Instrumented Revenue Vehicles for Heavy-haul Track Defect Monitoring and In-train Force Validation

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Agenda

- 1. Introducing Monash IRT
- 2. Introducing the Instrumented Revenue Vehicle
- 3. Examples of benefits
- 4. Further development





Monash Institute of Railway Technology

- Monash University is the largest university in Australia, ranked in the top 1% of Universities internationally
- Monash IRT is a centre delivering applied and translational research, dedicated to servicing railways







IRT History

- **1972 Founded as in-house department of BHP research labs**
- 2000 Established as Institute at Monash University
- **2002 First implementation of IRV technology**
- 2013 Highest industry funded research income at Monash University
- 2016 Recognised in parliament as the "Premier Track and Vehicle Research Centre in Australia"

2021 – Team now totaling 40+ staff continue to deliver industry focused research and technology for railways



IRT Services over 160 Clients



IRT Capabilities

- Materials Analysis and Physical Testing
- Condition Monitoring
- Data Analytics
- Wheel-Rail Interface
- Vehicle Dynamic Simulation
- Track Performance
- Welding Process Development
- Novel Technology Implementation







Broader Academic Capabilities

- Links to world class academic skills ۲ in:
 - Accident research
 - Human factors
 - AI and Machine Learning
 - Sustainable Materials
 - Industrial Design
 - Robotics and Automation



*İ***IIRT**









Instrumented Revenue Vehicles

- Autonomous structural health condition monitoring system on revenue service rollingstock
- Over 90 instrumented vehicles have been installed by IRT
- Near real time reporting of the condition of the track and rolling stock performance
- Effectiveness of maintenance activities









IRV System Examples



- Mature technology, since 2002
- Ruggedized integrated monitoring system
- Passenger and freight applications
- Local and self powered solutions







IRV Sensor Examples

 Wagon Stability 	Roll, Yaw and Pitch
• Bogie Stability	 Primary Spring Displacements
	 Bogie Vibration Modes
	 Hunting Detection and Steering
	 Spring Binding Detection
 Passenger Comfort 	 Peak Accelerations, Ride Index, Ride Comfort, Ride
	Safety based on acceleration Jerk (g/s)
	Noise monitoring





IRV System Benefits





	IRV	Geometry Car
Rail Running Surface	\checkmark	\checkmark
GPS Position	\checkmark	\checkmark
Altitude	\checkmark	\checkmark
Vertical Alignment (Top / Surface)	\checkmark	\checkmark
Lateral Alignment	Bogie Steer	\checkmark
Twist	\checkmark	\checkmark
Curvature	\checkmark	\checkmark
Measures Under Dominant Vehicle Loading	\checkmark	
Vehicle Dynamic Response to Track	\checkmark	
Vehicle Hunting	\checkmark	
Vehicle In-Train Force	\checkmark	
Requires Separate Train Path & Operators		\checkmark
Track Measurement Interval	~20-150 per week	~1-3 months





IRV Track Geometry vs Track Geometry Car (TGC)

- TGC data (red line) and IRV data (black line) shows close correlation
- From actual vehicles, at operating speed, multiple times per day





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Example – Weld Condition



- Rail longitudinal profiles sampled to 5mm increments along the track
- Running surface information can be extracted
- Dipped and peaked welds can be identified as well as vehicle dynamics due to weld condition



Example – Weld Condition

- View system wide weld profile data
- Convert results to system of choice (e.g. dip angle)
- Assess actual vehicle response to defects to produce standards relevant to safe operations





How is it Delivered? **Continuous Data Automated Tracking** Automated **Collection During During Normal** Data **Traffic Hours** Operation Processing **Emergency Response** Flexible **Integrate Reports** Near Customized Time with Reporting **Internal Systems** Reporting System Performance & Maintenance Planning Trends In-Train Forces and **Track Responses** Acceleration and Condition ANY JANK -Negl Hopping - Christian - Market - M ê T T T T V T (F) 把 the second state is -------

Long Term Trending



Adding Maintenance Data

Running Surface - Vertical Accelerations All (g) vs. Date Running Surface - Vertical Accelerations All (g) vs. Date 17/2/2018 8:00:00 AM DateTime: Maintenance Action: Grinding Maintenance Effectiveness: 53% Improved (-5.70g) 24 51 DateTime: 10/5/2018 8:00:00 AM 24 Maintenance Action: Grinding Fauinment Plain Track RailHand: BH Maintenance Effectiveness: 77% Improved (-6.77g) Plain Track DateTime: 17/5/2018 8:00:00 AM Equipment: RailHand BH 22 22 Maintenance Action: Grinding Maintenance Effectiveness: 27% Improved (-2.91g) DateTime: 27/5/2018 8:00:00 AM Equipment: Plain Track Maintenance Action Tamping 0% Worse (+0.01g) 20 20 Maintenance Effectiveness RailHand: BH Equipment: Plain Track RailHand: BH 18 18 DateTime: 11/8/2018 8:00:00 AM 16 16 Maintenance Action Grinding 70% Improved (-7.24g) Maintenance Effectivenes Plain Track BH Equipment: RailHand 14 14 /alue **S**3 12 12 10 10 8 6 6 Date 2 to 2 0 1 Feb 1 Mar 1 Apr 1 May 1 Jun 1 Jul 1 Aug 1 Sep 1 Oct 1 May 1 Feb 1 Mar 1 Apr 1 Jun 1 Jul 1 Aug 1 Sep 1 Oct Date [2018] Date [2018] Monash Institute of Railway Technology WRI 2021 *ШIRT* HEAVY HAUL SEMINAR . OCTOBER 20 - 21, 2021

Detrimental Maintenance?

5.5 Severity 1 5.0 4.5 4.0 3.5 3.0 /alue 19/7/2018 8:00:00 AM DateTime 2.5 Welding Maintenance Action: Maintenance Effectiveness: 27% Worse (+0.99mm) Equipment: Switch & Stock BH RailHand: 2.0 1.5 8/3/2018 8:00:00 AM DateTime: Maintenance Action: Replaced 1.0 Maintenance Effectiveness: 3% Worse (+0.10mm) Equipment Switch & Stock BH RailHand 0.5 0.0 1 Feb 1 Mar 1 Apr 1 May 1 Jul 1 Aug 1 Sep 1 Oct 1 Jun Date [2018]

Wagon Dynamics - Spring Deflection 3 (mm) vs. Date

- Welding a crossing resulted in worse performance
- IRV can form an essential part of RAMS engineering processes





Forecasting of Maintenance



In-train Forces



Instrumentation ⇒ Dynamic Model ⇒ Prediction of maximum Fatigue Damage





Dynamic Track Gauge

- Installed as part of the IRV system in a revenue car
- Continuously measures gauge during normal traffic hours
- Satisfies EN 13848-1:2003+A1:2008
 "Railway applications – Track Geometry Quality"









Dynamic Track Gauge

- Twin lasers used to calculate gauge
- Reported down to 1m when required
- Revenue vehicle loading so representative of any dynamic movement under heavy axle load









Expansion in Capability

- Work ongoing to expand to cant and other geometry measures
- Rail wear calculation
- Grooved light rail









Instrumented Revenue Vehicles

- Lower cost, rugged, revenue vehicle monitoring
- Provides near real-time track, vehicle and component performance
- Forecasting of maintenance and improvement of standards
- Growing capabilities









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