REGISTRATION PROCES CONTINUES FOR ALL TRACK MACHINES BUT CHANGE TO RECERTIFICATION PROCESS MAY APPLY.
TRAINING WAS PART OF A PROGRAM FOR NETWORK RAIL MORE ALIGNED TO OPERATIONS

OTP Awareness for Site Supervision
Key Points
(Part 1)

Produced by Allan Breen (IP – Safety Improvement Team)
4th June 2011
NETWORK RAIL WERE ALSO ANALYSING SAFETY IMPROVEMENTS INCLUDING BRAKES
### AS7505.4 Signalling Detection Interface

<table>
<thead>
<tr>
<th>Sect</th>
<th>CI</th>
<th>Requirement</th>
<th>Type</th>
<th>ML</th>
<th>Poss</th>
<th>R/R</th>
<th>N = new/modified, E = existing rolling stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td></td>
<td>PURPOSE</td>
<td>SUP</td>
<td>N</td>
<td>E</td>
<td></td>
<td>Recommend early attention</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>The main purpose of the requirements is to prevent collisions.</td>
<td>SUP</td>
<td></td>
<td></td>
<td></td>
<td>Recommend medium term action</td>
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<tr>
<td>1.5</td>
<td></td>
<td>SCOPE</td>
<td>SUP</td>
<td>N</td>
<td>E</td>
<td></td>
<td>Other action</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>This document applies to new and modified infrastructure maintenance rolling stock, and existing infrastructure maintenance rolling stock being proposed for operation in another network.</td>
<td>SUP</td>
<td></td>
<td></td>
<td></td>
<td>Note</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>The document covers the design, construction and maintenance of rolling stock.</td>
<td>SUP</td>
<td></td>
<td></td>
<td></td>
<td>Note</td>
</tr>
<tr>
<td>4.1</td>
<td></td>
<td>TRACK CIRCUIT SHUNTING</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4.1.1</td>
<td></td>
<td>General</td>
<td>SUP</td>
<td></td>
<td></td>
<td></td>
<td>All items highlighted under New rolling stock should be</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>UIC Code 737-2 and RSSB Guidance Note GM/GN2576 contain general discussions on track circuit shunting.</td>
<td>SUP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Infrastructure Maintenance rolling stock that travel outside work closures shall be either detectable or non-detectable in regards to track circuit shunting.</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance/Operating Procedure required to maintain</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Infrastructure maintenance rolling stock when in travel mode shall not leave insulating materials deposited on the rail contact surface to an extent which prevents trains from being detected by the signalling system.</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance/Operating Procedure required to maintain</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Where, in working mode, material is unavoidably deposited on the rail then procedures may need to be put in place to remove the material before the track is released to general traffic.</td>
<td>SUP</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance/Operating Procedure required to maintain</td>
</tr>
<tr>
<td>4.1.2</td>
<td></td>
<td>Detectable Rolling Stock</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance Procedure required to maintain compliance</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>Detectable infrastructure maintenance rolling stock shall have a dc electrical resistance between rail contact surfaces of wheels on the same axle of not greater than 10 mΩ, measured with a voltage source no greater than 300mV.</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance Procedure required to maintain compliance</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Detectable infrastructure maintenance rolling stock should provide the leading and trailing wheelset (the extremity axles) of each vehicle with a means to remove surface contaminants from wheel tread surfaces.</td>
<td>REC</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance Procedure required to maintain compliance</td>
</tr>
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<td>4</td>
<td></td>
<td>Detectable infrastructure maintenance rolling stock shall meet the axle load requirements of Table 8.</td>
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<td></td>
<td></td>
<td>Maintenance Procedure required to maintain compliance</td>
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<td>4.1.3</td>
<td></td>
<td>Non-Detectable Rolling Stock</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance Procedure required to maintain compliance</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>Non-detectable infrastructure maintenance rolling stock shall have a dc electrical resistance between rail contact surfaces of wheels on the same axle of greater than 20,000 Ω.</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance Procedure required to maintain compliance</td>
</tr>
<tr>
<td>4.2</td>
<td></td>
<td>VEHICLE DIMENSIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4.2.1</td>
<td></td>
<td>Overhang</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>See Section 4.2.1.2 of AS 7504.4 for Table</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>The extremities of detectable infrastructure maintenance rolling stock shall not extend longitudinally past the outermost detectable axles by the amount defined in Table 9.</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>See Section 4.2.1.2 of AS 7504.4 for Table</td>
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<tr>
<td>4.2.2</td>
<td></td>
<td>Axle Spacing</td>
<td>MAN</td>
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<td></td>
<td></td>
<td>See Section 4.2.2.2 of AS 7504.4 for Table</td>
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<td>6.3</td>
<td></td>
<td>LONGITUDINAL VOLTAGE</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td></td>
<td>New or modified infrastructure maintenance rolling stock operating over any network utilising DC track circuits shall not be able to cause a longitudinal voltage along a rail between any two wheels exceeding 200 mV rms between 0 and 2.4 Hz.</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance Procedure required to maintain compliance</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>New or modified infrastructure maintenance rolling stock operating over any network utilising AF track circuits shall not be able to cause a longitudinal voltage along a rail between any two wheels exceeding 173mV rms at any of the specific operating frequencies of AF track circuits.</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance Procedure required to maintain compliance</td>
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<tr>
<td>3</td>
<td></td>
<td>New or modified infrastructure maintenance rolling stock operating over any network utilising 50Hz vane relay track circuits shall not be able to cause a longitudinal voltage along a rail between any two wheels exceeding 150mV rms at 50Hz.</td>
<td>MAN</td>
<td></td>
<td></td>
<td></td>
<td>Maintenance Procedure required to maintain compliance</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>TESTING</td>
<td></td>
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</tbody>
</table>
FINDINGS

• STANDARDS FOR ROLLING STOCK LARGELY CENTRED AROUND LOCOS AND WAGONS

• A NUMBER OF TRACK MACHINE STANDARDS (PART 4) WERE ALIGNED TO THE ABOVE

• STANDARDS RELATING TO HI-RAIL VEHICLES WERE NOT AS CLEARLY DEFINED OR NOT DEFINED AT ALL

• A NUMBER OF ROLLING STOCK STANDARDS WERE STILL IN DRAFT

• THE MAIN ONE IN DRAFT WAS THE STANDARD FOR BRAKING SYSTEMS (AS 7510)

• ALTHOUGH A NUMBER OF DRAFT STANDARDS ADOPTED OTHER STANDARDS WERE ALSO REFERENCED E.G. RAILCORP RSU OR THE ROA MANUAL

• LAING O'ROURKE KEEN TO WORK WITH INDUSTRY TO DEVELOP STANDARDS / GUIDELINES TO SUPPLEMENT OTHER MATERIAL
However alerts were still being issued
DISC BRAKES WERE ORDERED FOR RRV HI-RAIL
ON RECEIPT AND FOLLOWING SOME ISSUES THEY WERE PROGRESSIVELY FITTED
Process Summary

- Hazard ID
- Cause
- Consequence

Day one

- Existing control(s)
- Enough?
  - For you to make the decision?
- Propose new control(s)

Day two
Actions required to improve safe operations

PHA results, Bow tie & actions

Wednesday 31 October 2012
Jesse Baker, Alex Borodin, Lindsay Holt, Adrian Rowland

PHA RESULTS & BOW TIE
<table>
<thead>
<tr>
<th>Hazardous event</th>
<th>Technical (technical failures)</th>
<th>Potential Cause(s)</th>
<th>Potential Consequence(s)</th>
<th>Existing control(s)</th>
<th>Proposed control(s)</th>
</tr>
</thead>
</table>
| RRV Runaway    | • Equipment failure [Control ID: 1, 2, 3, 5, 6, 7, 8, 12, 14, 20, 22, 23, 24, 25, 26, 32, 33, 35, 36, 38]  
  • Electro / hydraulic pneumatic / mechanical  
  • Inadequate design (interlocking) [Control ID: 2, 3, 5, 9, 11, 12, 18, 32, 33]  
  • Unfit for purpose [Control ID: 1, 2, 3, 5, 6, 7, 9, 12, 14, 18, 22, 33, 38, 39]  
  • Inadequate maintenance [Control ID: 1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 18, 32, 33, 38, 39]  
  • Lack of pre-work inspection / daily checks [Control ID: 1, 6, 7, 8, 9, 10, 11, 13, 18, 38, 39]  
  • Lack of annunciation [Control ID: 2, 3, 5, 6, 7, 9, 10, 11, 12, 13]  
  • Lack of physical barriers (for stowage) [Control ID: 1, 6, 10, 13, 15, 16, 18, 21, 22, 23, 24, 38]  
| Environment (local conditions) | • Gradient / location / terrain [Control ID: 1, 4, 5, 6, 9, 10, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 28, 31, 32, 33, 35, 36, 37, 38]  
  • Lack of visibility [Control ID: 12, 10, 14, 15, 16, 17, 18, 19, 21, 26, 30, 31, 37, 38, 39]  
  • Inadequate condition of base for on / off raling [Control ID: 1, 2, 3, 7, 9, 10, 14, 16, 18, 20, 21, 26, 30, 32, 35, 36, 38, 39]  
  • Vandalism (during stowage) [Control ID: 1, 2, 3, 9, 10, 18, 21, 22, 23, 24, 21]  
  • Site constraints [Control ID: 1, 2, 3, 10, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 30, 31, 35, 36, 37, 38, 39]  
| People (individual / team actions) | • Fatigue [Control ID: 1, 8, 10, 13, 15, 34, 38]  
  • Inadequate incident reporting [Control ID: 1, 5, 9, 10, 11, 13, 14, 18, 33, 38]  
  • Operator error / violation [Control ID: 1, 5, 6, 8, 9, 10, 13, 15, 16, 17, 18, 20, 21, 25, 26, 27, 30, 33, 35, 36, 37]  
  • Inadequate communication [Control ID: 1, 5, 6, 10, 12, 13, 19, 30, 38, 15]  
  • Lack of visibility (???)  
  • Error annunciation (???)  
  • Human performance limitation (???)  
  • Infrequent emergency rehearsals / contingency planning [Control ID: 1, 2, 5, 10, 13, 23, 37, 38]  
  • Competency / capacity / knowledge / decision making [Control ID: 1, 3, 5, 8, 10, 13, 36, 38]  
| Systems (organisational factors) | • Inadequate interface management between infrastructure contractors – inconsistent standards [Control ID: 1, 2, 4, 5, 6, 7, 11, 14, 16]  
  • Inadequate incident reporting [Control ID: 1, 5, 10, 11]  
  • Safe work practice (inc. SWMS, pre-work insp.etc.) [Control ID: 1, 4, 5, 18, 10, 11]  
  • Inadequate policies / procedures / rules [Control ID: 1, 11, 16, 18]  
  • Time, budget, resource constraints [Control ID: 1, 2, 6, 7, 12, 14, 33]  
  • Poor organisation culture [Control ID: 11, 13, 18, 1, 4, 5, 10, 15, 38]  
  • No MOU with emergency services [Control ID: 1, 6, 4, 5, 10, 11, 14, 18]  
  • No road licence [Control ID: 1, 5, 6, 10, 13, 38]  
  • Complexity of operation [Control ID: 1, 5, 7, 9, 10, 13, 38]  
| | • Collision with train / vehicle / other plant / infrastructure / personnel  
  • Derailment / rollover  
  • SPAD  
  • Overrun territory  
  • Overrun authority  
  • Damage to plant, equipment, infrastructure, reputation  
  • Personnel injury (LTI) / fatality  
  • Loss of insurance / accreditation  
  • Public liability  
  • Prosecution  
  • Electrocution  
  • Loss to productivity  
| | 1. SOPs / JSAs / SWMS / Management standards  
  2. Technical and performance specifications  
  3. Design input  
  4. Accreditation of organisation / equipment  
  5. Technical registration / certification / training  
  6. System checks – sampling of procedural controls  
  7. Long-term monitoring  
  8. Fatigue, D&A management program  
  9. Maintenance / inspection schedules & plans  
  10. Inductions  
  11. Industry / regulator interactions / alerts  
  12. Procurement processes  
  13. People management – discipline arrangements / training / culture  
  14. Interface management  
  15. Possession management / coordination / network registration  
  16. Network rules  
  17. Route competency  
  18. Workplace inspections / management  
  20. Derailers / level crossing infrastructure  
  21. Catch points / derailers  
  22. Site security (for stowage)  
  23. Chocks for stowage (for stowage)  
  24. Stow vehicle off-track  
  25. derailers, skids, speed limiters  
  26. braking systems  
  27. speed board  
  28. data logger  
  29. GPS tracking  
  30. Comms. Protocols  
  31. Train protection  
  32. Asset lifecycle management  
  33. Change management  
  34. Health standards  
  35. on/off track pads  
  36. interlocks  
  37. Weather monitoring  
  38. supervision  
  39. Rail safety investigations  
  40. Driver safety systems
Runaway

Collision with train
Collision with vehicle / other plant
Collision with infrastructure
Collision with personnel
Derailment / rollover
SPAD
Overrun territory
Overrun authority
Damage to plant / infrastructure / equipment / reputation
Personnel injury (LTI) / fatality
Loss of insurance
Loss of accreditation
Public liability
Prosecution
Electrocution
Loss of productivity

Technical Failures (Technical)
- Equipment failure
- Inadequate design (interlocking)
- Unfit for purpose
- Inadequate maintenance
- Lack of pre-work inspection / daily checks
- Lack of annunciation
- Lack of physical barriers (for stowage)

Local Conditions (Environment)
- Gradient / location / terrain
- Weather events
- Bugs / insects
- Rail / track interface (coefficient of friction), contamination
- Lack of visibility
- Inadequate condition of base for on / off railing
- Vandalism (during stowage)
- Site constraints

Individual / Team Action (People)
- Fatigue
- Inadequate incident reporting
- Operator error / violation
- Inadequate communication
- Lack of visibility
- Error annunciation
- Human performance limitation
- Infrequent emergency rehearsals / contingency planning
- Competency / capacity / knowledge / decision making
- Driver incapacitation

Organisational Factors (Systems)
- Inadequate interface management between infrastructure contractors – inconsistent standards
- Inadequate incident reporting
- Safe work practice (inc. SWMS, pre-work insp.etc.)
- Inadequate policies / procedures / rules
- Time, budget, resource constraints
- Poor organisation culture
- No MOU with emergency services
- No road licence
- Complexity of operation

Refer to control slide
Runaway control slide

Technical (technical failures)
- Equipment failure [Control ID: 1, 2, 3, 5, 6, 7, 8, 12, 14, 20, 22, 23, 24, 25, 26, 32, 33, 35, 36, 38]
  - Electro / hydraulic pneumatic / mechanical
- Inadequate design (interlocking) [Control ID: 2, 3, 5, 39, 9, 11, 12, 18, 32, 33]
- Unfit for purpose [Control ID: 1, 2, 3, 5, 6, 7, 9, 12, 14, 18, 22, 32, 33, 38, 39]
- Inadequate maintenance [Control ID: 1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 18, 32, 33, 38, 39]
- Lack of pre-work inspection / daily checks [Control ID: 1, 6, 7, 8, 9, 10, 11, 13, 18, 38, 39]
- Lack of annunciation [Control ID: 2, 3, 5, 6, 7, 9, 10, 11, 12, 13]
- Lack of physical barriers (for stowage) [Control ID: 1, 6, 10, 13, 15, 16, 18, 21, 22, 23, 24, 38]

Environment (local conditions)
- Gradient / location / terrain [Control ID: 1, 4, 5, 6, 9, 10, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 29, 31, 32, 33, 35, 36, 37, 38]
- Weather events [Control ID: 1, 10, 13, 16, 17, 18, 19, 26, 30, 35, 37, 38]
- Bugs / insects [Control ID: 1, 10, 13, 16, 17, 18, 19, 26, 30, 35, 37, 38]
- Rail / track interface (coefficient of friction), contamination [Control ID: 1, 2, 3, 6, 7, 9, 10, 14, 16, 17, 18, 21, 23, 24, 26, 35, 36, 37, 38, 39]
- Lack of visibility [Control ID: 12, 10, 14, 15, 16, 17, 18, 19, 21, 26, 30, 31, 37, 38, 39]
- Inadequate condition of base for on / off railing [Control ID: 1, 2, 3, 7, 9, 10, 14, 16, 18, 20, 21, 26, 30, 32, 35, 36, 38, 39]
- Vandalism (during stowage) [Control ID: 1, 2, 3, 9, 10, 18, 21, 22, 23, 24, 21]
- Site constraints [Control ID: 1, 2, 3, 10, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 30, 31, 35, 36, 37, 38, 39]

People (individual / team actions)
- Fatigue [Control ID: 1, 8, 10, 13, 15, 34, 38]
- Inadequate incident reporting [Control ID: 1, 5, 9, 10, 11, 13, 14, 18, 33, 38]
- Operator error / violation [Control ID: 1, 5, 6, 8, 9, 10, 13, 15, 16, 17, 18, 20, 21, 25, 26, 27, 30, 33, 35, 36, 37]
- Inadequate communication [Control ID: 1, 5, 6, 10, 12, 13, 19, 30, 38, 15]
- Lack of visibility (???)
- Error annunciation (???)
- Human performance limitation (???)
- Infrequent emergency rehearsals / contingency planning [Control ID: 1, 2, 5, 10, 13, 23, 37, 38]
- Competency / capacity / knowledge / decision making [Control ID: 1, 5, 8, 10, 13, 38]
- Driver incapacitation [Control ID: 1, 3, 5, 8, 10, 13, 36, 38]

Systems (organisational factors)
- Inadequate interface management between infrastructure contractors – inconsistent standards [Control ID: 1, 2, 4, 5, 6, 7, 11, 14, 16]
- Inadequate incident reporting [Control ID: 1, 5, 10, 11]
- Safe work practice (inc. SWMS, pre-work insp.etc.) [Control ID: 1, 4, 5, 18, 10, 11]
- Inadequate policies / procedures / rules [Control ID: 1, 11, 16, 18]
- Time, budget, resource constraints [Control ID: 1, 2, 6, 7, 12, 14, 33]
- Poor organisation culture [Control ID: 11, 13, 18, 1, 4, 5, 10, 15, 38]
- No MOU with emergency services [Control ID: 1, 6, 4, 5, 10, 11, 14, 18]
- No road licence [Control ID: 1, 5, 6, 10, 13, 38]
- Complexity of operation [Control ID: 1, 5, 7, 9, 10, 13, 38]
<table>
<thead>
<tr>
<th>Hazardous event</th>
<th>Potential Cause(s)</th>
<th>Potential Consequence(s)</th>
<th>Existing control(s)</th>
<th>Proposed control(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RRV Collision</td>
<td>• Technical (technical failures)</td>
<td>• Environmental damage</td>
<td>1. OEM / RIM standards</td>
<td>Separation alarm systems</td>
</tr>
<tr>
<td></td>
<td>• Travelling outside kinematic envelope [Control ID: 1, 2, 5, 10, 8, 17, 20, 25]</td>
<td>• Collision with train / vehicle / other plant / infrastructure / personnel</td>
<td>2. Visual inspections</td>
<td>All trailers brake system fitted</td>
</tr>
<tr>
<td></td>
<td>• Loss of load / trailer [Control ID: 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13, 17, 19, 20, 22, 23, 25]</td>
<td>• Derailment / rollover</td>
<td>3. Training</td>
<td>Clarification of where vigilance control systems are required</td>
</tr>
<tr>
<td></td>
<td>• Mechanical failure [Control ID: 1, 2, 3, 5, 6, 10, 13, 15, 17, 18, 19, 20, 25]</td>
<td>• SPAD</td>
<td>4. Weight guides</td>
<td>Clarify design consistency needs (RIM/OEM, engineering issues)</td>
</tr>
<tr>
<td></td>
<td>• Failure of RRV to activate signals / telemetry [Control ID: 1, 2, 3, 5, 7, 8, 10, 17, 19, 20, 25]</td>
<td>• Overrun territory</td>
<td>5. Vehicle maintenance</td>
<td>Proximity sensors</td>
</tr>
<tr>
<td></td>
<td>• No track protection at a breakdown [Control ID: 1, 2, 3, 8, 17, 18, 20, 25]</td>
<td>• Overrun authority</td>
<td>6. Driving to conditions</td>
<td>Audible alarms (loss of traction (better alarms automated))</td>
</tr>
<tr>
<td></td>
<td>• Equipment design (e.g. Deadman / vigilance) [Control ID: 1, 2, 4, 5, 8, 10, 13, 15, 19, 20]</td>
<td>• Damage to plant, equipment, infrastructure, reputation</td>
<td>7. Vigilance system</td>
<td>Coupling rules (physical connections rules in context with equipment)</td>
</tr>
<tr>
<td></td>
<td>• Poor tyre tread condition [Control ID: 1, 2, 3, 4, 5, 6, 8, 10, 13, 17, 19, 20, 23, 24, 25]</td>
<td>• Personnel injury (LTI) / fatality</td>
<td>8. Rules &amp; procedures</td>
<td>Emergency response (expanded scenarios)</td>
</tr>
<tr>
<td></td>
<td>• Brake failure [Control ID: 1, 2, 3, 5, 6, 10, 13, 15, 17, 18, 19, 20, 24, 25]</td>
<td>• Loss of insurance / accreditation</td>
<td>9. Cameras, audible alarms (some RRVs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Not fit for purpose [Control ID: 1, 3, 2, 4, 5, 8, 10, 13, 15, 19, 20]</td>
<td>• Public liability</td>
<td>10. Maintenance</td>
<td></td>
</tr>
<tr>
<td>Environment (local conditions)</td>
<td>• Temporary works unknown [Control ID: 1, 2, 3, 6, 8, 9, 12, 13, 20, 17, 25, 14]</td>
<td>• Personnel injury (LTI) / fatality</td>
<td>11. 6m Rule (some)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• line of sight [Control ID: 1, 2, 3, 5, 6, 8, 9, 10, 12, 17, 20, 21, 24, 25]</td>
<td>• Loss of insurance / accreditation</td>
<td>12. 15km/h limit (some)</td>
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<tr>
<td></td>
<td>• Flooding, Rain, mud, cold, heat, animals etc. [Control ID: 2, 4, 6, 21, 8, 10, 12, 13, 14, 20, 17, 24, 25]</td>
<td>• Public liability</td>
<td>13. Braking systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Adverse weather conditions [Control ID: Refer to flooding etc.]</td>
<td>• Personnel injury (LTI) / fatality</td>
<td>14. Speed board</td>
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<tr>
<td></td>
<td>• Crossings [Control ID: 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13, 17, 18, 20, 24, 25]</td>
<td>• Loss of insurance / accreditation</td>
<td>15. Data logger</td>
<td></td>
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<td></td>
<td>• Infrastructure impedes travel (due to failure) [Control ID: 1, 2, 3, 6, 8, 12, 14, 17, 18, 20, 25]</td>
<td>• Public liability</td>
<td>16. GPS tracking</td>
<td></td>
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<tr>
<td></td>
<td>• Track obstructions (tree or work tools, vandalism etc) [Control ID: 2, 3, 6, 8, 12, 13, 17, 20, 25]</td>
<td>• Personnel injury (LTI) / fatality</td>
<td>17. Comms. Protocols</td>
<td></td>
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<tr>
<td></td>
<td>• Wheel / track interface (coefficient of friction) [Control ID: 1, 2, 3, 4, 5, 6, 8, 9, 12, 10, 13, 17, 19, 25, 20, 24, 23]</td>
<td>• Loss of insurance / accreditation</td>
<td>18. Train protection and worksite protection</td>
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<tr>
<td></td>
<td>• Track defect [Control ID: 1, 2, 3, 4, 5, 6, 14, 8, 12, 17, 19, 20, 25, 24]</td>
<td>• Public liability</td>
<td>19. Asset lifecycle management</td>
<td></td>
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<tr>
<td></td>
<td>People (individual / team actions)</td>
<td>• Personnel injury (LTI) / fatality</td>
<td>20. Change management</td>
<td></td>
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<tr>
<td></td>
<td>• Poor / non existent communications (radio protocols) [Control ID: 3, 17, 8, 10, 16, 25]</td>
<td>• Loss of insurance / accreditation</td>
<td>21. Health standards / fatigue management</td>
<td></td>
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<tr>
<td></td>
<td>• Lack of situational awareness [Control ID: 16, 8, 17, 21, 25, 24]</td>
<td>• Public liability</td>
<td>22. on/off track pads</td>
<td></td>
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<tr>
<td></td>
<td>• poor possession management / level of knowledge [Control ID: 25, 3, 8, 17, 18]</td>
<td>• Personnel injury (LTI) / fatality</td>
<td>23. interlocks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Poor speed management [Control ID: 6, 21, 3, 15, 16, 14, 24, 25]</td>
<td>• Loss of insurance / accreditation</td>
<td>24. Weather monitoring</td>
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<td></td>
<td>• line of sight [Control ID: 9, 6, 24, 8, 11, 21]</td>
<td>• Public liability</td>
<td>25. supervision</td>
<td></td>
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<tr>
<td></td>
<td>• Route knowledge / competency [Control ID: 3, 6, 8, 14, 24, 25]</td>
<td>• Personnel injury (LTI) / fatality</td>
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<tr>
<td></td>
<td>• Fitness for work [Control ID: 3, 21, 25]</td>
<td>• Loss of insurance / accreditation</td>
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<td></td>
<td>• Violation [Control ID: 3, 8, 21, 6, 14, 15, 25, 17, 20]</td>
<td>• Public liability</td>
<td></td>
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<tr>
<td></td>
<td>• SPAD [Control ID: 3, 6, 7, 5, 21, 8, 13, 18, 17, 25, 24]</td>
<td>• Personnel injury (LTI) / fatality</td>
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<tr>
<td></td>
<td>• Driver incapacitation [Control ID: 7, 21, 25]</td>
<td>• Loss of insurance / accreditation</td>
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<tr>
<td></td>
<td>• Vehicle attachment not stowed [Control ID: 2, 3, 6, 8, 5, 23, 9, 10]</td>
<td>• Public liability</td>
<td></td>
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</tr>
<tr>
<td>Systems (organisational factors)</td>
<td>• Poor / non existent communications (radio protocols) [Control ID: 8, 17, 18, 3, 5]</td>
<td>• Personnel injury (LTI) / fatality</td>
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<tr>
<td></td>
<td>• poor possession management / level of knowledge [Control ID: 3, 8, 20, 17, 25, 18]</td>
<td>• Loss of insurance / accreditation</td>
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<td>• Time pressures / work patterns [Control ID: 8, 20, 21, 25, 3]</td>
<td>• Public liability</td>
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<tr>
<td></td>
<td>• Moving in convoy [Control ID: 1, 3, 6, 5, 10, 8, 9, 17, 12, 14, 25, 24, 18, 7]</td>
<td>• Personnel injury (LTI) / fatality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazardous event</td>
<td>Potential Cause(s)</td>
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<td>Existing control(s)</td>
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<tr>
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</tr>
</tbody>
</table>
| RRV Collision (specific to off rail) | Technical (technical failures) [Control ID: 7, 8]  
- Equipment failure  
- No brakes  
- Design modification  
- Inadequate design  
Environment (local conditions) [Control ID: 1, 3]  
- Accident by road vehicle at level crossing  
- Contamination on rail  
- Gradient  
- Sun glare  
People (individual / team actions)  
- Travelling in convoy (poor communication protocol) [Control ID: 6, 7]  
- Not sticking to plan [Control ID: 6, 7]  
- Not competent on type of equipment [Control ID: 5]  
- Not questioning authority if in doubt (safety culture) [Control ID: 3]  
- Violations [Control ID: 1, 3, 5, 6, 7]  
- Fitness for duty – fatigue, D&A, incapacitation  
Systems (organisational factors)  
- Inadequate training processes [Control ID: 4, 5, 7, 8]  
- Inadequate procedures [Control ID: 9, 10]  
- Inadequate standards [Control ID: 9, 10]  
- Production demands [Control ID: 6, 7, 8, 9, 10]  
- Inadequate resourcing [Control ID: 5, 11]  
- Not competent on type of equipment [Control ID: 4, 5, 7, 8]  
- Inadequate change management [Control ID: 3, 7, 6] |  
- Environmental damage  
- Collision with train / vehicle / other plant / infrastructure / personnel  
- Derailment / rollover  
- SPAD  
- Overrun territory  
- Overrun authority  
- Damage to plant, equipment, infrastructure, reputation  
- Personnel injury (LTI) / fatality  
- Loss of insurance / accreditation  
- Public liability  
- Prosecution  
- Electrocution  
- Loss to productivity  
- Delayed emergency services  
- Delay of services  
- Fire | 1. Protection/Safeworking  
2. Education  
3. Communication  
4. Up skilling  
5. Competencies  
6. Network rules  
7. Procedures  
8. Standards  
9. Project review  
10. SMS review  
11. Resourcing capacity  
12. Fit to task / people / equipment |
| RRV Collision (specific to emergency off rail) | Technical (technical failures) [Control ID: 6, 8]  
- Unable to move machine  
- No brakes  
- Design modification  
- Inadequate design  
Environment (local conditions) [Control ID: 1, 4, 6, 2]  
- Off rail at non specified location / inappropriate location  
- Contamination  
- Gradient  
- Visibility  
- Terrain / infrastructure problem  
- Washaway  
- Bushfires / snow  
People (individual / team actions) [Control ID: 1, 2, 3, 4, 5, 6, 7, 8, 9]  
- Competency  
- Violation  
- Lack of skills in emergency situation  
- Communication error  
Systems (organisational factors)  
- Safe work component [Control ID: 1, 2]  
- Inadequate consideration of all aspects of an “emergency” [Control ID: 1, 2, 3]  
- Production demands [Control ID: 1, 2, 7]  
- Inadequate training procedures [Control ID: 3, 6]  
- Inadequate resourcing [Control ID: 9, 6]  
- Inadequate procedures [Control ID: 10] |  
- Environmental damage  
- Collision with train / vehicle / other plant / infrastructure / personnel  
- Derailment / rollover  
- SPAD  
- Overrun territory  
- Overrun authority  
- Damage to plant, equipment, infrastructure, reputation  
- Personnel injury (LTI) / fatality  
- Loss of insurance / accreditation  
- Public liability  
- Prosecution  
- Electrocution  
- Loss to productivity  
- Delayed emergency services  
- Delay of services  
- Fire | 1. Protection / safetyworking  
2. Communication  
3. Training  
4. Competencies  
5. Fit to task / PPL and equipment  
6. Procedures  
7. Network rules  
8. Engineering standards  
9. Resourcing  
10. SMS review
Collision control slide

Technical (technical failures)
- Travelling outside kinematic envelope [Control ID: 1, 2, 5, 10, 8, 17, 20, 25]
- Loss of load / trailer [Control ID: 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13, 17, 19, 20, 22, 23, 25]
- Mechanical failure [Control ID: 1, 2, 3, 5, 6, 10, 13, 15, 17, 18, 19, 20, 25]
- Failure of RRV to activate signals / telemetry [Control ID: 1, 2, 3, 5, 7, 8, 10, 17, 19, 20, 25]
- No track protection at a breakdown [Control ID: 1, 2, 3, 8, 17, 18, 20, 25]
- Equipment design (e.g. Deadman / vigilance) [Control ID: 1, 2, 3, 5, 6, 10, 13, 15, 19, 20]
- Poor tyre tread condition [Control ID: 1, 2, 3, 4, 5, 6, 8, 10, 13, 17, 19, 20, 23, 24, 25]
- Brake failure [Control ID: 1, 2, 3, 5, 6, 10, 13, 15, 17, 18, 19, 20, 24, 25]
- Not fit for purpose [Control ID: 1, 3, 2, 4, 5, 8, 10, 13, 15, 19, 20]

Environment (local conditions)
- Temporary works unknown [Control ID: 1, 2, 3, 6, 8, 9, 12, 13, 20, 17, 25, 14]
- line of sight [Control ID: 1, 2, 3, 5, 6, 8, 9, 10, 12, 17, 20, 21, 24, 25]
- Flooding, Rain, mud, cold, heat, animals etc. [Control ID: 2, 24, 4, 6, 21, 8, 10, 12, 13, 14, 20, 17, 24, 25]
- Adverse weather conditions [Control ID: Refer to flooding etc.]
- Crossings [Control ID: 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13, 17, 18, 20, 24, 25]
- Infrastructure impedes travel (due to failure) [Control ID: 1, 2, 3, 6, 8, 12, 14, 17, 18, 20, 25]
- Track obstructions (tree or work tools, vandalism etc) [Control ID: 2, 3, 6, 8, 12, 13, 17, 20, 25]
- Wheel / track interface (coefficient of friction) [Control ID: 1, 2, 3, 4, 5, 6, 8, 9, 12, 10, 13, 17, 19, 25, 20, 24, 23]
- Track defect [Control ID: 1, 2, 3, 4, 5, 6, 14, 8, 12, 17, 19, 20, 25, 24]

People (individual / team actions)
- Poor / non existent communications (radio protocols) [Control ID: 3, 17, 10, 16, 25]
- Lack of situational awareness [Control ID: 16, 8, 17, 21, 25, 24]
- poor possession management / level of knowledge [Control ID: 25, 3, 8, 17, 18]
- Poor speed management [Control ID: 6, 21, 3, 15, 16, 14, 24, 25]
- line of sight [Control ID: 9, 6, 24, 8, 11, 21]
- Route knowledge / competency [Control ID: 3, 6, 8, 14, 24, 25]
- Fitness for work [Control ID: 3, 21, 25]
- Violation [Control ID: 3, 8, 21, 6, 14, 15, 25, 17, 20]
- SPAD [Control ID: 3, 6, 7, 5, 21, 8, 13, 18, 17, 25, 24]
- Driver incapacitation [Control ID: 7, 21, 25]
- Vehicle attachment not stowed [Control ID: 2, 3, 6, 8, 5, 23, 9, 10]

Systems (organisational factors)
- Poor / non existent communications (radio protocols) [Control ID: 8, 17, 18, 3, 5]
- poor possession management / level of knowledge [Control ID: 3, 8, 20, 17, 25, 18]
- Time pressures / work patterns [Control ID: 8, 20, 21, 25, 3]
- Moving in convoy [Control ID: 1, 3, 6, 5, 10, 8, 9, 17, 12, 14, 25, 24, 18, 7]
Collision control slide (off rail)

Non-emergency

Technical (technical failures) [Control ID: 7, 8]
• Equipment failure
• No brakes
• Design modification
• Inadequate design

Environment (local conditions) [Control ID: 1, 3]
• Accident by road vehicle at level crossing
• Contamination on rail
• Gradient
• Sun glare

People (individual / team actions)
• Travelling in convoy (poor communication protocol) [Control ID: 6, 7]
• Not sticking to plan [Control ID: 6, 7]
• Not competent on type of equipment [Control ID: 5]
• Not questioning authority if in doubt (safety culture) [Control ID: 3]
• Violations [Control ID: 1, 3, 5, 6, 7]
• Fitness for duty – fatigue, D&A, incapacitation

Systems (organisational factors)
• Inadequate training processes [Control ID: 4, 5, 7, 8]
• Inadequate procedures [Control ID: 9, 10]
• Inadequate standards [Control ID: 9, 10]
• Production demands [Control ID: 6, 7, 8, 9, 10]
• Inadequate resourcing [Control ID: 5, 11]
• Not competent on type of equipment [Control ID: 4, 5, 7, 8]
• Inadequate change management [Control ID: 3, 7, 6]

Emergency

Technical (technical failures) [Control ID: 6, 8]
• Unable to move machine
• No brakes
• Design modification
• Inadequate design

Environment (local conditions) [Control ID: 1, 4, 6, 2]
• Off rail at non specified location / inappropriate location
• Contamination
• Gradient
• visibility
• Terrain / infrastructure problem
• Washaway
• Bushfires / snow

People (individual / team actions) [Control ID: 1, 2, 3, 5, 6, 7, 8, 9]
• Competency
• Violation
• Lack of skills in emergency situation
• Communication error

Systems (organisational factors)
• Safe work component [Control ID: 1, 2]
• Inadequate consideration of all aspects of an “emergency” [Control ID: 1, 2, 3, 4]
• production demands [Control ID: 1, 2, 7]
• Inadequate training procedures [Control ID: 3, 6]
• Inadequate resourcing [Control ID: 9, 6]
• Inadequate procedure [Control ID: 10]
<table>
<thead>
<tr>
<th>Hazardous event</th>
<th>Potential Cause(s)</th>
<th>Potential Consequence(s)</th>
<th>Existing control(s)</th>
<th>Proposed control(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RRV Derailment</td>
<td>Technical (technical failures)</td>
<td>• Environmental damage</td>
<td>1. OEM / RIM standards</td>
<td></td>
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<tr>
<td></td>
<td>• Poor interoperability (machine, network, operator) [Control ID: 26, 1, 3, 20, 5, 6, 13, 7, 8, 9, 10, 11, 12, 16, 17, 22]</td>
<td>• Collision with train / vehicle / other plant / infrastructure / personnel</td>
<td>2. Visual inspections</td>
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<td></td>
<td>• Not fit for purpose [Control ID: 1, 2, 3, 5, 4, 6, 8, 12, 13, 20, 23, 26]</td>
<td>• Derailment / rollover</td>
<td>3. training</td>
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<td></td>
<td>• Rail gear not correctly engaged [Control ID: 2, 3, 5, 8, 12, 23]</td>
<td>• SPAD</td>
<td>4. weight guides</td>
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<tr>
<td></td>
<td>• Rail gear not correctly aligned [Control ID: same as above]</td>
<td>• Overrun territory</td>
<td>5. vehicle maintenance</td>
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<tr>
<td></td>
<td>• Wrong sized tyres [Control ID: 1, 2, 3, 5, 8, 12, 23, 19]</td>
<td>• Overrun authority</td>
<td>6. driving to conditions</td>
<td></td>
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<tr>
<td></td>
<td>• Incorrect tyre pressures [Control ID: same as above]</td>
<td>• Damage to plant, equipment, infrastructure, reputation</td>
<td>7. vigilance system</td>
<td></td>
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<tr>
<td></td>
<td>• Tyre puncture [Control ID: 2, 5]</td>
<td>• Personnel injury (LTI) / fatality</td>
<td>8. rules &amp; procedures</td>
<td></td>
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<tr>
<td></td>
<td>• Poor tyre tread condition [Control ID: 2, 5]</td>
<td>• Loss of insurance / accreditation</td>
<td>9. deraillers, skids, speed limiters</td>
<td></td>
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<tr>
<td></td>
<td>• Brake failure [Control ID: 2, 13, 1, 5, 4, 6]</td>
<td>• Public liability</td>
<td>10. D&amp;A testing</td>
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<tr>
<td></td>
<td>• Stub axle failure [Control ID: 5, 3, 12, 13, 25, 23, 4]</td>
<td>• Prosecution</td>
<td>11. Fatigue management</td>
<td></td>
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<tr>
<td></td>
<td>• Loading [Control ID: 1, 2, 3, 4, 6, 8, 12, 13, 20, 25]</td>
<td>• Electrocution</td>
<td>12. Pre-work inspections</td>
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<tr>
<td></td>
<td>Environment (local conditions)</td>
<td>• Track obstructions</td>
<td>13. braking systems</td>
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<tr>
<td></td>
<td>• Substandard infrastructure [Control ID: 1, 2, 3, 6, 8, 13, 25]</td>
<td>• Wheel / track interface (friction coefficient)</td>
<td>14. speed board (including TSR)</td>
<td></td>
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<tr>
<td></td>
<td>• Variability in operating areas (weathers, heat etc) [Control ID: 1, 3, 6, 8, 24]</td>
<td>• Track defect [Control ID: 6, 8, 17, 14]</td>
<td>15. data logger</td>
<td></td>
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<tr>
<td></td>
<td>• Time of day for operation [Control ID: 6]</td>
<td>• Ergonomics</td>
<td>16. GPS tracking</td>
<td></td>
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<tr>
<td></td>
<td>• Points moving under vehicle [Control ID: 1, 3, 6, 8, 17]</td>
<td>• Fatigue management</td>
<td>17. Comms. Protocols</td>
<td></td>
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<tr>
<td></td>
<td>• Track obstructions [Control ID: 6, 17, 24]</td>
<td>• Weather monitoring</td>
<td>18. Train protection</td>
<td></td>
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<tr>
<td></td>
<td>• Wheel / track interface (friction coefficient) [Control ID: 5, 2, 3, 1, 6, 8, 12]</td>
<td>• Asset lifecycle management</td>
<td>19. Asset lifecycle management</td>
<td></td>
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<tr>
<td></td>
<td>• Track defect [Control ID: 6, 8, 17, 14]</td>
<td>• Change management</td>
<td>20. Change management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>People (individual / team actions)</td>
<td>• Planned derailment</td>
<td>21. Health standards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Planned derailment [Control ID: 9, 3, 17]</td>
<td>• Error / violation / Distractions [Control ID: 3, 6, 10, 11, 8, 12, 17, 14, 21, 25]</td>
<td>22. on/off track pads</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Competency [Control ID: 1, 38, 12, 17, 25]</td>
<td>• Overspeeding [Control ID: 3, 6, 8, 14, 17, 25]</td>
<td>23. interlocks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Rail gear not correctly engaged [Control ID: 2, 3, 5, 8, 12, 23]</td>
<td>• Exceed authority [Control ID: 3, 8, 9, 17, 25]</td>
<td>24. Weather monitoring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Competency [Control ID: 1, 38, 12, 17, 25]</td>
<td>Systems (organisational factors)</td>
<td>25. supervision</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Inappropriate speed limitations [Control ID: 1, 8, 14, 6, 25, 17]</td>
<td>• Inappropriate loading limits [Control ID: 1, 2, 4, 3, 8, 12, 25]</td>
<td>26. Ergonomics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Planned derailment [Control ID: 9, 3, 17]</td>
<td>• Planned pre-work inspections / maintenance [Control ID: 1, 3, 8, 25]</td>
<td>27.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Substandard pre-work inspections / maintenance [Control ID: 1, 3, 8, 25]</td>
<td></td>
<td>28.</td>
<td></td>
</tr>
</tbody>
</table>
Derailment

Technical Failures (Technical)
- Poor interoperability
- Not fit for purpose
- Rail gear not correctly engaged
- Rail gear not correctly aligned
- Wrong sized tyres
- Incorrect tyre pressures
- Tyre puncture
- Poor tyre tread condition
- Brake failure
- Stub axle failure
- Loading

Local Conditions (Environment)
- Substandard infrastructure
- Variability in operating areas (weathers, heat etc)
- Time of day for operation
- Points moving under vehicle
- Track obstructions
- Wheel / track interface (friction coefficient)
- Track defect

Individual / Team Action (People)
- Planned derailment
- Error / violation / Distractions
- Competency
- Rail gear not correctly engaged
- Overspeeding
- Exceed authority

Organisational Factors (Systems)
- Inappropriate speed limitations
- Inappropriate loading limits
- Planned derailment
- Substandard pre-work inspections / maintenance

Refer to control slide
Derailment control slide

Technical (technical failures)

- Poor interoperability (machine, network, operator) [Control ID: 26, 1, 3, 20, 5, 6, 13, 7, 8, 9, 10, 11, 12, 16, 17, 22]
- Not fit for purpose [Control ID: 1, 2, 3, 5, 4, 6, 8, 12, 13, 20, 23, 26]
- Rail gear not correctly engaged [Control ID: 2, 3, 5, 8, 12, 23]
- Rail gear not correctly aligned [Control ID: same as above]
- Wrong sized tyres [Control ID: 1, 2, 3, 5, 8, 12, 23, 19]
- Incorrect tyre pressures [Control ID: same as above]
- Tyre puncture [Control ID: 2, 5]
- Poor tyre tread condition [Control ID: 2, 5]
- Brake failure [Control ID: 2, 13, 1, 5, 4, 6]
- Stub axle failure [Control ID: 5, 3, 12, 13, 25, 23, 4]
- Loading [Control ID: 1, 2, 3, 4, 6, 8, 12, 13, 20, 25]

Environment (local conditions)

- Substandard infrastructure [Control ID: 1, 2, 3, 6, 8, 13, 25]
- Variability in operating areas (weathers, heat etc) [Control ID: 1, 3, 6, 8, 24]
- Time of day for operation [Control ID: 6]
- Points moving under vehicle [Control ID: 1, 3, 6, 8, 17]
- Track obstructions [Control ID: 6, 17, 24]
- Wheel / track interface (friction coefficient) [Control ID: 5, 2, 3, 1, 6, 8, 12]
- Track defect [Control ID: 6, 8, 17, 14]

People (individual / team actions)

- Planned derailment [Control ID: 9, 3, 17]
- Error / violation / Distractions [Control ID: 3, 6, 10, 11, 8, 12, 17, 14, 21, 25]
- Competency [Control ID: 1, 38, 12, 17, 25]
- Rail gear not correctly engaged [Control ID: 2, 3, 5, 8, 12, 23]
- Overspeeding [Control ID: 3, 6, 8, 14, 17, 25]
- Exceed authority [Control ID: 3, 8, 9, 17, 25]

Systems (organisational factors)

- Inappropriate speed limitations [Control ID: 1, 8, 14, 6, 25, 17]
- Inappropriate loading limits [Control ID: 1, 2, 4, 3, 8, 12, 25]
- Planned derailment [Control ID: 9, 3, 17]
- Substandard pre-work inspections / maintenance [Control ID: 1, 3, 8, 25]
<table>
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</thead>
</table>
| RRV Fire       | Technical (technical failures)  
• engine failure [Control ID: 1, 2, 3, 5, 6, 7, 8, 9, 10]  
• failure generating sparks [Control ID: 1, 2, 3, 6, 7, 8, 9]  
• friction heat [Control ID: 1, 2, 3, 6, 7, 8]  
• exhaust heat [Control ID: 1, 2, 3, 6, 7, 8]  
• equipment damage [Control ID: refer to engine failure]  
• Non-compliance maintenance procedures [Control ID: 1, 4, 6, 7, 9, 10]  
• poor design [Control ID: 3]  
Environment (local conditions)  
• bushfire [Control ID: 1, 9, 10, 7, 6, 4]  
• vandalism [Control ID: 6, 7, 9, 10, 4, 1, 7]  
People (individual / team actions)  
• smoking [Control ID: 1, 4, 6, 9, 10]  
• human error [Control ID: as above]  
Systems (organisational factors) [Control ID: 1, 6, 9, 10] | Runaway | 1. Extinguishers  
2. spark suppression (some)  
3. design standards  
4. Rules & procedures  
5. Dust suppression (some)  
6. Maintenance procedures / SOPs  
7. Pre-work inspections  
8. System checks  
9. People management / training / culture  
10. Supervision |
Technical Failures (Technical)
- engine failure
- failure generating sparks
- friction heat
- exhaust heat
- equipment damage
- Non-compliance maintenance procedures
- poor design

Local Conditions (Environment)
- bushfire
- vandalism

Individual / Team Action (People)
- smoking
- human error

Organisational Factors (Systems)
- None identified

RRV Fire

Refer to control slide
Fire control slide

Technical (technical failures)
- engine failure [Control ID: 1, 2, 3, 5, 6, 7, 8, 9, 10]
- failure generating sparks [Control ID: 1, 2, 3, 6, 7, 8, 9]
- friction heat [Control ID: 1, 2, 3, 6, 7, 8]
- exhaust heat [Control ID: 1, 2, 3, 6, 7, 8]
- equipment damage [Control ID: refer to engine failure]
- Non-compliance maintenance procedures [Control ID: 1, 4, 6, 7, 9, 10]
- poor design [Control ID: 3]

Environment (local conditions)
- bushfire [Control ID: 1, 9, 10, 7, 6, 4]
- vandalism [Control ID: 6, 7, 9, 10, 4, 1, 7]

People (individual / team actions)
- smoking [Control ID: 1, 4, 6, 9, 10]
- human error [Control ID: as above]

Systems (organisational factors) [Control ID: 1, 6, 9, 10]
PROPOSED CONTROLS
FOLLOW UP ACTIONS
Proposed controls

- Separation alarm systems
- All trailers brake system fitted
- Clarification of where vigilance control systems are required
- Clarify design consistency needs (RIM/OEM, engineering issues)
- Proximity sensors
- Audible alarms (loss of traction (better alarms automated))
- Coupling rules (physical connections rules in context with equipment)
- Emergency response (expanded scenarios)
• Standards
  – Applicability of current rolling stock standards
  – Proliferation of requirements (eg multiple RIMS etc)
  – Differing terminology /classification systems (UK/ local)
  – Potential for specific RRV national standard ?
  – Capture existing good work (LOR, JHR, V-line etc)
Issues

- Data
  - No national approach to incident data collection
  - Ability to trend data
  - RISSB building capacity for data collection/analysis
  - Will strengthen risk basis of RISSB standards
• Competence and culture
  – National approach, and
  – Vehicle specific training
  – Gangers vs head office
  – Low literacy may be an issue
Issues

• Risk management
  – Accidents/incidents occurring despite controls
  – Control effectiveness??

• Road authority vs. rail compatibility
  – Expense of crash testing
NETWORK STANDARDS

(SEE SEPARATE PRESENTATION)
WORKFORCE CAPABILITY
(SEE SEPARATE PRESENTATION)
CERTIFICATION AND REGISTRATION ISSUES
Focus on safety

• New National Rail Safety Law
  – Imposes the duty to achieve the best possible safety outcome ‘so far as is reasonably practicable’

• New Office of the National Rail Safety Regulator
  – Very supportive of RISSB
  – Working with RISSB to advance safety agenda
  – Safety plans
Safety plans

Industry good practice
TLISC Rail Infrastructure Steering Committee Mtg 4 June

Standard Development (RISSB)

Form Tech Adv Gp, develop units with industry and consult publicly

Units placed into training packages as skill sets

RTOs develop materials & assessments

Regulator involvement? (eg raising poor performers)

Regulator / ASQA mandate or leave to industry?

RISSB SISAR case

RISSB build support, then build SISAR, and eventually yield meaningful information

What else can industry do while RISSB progresses SISAR???

Other ‘stuff’?

<table>
<thead>
<tr>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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</tbody>
</table>
• More workshops (Sydney/Adelaide)
• Consolidation of results and information
• Web based summary of findings and actions (RISSB & ONRSR)
• Standards development group (July)
• Research bulletin (ONRSR)