Wheel Profile and Track Geometry Threshold Optimization in an Australian Mining Railroad using VAMPIRE®

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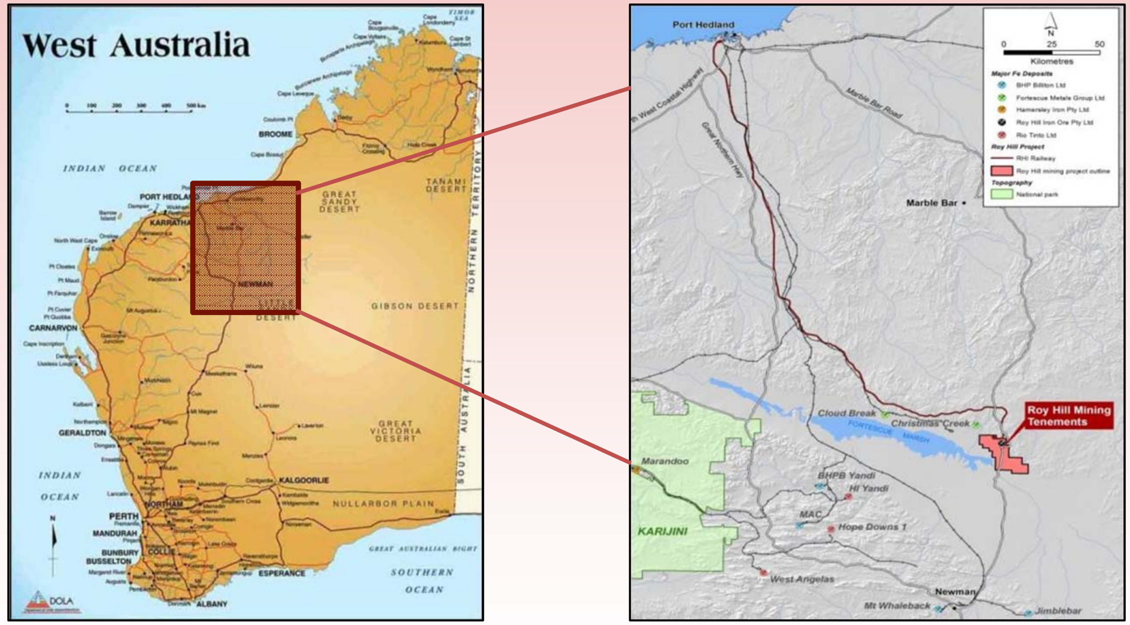
Overview

- Roy Hill Background and the Mining Operation
- Unique Overall Solution Need
- Wheel/Rail Contact Analysis
- Track Geometry Threshold and Speed Restriction Determination

ROY HILL BACKGROUND AND THE MINING OPERATION

Where is Roy Hill?

- Mining operation project in Western Australia in the East Pilbara



Mining Operations

Open cut mine operating multiple pits & 55 Mtpa wet processing plant

Maximum operating axle load of 42.8t

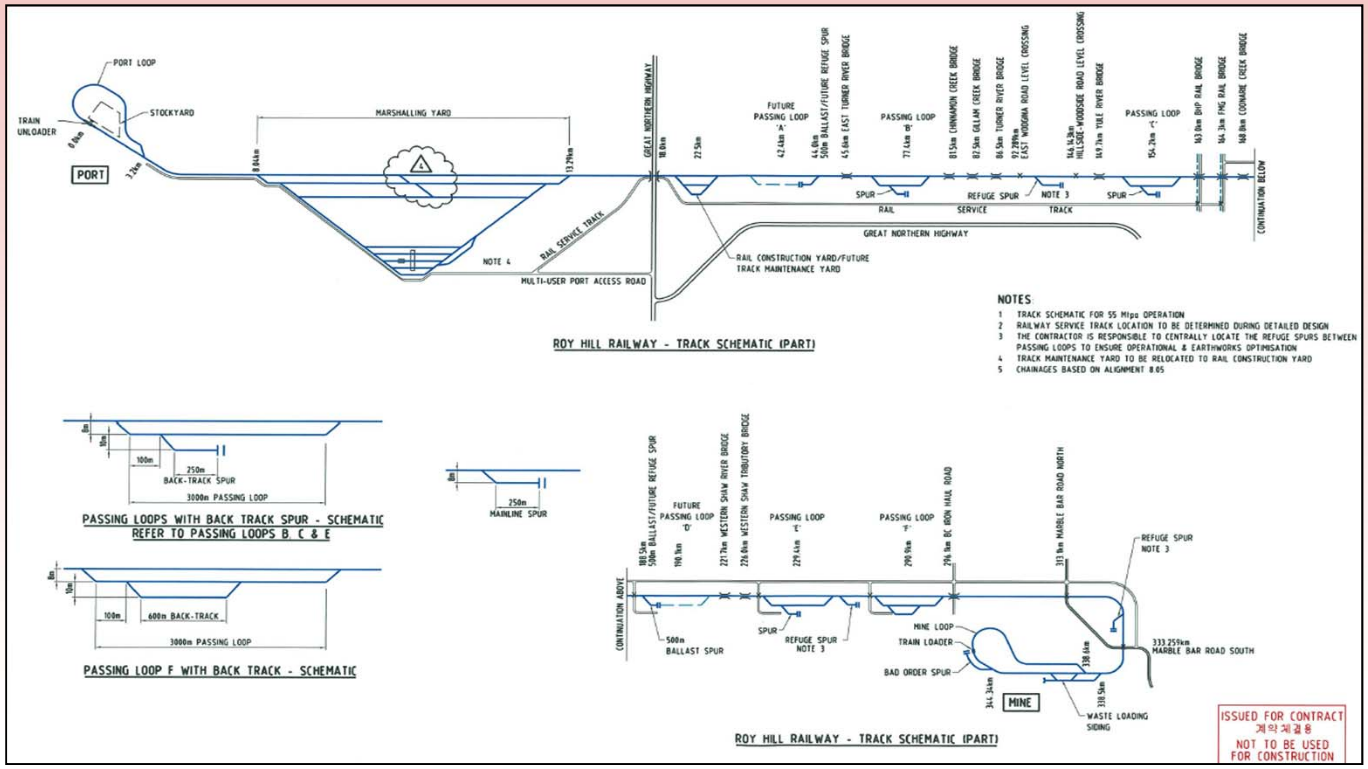
344km Heavy Haul Railway

5 loaded movements per day

Track Schematic

Features

- 136 lb - RE
- 1000m curves in mainline
- 450m curve in loading/unloading loops
- Standard track gage
- 1:40 rail cant



The Ore Wagon

CRRC Design and Build

- 1196 Ore Cars in tandem pairs

Standard Features

- 21.6t Tare
- 160t Gross
- ECP Brakes
- Auto Park Brake
- Amsted SSRM Bogie

Truck Design Details

- 125-ton NA design with modifications
- 40 ton axle
- 38” wheels

Variable Damping

Stucki Side Bearing

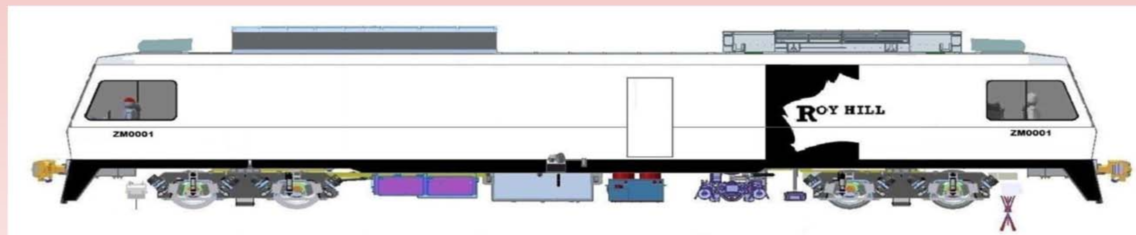
Low Friction Centre Bowl

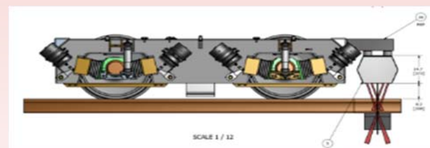
Amsted SSRM Bogie

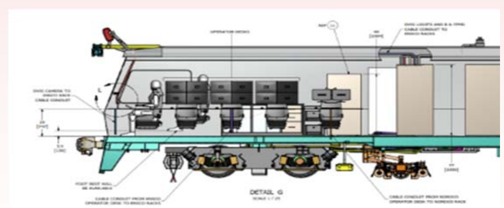
Track Measurement Vehicle

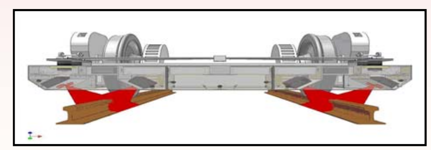
<u>Track Measurement Vehicle</u>

- Track Geometry
- Rail Profile
- Corrugation
- Ultrasonic Rail Flaw
- Ground Penetrating Radar
- Track Bed Imaging
- Rail Surface Imaging
- Ballast/Formation Profile
- Right Of Way Video





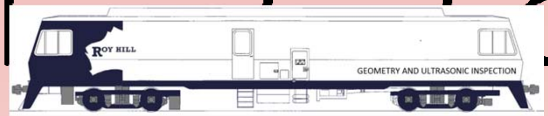




NEED TO TIE EVERYTHING TOGETHER !!!!

Railway Track Conditioning Monitoring (RTCM)

Inspector Entries



Automated Inspection Systems

In Motion Weighbridge Tonnes

SAP

Work Orders

GIS

Rail Track Condition Monitoring System (RTCM)

Digital Track Notebook (DTN)

TrackIT

Automated Maintenance Advisor (AMA)

Regulatory Reporting

Specialised Reports

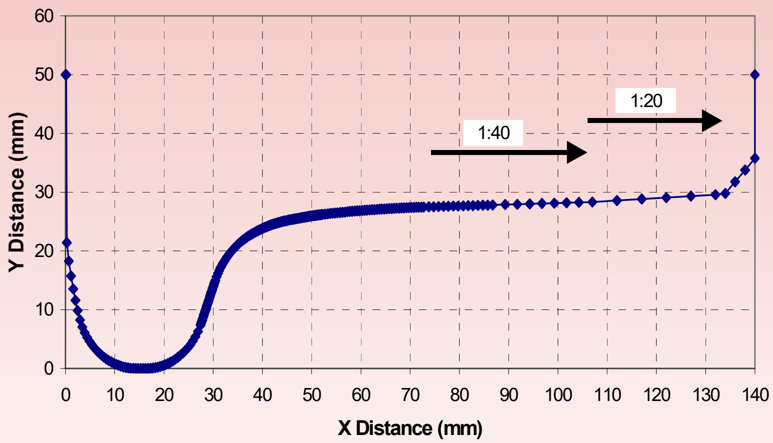
Overview of Process

- Pieces of the Big Puzzle
- Once the thresholds are determined track measurements will be used to flag locations of concern

1. Optimize wheel profiles to provide good baseline operating conditions
2. Develop Optimized Track Geometry Thresholds for Safe Vehicle Operations
3. Use Track Geometry Thresholds in the RTCM Process

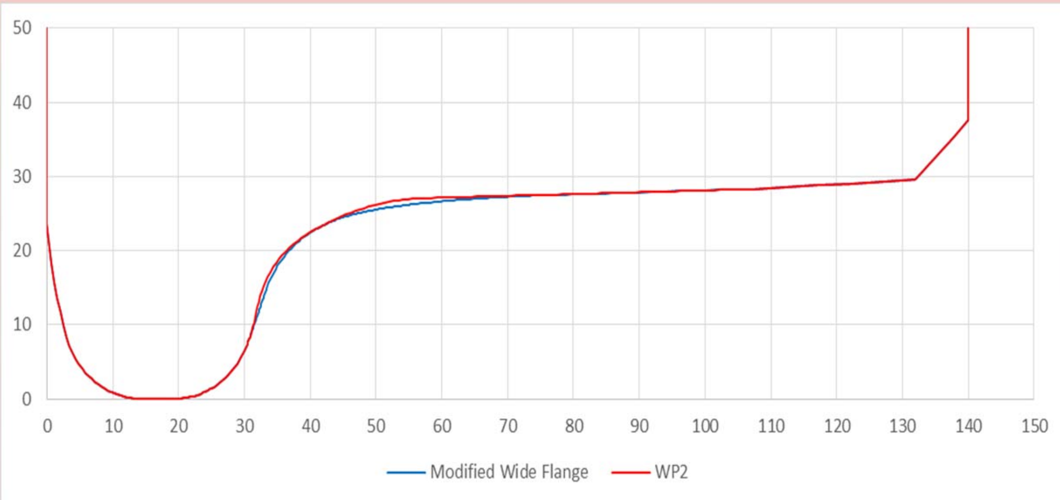
WHEEL PROFILE ANALYSIS

Review of Wheel Profile



- Developed to match the Roy Hill rail design - AREMA 136 lb RE-10 inch
- Wide Flange Profile - 34mm width
- High conicity near the flange – 1:10
- Taper at the taping line 1:40
- Concerns with high stresses on the gauge corner based on high conicity and observations on other track in the Pilbara.

Optimized Wheel Profile



- WP2 profile based on the modified wide flange wheel.
- Flange and flange root were altered to a shape similar to that of the AAR-1B-WF, with a constant tread taper carrying to the flange root.
- Several criteria analyzed including Nadal Limit, Base/Height (B/H) Ratio, Equivalent Conicity, and Hertzian Contact Stress.

Parameters Analyzed

- Hertzian contact force and stress
- Equivalent conicity to ensure stability
- General contact conditions with a change in lateral shift
- Nadal limit for potential wheel climb
- B/H ratio for rail roll over evaluation

Results of Wheel Profile Analysis

- In general track does not have sharp curves so it allowed us to tailor it more towards lower RCF potential
- Lowered contact stress to provide reduced wear and fuel consumption
- Lowered equivalent conicity to provide higher stability
- Wheel wear – Roy Hill expects to achieve 400,000km between turns on the ore car fleet
- Truing will remove approximately 5mm every two years

TRACK GEOMETRY THRESHOLD OPTIMIZATION

Need for Track Geometry Thresholds

- Operation is very complex with large wheel/rail forces
- Captive fleet with a specific design of the ore wagons
- Need to understand the limits for track deterioration and speed restrictions
- Gets used in the RTCM process as baseline and then continuous monitoring using near real-time VAMPIRE module

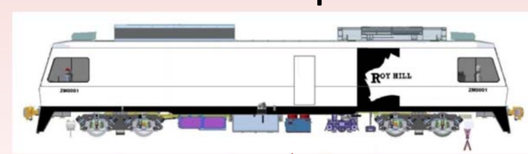
Threshold and Speed Limitation Determination Process

Inputs for Simulations
- Track design
- Vehicle design
- Contact conditions
- Operating conditions

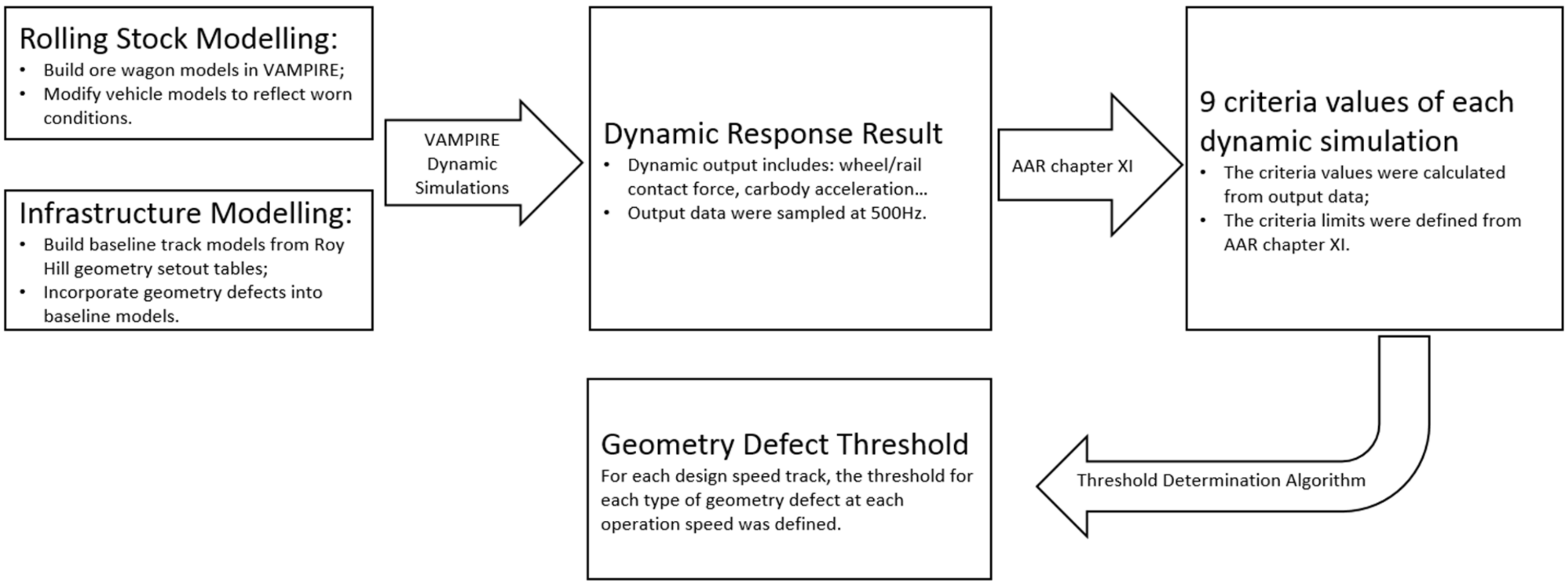
VAMPIRE

Track Geometry Thresholds and Speed Restrictions

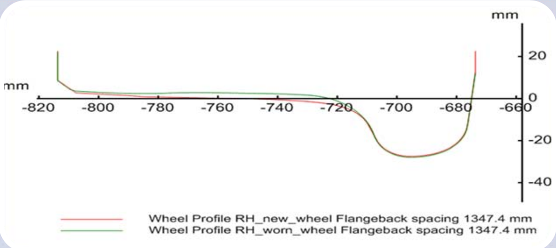
Track Measurements and Exceptions



Analytical Process



Simulation Details



Vehicle models constructed

- Empty/loaded
- CG biased/unbiased
- Wedge rise /No wedge rise
- 32 different vehicle configurations

Track modeling

- 16 design track models
- 8 perturbation types
- Magnitude variations
- Speed were varied in 4 steps

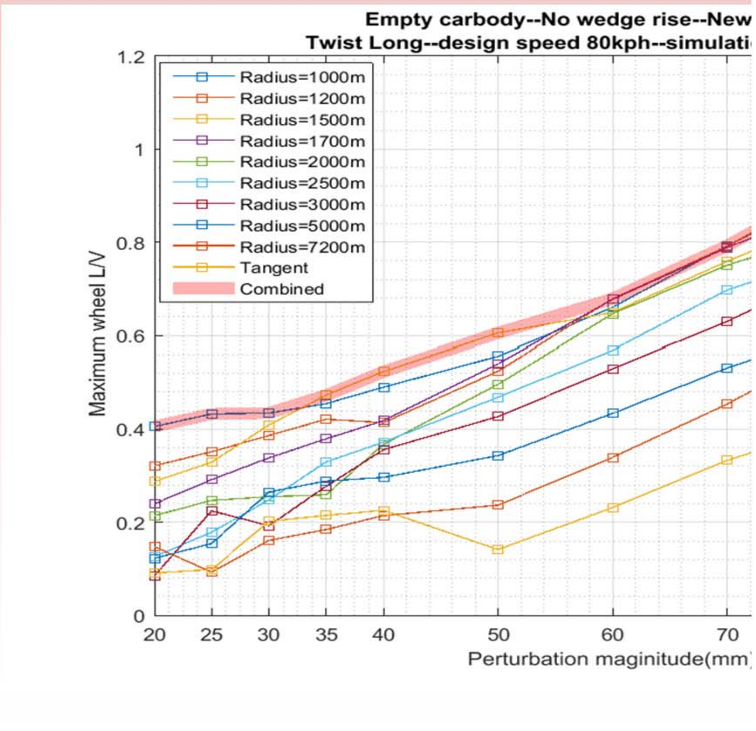
Wheel rail modeling

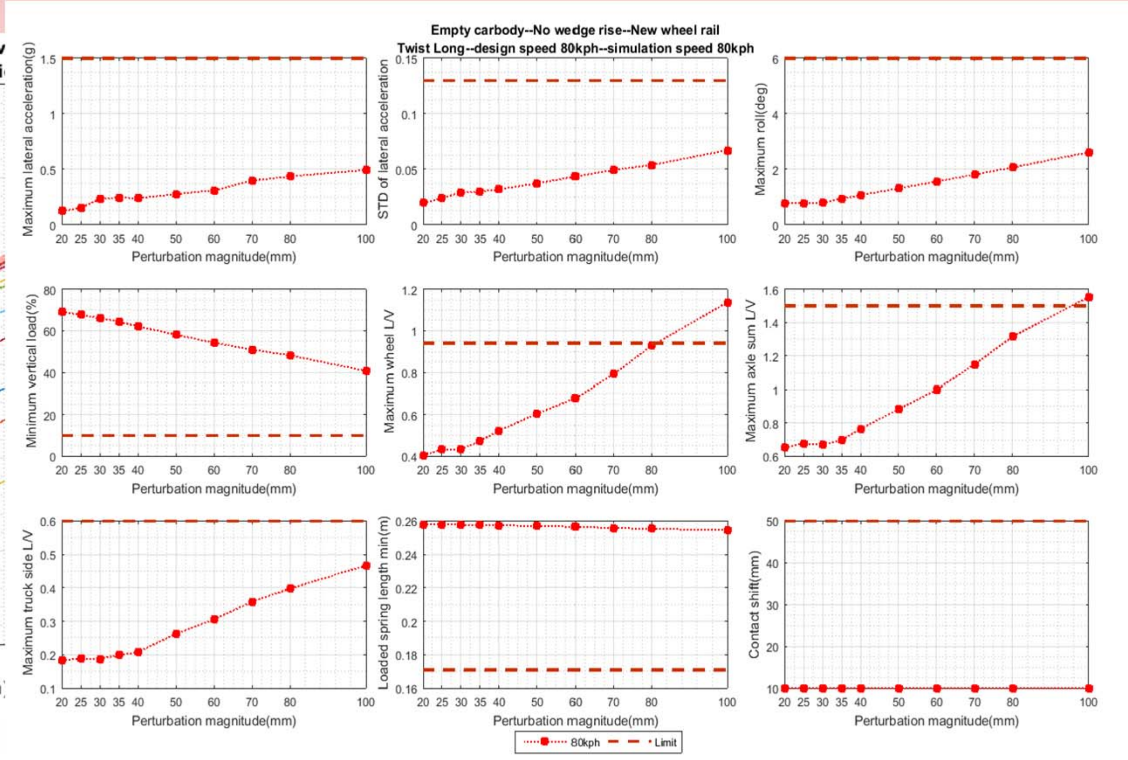
- New/worn wheel
- New/worn rail

Perturbation Type and Magnitude

	Type of Perturbation	Wavelength(m)	Shape	Speed(km/h)	Magnitude(mm)
Track Lateral	Narrow gauge	10	Versine	20 40 60 80	8 to 28
	Wide gauge	10	Versine	20 40 60 80	20 to 70
	Lateral perturbation	10	Versine	20 40 60 80	20 to 200
Track Vertical	Vertical perturbation	10	Versine	20 40 60 80	20 to 90
	Twist: Long	14.47	Versine	20 40 60 80	20 to 100
	Twist: Medium	6.25	Versine	20 40 60 80	20 to 90
	Twist: Short	1.83	Versine	20 40 60 80	20 to 150
	Cross Level	10	Versine	20 40 60 80	30 to 100

Example of Threshold Determination





Example of Threshold Determination

- Conduct simulations for all scenarios including varying vehicle, track and speed conditions
- For the example of twist long chord of 14.47m a threshold of 60mm was determined for 80 kmph design speeds
- Furthermore, thresholds were then obtained for the same 80 kmph design track for speed restrictions – Larger perturbations -> slower speeds !!!!
- The same process was followed for tracks with design speeds of 60 kmph and 40 kmph

Lateral Perturbation Thresholds

Perturbation (wavelength)	Simulation Speed(km/h)	RH Initial (mm)	FRA Standard(mm)	AUS Standard(mm)	Recommended Threshold(mm)
Narrow Gauge (10m)	20	N/A	13	N/A	**10**
Narrow Gauge (10m)	40	N/A	13	N/A	**10**
Narrow Gauge (10m)	60	N/A	13	N/A	**10**
Narrow Gauge (10m)	80	N/A	13	N/A	**10**
Wide Gauge (10m)	20	N/A	38	35-38	**33**
Wide Gauge (10m)	40	N/A	32	35-38	**30**
Wide Gauge (10m)	60	N/A	32	35-38	**28**
Wide Gauge (10m)	80	N/A	25	29-34	**23**
Lateral (10m)	20	43	N/A	125-156	**45**
Lateral (10m)	40	20	N/A	125-156	**40**
Lateral (10m)	60	15	32	125-156	**38**
Lateral (10m)	80	10	25	45	**19**

Vertical Threshold Perturbation

Perturbation (wavelength)	Simulation Speed(km/h)	RH Initial (mm)	FRA Standard(mm)	AUS Standard(mm)	Recommended Threshold(mm)
Twist Long (14.47m)	20	140	76	65-74	**74**
Twist Long (14.47m)	40	30	57	65-74	**60**
Twist Long (14.47m)	60	26	51	65-74	**53**
Twist Long (14.47m)	80	20	44	56-64	**45**
Twist Middle (6.25m)	20	60	51	N/A	**53**
Twist Middle (6.25m)	40	25	44	N/A	**40**
Twist Middle (6.25m)	60	20	32	N/A	**35**
Twist Middle (6.25m)	80	16	25	N/A	**25**
Twist Short (1.83m)	20	20	N/A	23-25	**25**
Twist Short (1.83m)	40	17	N/A	23-25	**23**
Twist Short (1.83m)	60	13	N/A	23-25	**20**
Twist Short (1.83m)	80	10	N/A	21-22	**17**

Vertical Threshold Perturbation

Perturbation (wavelength)	Simulation Speed(km/h)	RH Initial (mm)	FRA Standard(mm)	AUS Standard(mm)	Recommended Threshold(mm)
Vertical (10m)	20	36	89	32-37	**45**
Vertical (10m)	40	25	76	32-37	**38**
Vertical (10m)	60	20	51	32-37	**30**
Vertical (10m)	80	15	38	28-31	**23**
Cross Level (10m)	20	130	76	60	**45**
Cross Level (10m)	40	40	51	60	**38**
Cross Level (10m)	60	32	44	60	**32**
Cross Level (10m)	80	25	32	60	**25**

Summary and Conclusions

- Custom thresholds are in place on the TMV
- Highly monitored captive fleet system
- Performance assessments are routine and aggressive
- Unique opportunity to allow constant improvement