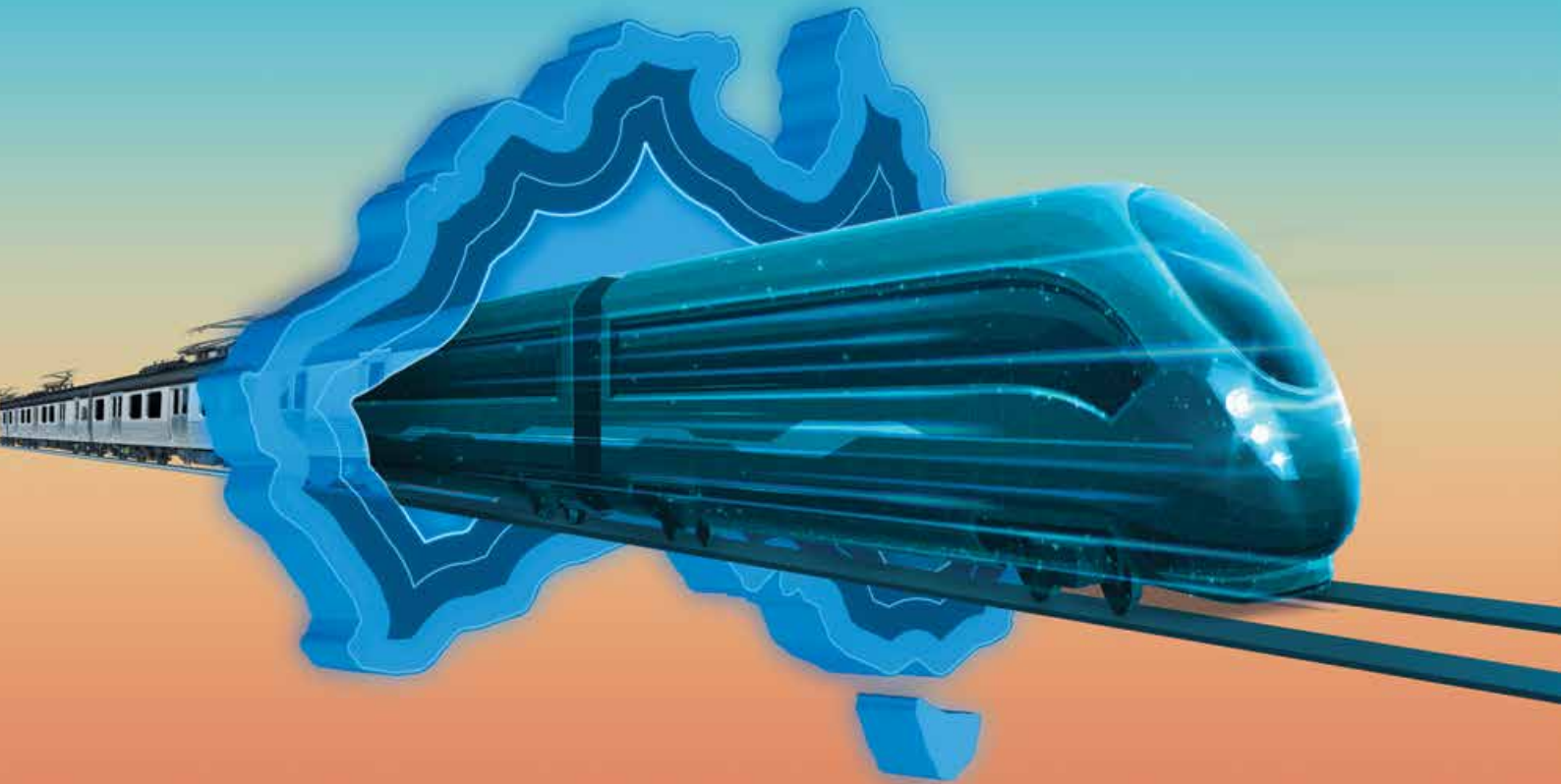




Monash Institute of Railway Technology

AN INSTITUTE OF MONASH UNIVERSITY



SHAPING THE FUTURE OF RAILWAY



**“Monash Institute of Railway Technology
is the premier track and vehicle railway
research centre in Australia.”**

Interim Chief Executive Officer
V/Line Standing Committee on the Economy and Infrastructure
9 February 2016

The Monash Institute of Railway Technology (IRT) based at Monash University is the premier track and vehicle railway research centre in Australia, and enjoys an international reputation for excellence in railway research.

Monash IRT is one of the main technology service providers to heavy haul railway operations and leading mass transit railway systems. Monash IRT provides a “one-stop” technology access point for the railway industry.

Monash IRT evolved from BHP’s Melbourne Research Laboratories (MRL) in January 2000, and together with its predecessor has been advancing the railway industry through technology for over 50 years.

The Institute has an established track record in solving railway related technical issues, and its solutions have been adopted by railway systems throughout the world.

The Institute’s comprehensive and systematic approach to problem solving using its team of experienced technical specialists has led to significant savings to its customers’ operating and capital costs, surpassing all expectations and providing value added environmental benefits.

The Monash Institute of Railway Technology is continuously developing new technologies and processes to support increasing productivity and safety requirements at the same time as reducing risks and costs, ultimately improving the bottom line for their clients.



CAPABILITIES

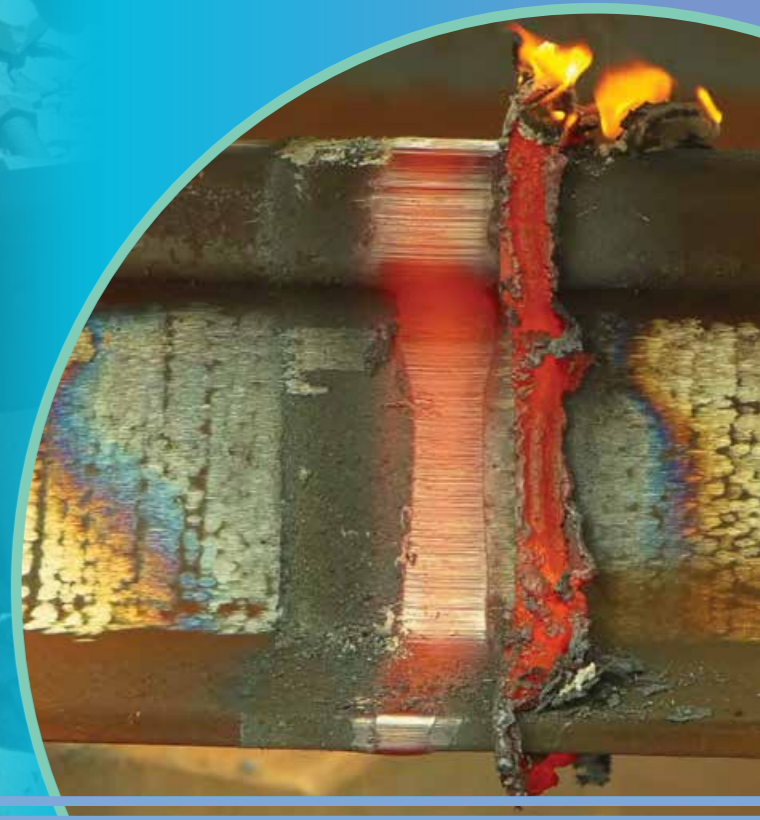
The Monash Institute of Railway Technology consists of a group of highly skilled Engineers, Scientists and Technicians that cover a wide range of mechanical, civil, electrical, metallurgical and general science disciplines. The Institute's Rail Research Associates from Monash University's world leading academic and researchers staff, enhance Monash IRT's broader industry-focused capabilities.

Primary areas of expertise include track structure, simulation modelling, vehicle-track interaction, vehicle dynamics, wheel-rail interface, real-time railway infrastructure condition monitoring, vehicle and track instrumentation, railway materials, rail welding, component testing, failure analysis, capacity increase, maintenance planning and optimisation, quality control, standards development and professional training.

Over the past 50 years, Monash IRT has developed a reputation for providing efficient and practical solutions to a wide range of railway operations including heavy haul, mass transit, high speed, general freight, metro and light rail systems.

KEY AREAS OF EXPERTISE

- Track structure design and maintenance
- Rail welding including aluminothermic and flashbutt processes
- Wheel-rail interface including profile design and maintenance strategies including rail grinding
- Wheel and rail materials specification and performance
- Multi-body dynamic simulation using Universal Mechanism®
- Vehicle-track interaction and track quality assessment
- Vehicle performance evaluation including stability, ride comfort and life extension
- Vehicle component condition assessment including brakes, couplers and suspension components
- Instrumented revenue vehicles for real time track condition, vehicle performance and passenger comfort monitoring
- Longitudinal train dynamics and driving strategies
- Effects of increased axle load including costs, benefits and component assessment
- Extending asset life including bridges, car body, rails and wheels
- On-site instrumentation of track and vehicles including remote area data collection
- Complex data analytics and visualisation
- Comprehensive in-house mechanical testing facilities
- Component development, testing, failure analysis and quality control auditing
- Development of railway national standards and specifications
- Risk assessments including Failure Mode and Effects Analysis (FMEA)
- Professional training



RAIL MANAGEMENT AND MAINTENANCE

The Monash Institute of Railway Technology has significant experience and expertise in rail management and maintenance. While operational characteristics may vary significantly between railway systems, the primary goal in all cases is to provide practical and cost effective rail management solutions.

Key areas of expertise:

- Rail performance and service life assessment including wear, rolling contact fatigue and whole-of-life cost analysis
- Rail grade and profile selection
- Non-destructive testing strategies and evaluation of broken rails and rail defects
- Metallurgical analysis of rail defects and failures

- Assessment of rail wear limits
- Management of longitudinal rail stress and track stability
- Auditing and assessment of rail grinding activities
- Performance monitoring and evaluation
- Development of rail maintenance management models
- Evaluation of other rail repair techniques including laser cladding and induction welding

Monash IRT's involvement in rail management and maintenance activities has provided industry partners with a wide range of benefits, including targeted rail maintenance strategies, development of economic rail management models, improved rail safety, improved maintenance effectiveness and the development of appropriate standards and procedures.

IMPROVEMENT OF RAIL WELD PERFORMANCE

Improvements in the quality and characteristics of rail steels has resulted in the performance of rail welds becoming increasingly important, particularly in the premium rail grades used under heavy haul conditions. Activities undertaken by Monash IRT have been aimed at improving the reliability of flashbutt and aluminothermic welds across all sectors in the rail industry.

Monash IRT personnel are internationally recognised for their expertise in rail welding including:

- Development and review of specifications and standards
- Qualification testing of flashbutt and aluminothermic welds
- Fatigue testing
- Residual stress measurement
- Metallurgical analysis of weld defects and failures
- Assistance with developing welding procedures for new rail grades
- Assistance with welder training and competency assessment

Monash IRT's position within the rail industry provides an independent forum under which rail welding issues can be discussed and resolved to the benefit of the industry as a whole.



WHEEL-RAIL INTERFACE

The Monash Institute of Railway Technology is internationally recognised for solving wheel-rail interface related issues for a wide range of operating conditions, including heavy haul, general freight, mass transit and high speed rail.

Key areas of expertise:

- Assessment of damage mechanisms in wheel-rail contact
 - Wear
 - Rolling contact fatigue
 - Corrugations
- Wheel-rail contact modelling
- Design and implementation of wheel and rail profiles
- Development of rail profiling procedures and practices
- Assessment of wheel and rail material behaviour
- Lubrication and friction management
- Wheel-rail noise reduction
- Derailment investigation including flange climb

Considerable benefits can be gained through appropriate wheel-rail interface management, including reduced defect rates, improved safety, extended wheel and rail life, improved vehicle-track interaction, reduced wheel-rail noise and ensuring the development of suitable standards and maintenance procedures.

ROLLINGSTOCK PERFORMANCE

The Monash Institute of Railway Technology has substantial expertise in the area of rollingstock performance covering comprehensive engineering programs including dynamic simulation modelling, laboratory testing of railway components, in-service monitoring, data analysis and expert interpretation. The highly reliable instrumented revenue vehicle (IRV) platform has further extended IRT's capability in terms of improved rollingstock performance, by providing critical data on the dynamic performance of rollingstock and components.

Key areas of expertise:

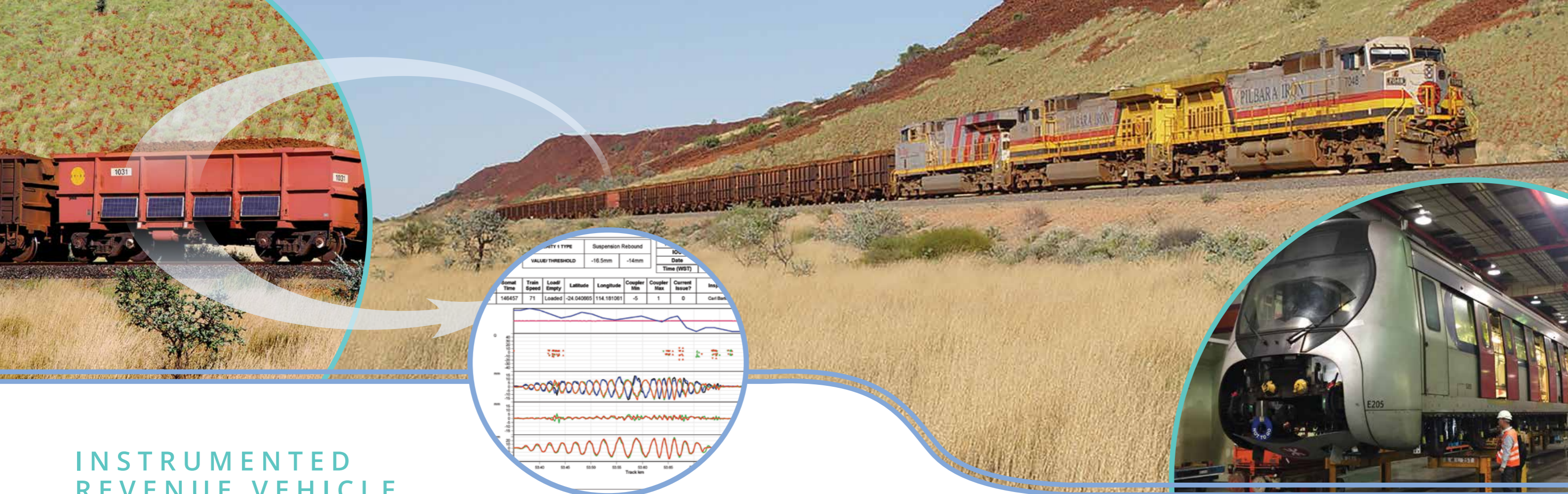
- Wagon and component testing and standards validation
- Structural and dynamic modelling
- Longitudinal train dynamics monitoring
- In-service structural and dynamic response measurements
- Vehicle stability and ride quality assessment
- Wayside monitoring of vehicle performance
- Maintenance program validation

WHEEL PERFORMANCE

Wheels used in freight and heavy haul operations are subjected to a combination of mechanical and thermal loads, both of which can contribute to increased rates of deterioration. Inadvertent overheating through the application of friction braking may also alter the residual stress distribution and increase the risk of wheel failure. Monash IRT has the broad range of capabilities to fully investigate such issues

Key areas of expertise:

- Metallurgical analysis of wheel defects and failures
- Cleanliness assessment using ultrasonic phased array testing
- Destructive and non-destructive measurement of residual stresses
- Assessment and qualification of wheel materials to industry requirements



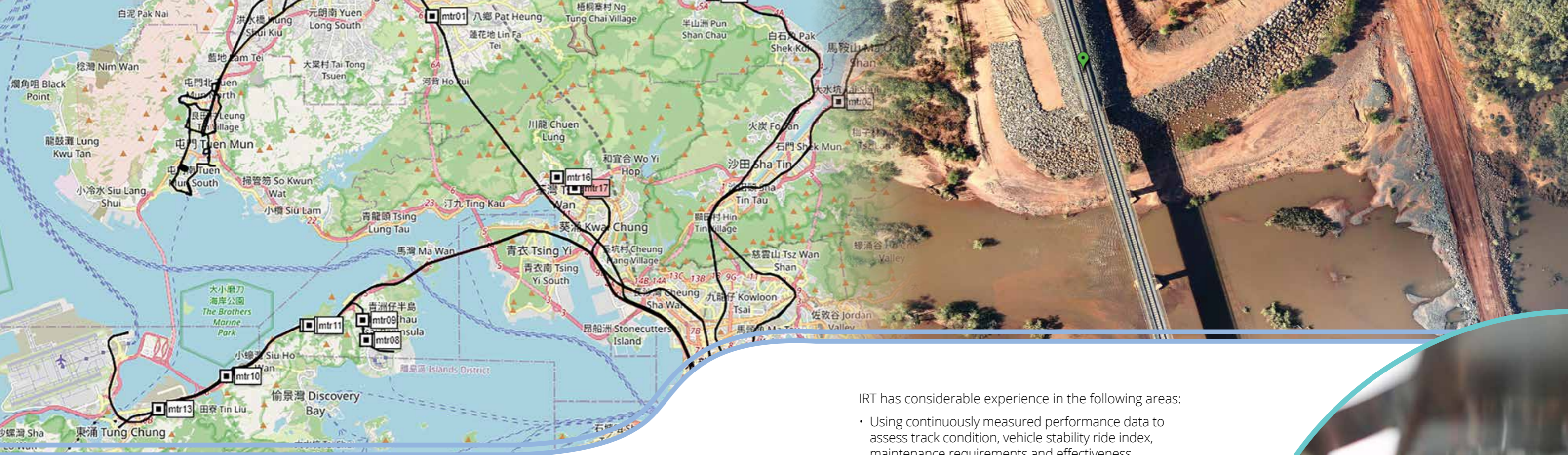
INSTRUMENTED REVENUE VEHICLE

The Instrumented Revenue Vehicle (IRV) program commenced in 2001 and has since provided innovative strategies for condition monitoring and targeted condition or evidence based economical track maintenance planning. The data recorded on these vehicles is also used for developing appropriate driving strategies and assessing rollingstock performance.

The IRV technology developed by Monash IRT utilises existing customer rollingstock which remains in normal revenue service and provides a platform for instrumentation, data collection and communication. The key advantage of an IRV, as opposed to traditional track recording equipment, is that it monitors the actual response of the rollingstock in both empty and loaded condition during normal operation and provides more regular feedback on track condition, typically daily. The principal premise is that if the rollingstock is riding poorly, then corrective actions are likely to be required.

The IRV fleet is designed around the customers' specific requirements and operates autonomously. Whilst IRVs provide an excellent tool for monitoring track condition and planning track maintenance, the following applications have also proven beneficial to existing customers:

- Continuous monitoring of ride comfort
- Application of appropriate temporary speed restrictions
- In-train force monitoring, often used for:
 - Development of improved driving strategies
 - Tuning of indexing cycles during car dumping
 - Development of REPOS tables to allow improved product design
- Wagon structural assessment and monitoring for design confirmation
- Dynamic monitoring to ensure adequate stability and ride comfort according to regulatory standards
- Strain gauging of individual components to provide improved understanding of their behaviour and loading
- Bearing and wheel temperature monitoring to allow hot bearing and hot wheel monitoring sites to be calibrated



DATA ANALYTICS AND VISUALISATION

Evidence based decision making is essential to progressive railway operations. The Monash Institute of Railway Technology provides innovative data solutions for complex railway engineering problems.

The Monash IRT team has considerable experience in data driven decision making to produce actionable intelligence in planning, analysis, design and process management operations.

The Institute has led the way in using continuously measured performance data from instrumented revenue vehicles and wayside instrumentation to forecast maintenance requirements. In doing so it has helped organisations to move from reactive maintenance regimes, where problems are largely dealt with as they arise, to proactive or prescriptive regimes where maintenance is conducted in a planned and conducted in a safe and economical manner.

IRT has considerable experience in the following areas:

- Using continuously measured performance data to assess track condition, vehicle stability ride index, maintenance requirements and effectiveness of maintenance
- The development of statistical and machine learning algorithms to characterise vehicle and track behaviour
- Root-cause investigation of current and historical data systems to identify track and rollingstock issues
- Optimisation of train speed profiles and driving strategy based on rollingstock and in-train response data
- Collating geospatial (GIS) data to generate detailed track maps
- Producing interactive, web-based dashboards that improve visualisation, data accessibility and facilitate self-service analytics
- Machine and deep learning and artificial intelligence



MULTI-BODY DYNAMIC MODELLING WITH UNIVERSAL MECHANISM

The Monash Institute of Railway Technology has considerable experience in modelling the dynamic response of various rail vehicle types. Monash IRT's modelling capability is greatly enhanced by extensive use of field recordings from instrumented vehicles, track instrumentation and specialised inspection equipment to ensure model accuracy validation.

Key areas of expertise:

- Derailment investigation
- Rail selection and whole-of-life cost analysis
- Wheel and rail profile design and evaluation
- Wheel and rail lubrication studies
- In-train force modelling and optimisation
- Speed / stability studies
- Establishing loading bias limits for safe operation
- Evaluation of suspension modification

The Institute is the official representative for the Universal Mechanism® (UM) software package in Australia, New Zealand, Brazil, Hong Kong and Singapore. UM is a generalised multi-body simulation package with specific modules for railway applications as well as 3D analysis of dynamics and visualisation of responses.

UM also supports:

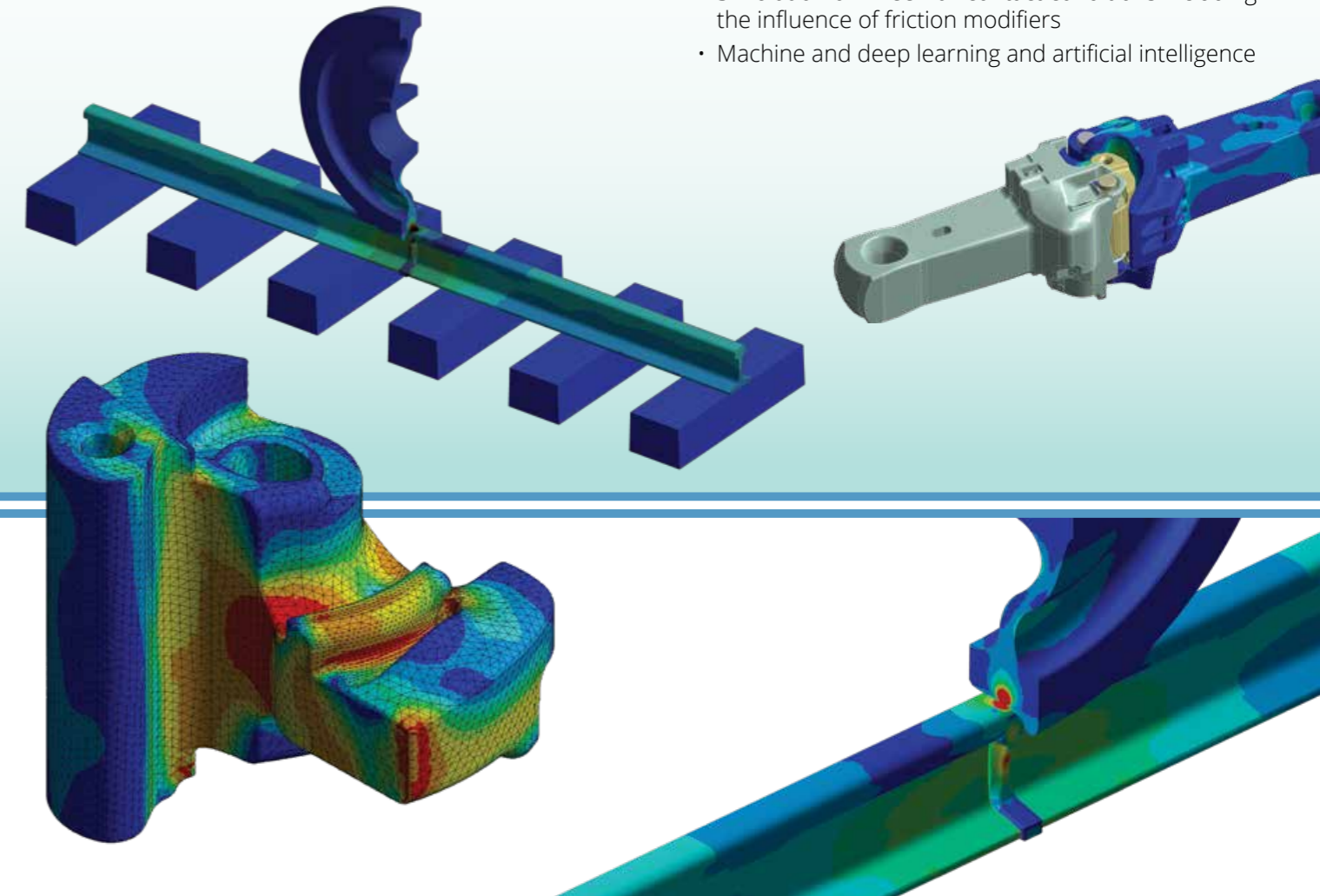
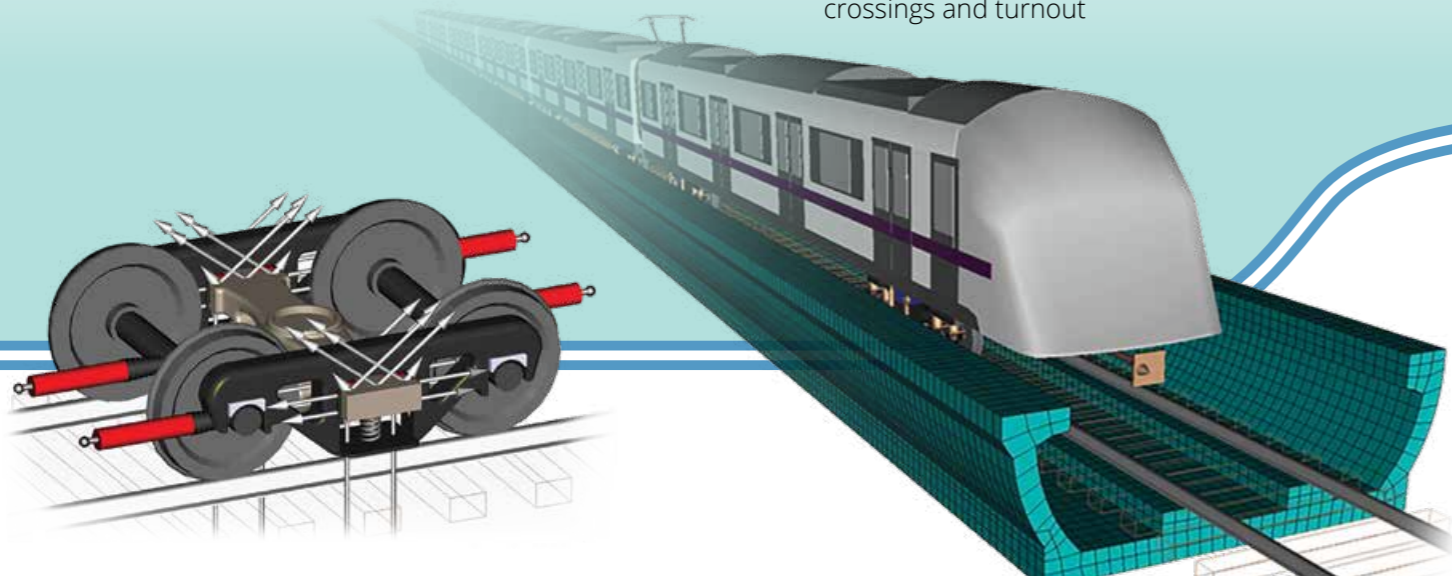
- Incorporation of flexible components using finite element models
- A control interface with Matlab and Simulink for extra flexibility
- Prediction of wheel/rail wear and profile evolution
- Fatigue analysis on any railway component
- Modelling of longitudinal dynamics in trains of any length
- Simulation of 2D granular media for ballast dynamics studies
- Assessment of track design and other infrastructure including bridges and viaducts, and vehicle dynamic behaviour under new design conditions
- Assessment of dynamic behaviour through railway crossings and turnout

PERFORMANCE ASSESSMENT AND COMPUTER SIMULATION

The Monash Institute of Railway Technology is a leading railway research facility in failure analysis and performance assessment using Finite Element Method and Fracture Mechanics. Being at the heart of Monash University, IRT has the advantage to access the latest technologies in computer simulation and laboratory testing.

Examples of applications in railway industry:

- Rail head wear limit analysis
- Failure analysis of rails and welds
- Qualification assessment and failure analysis of draft gear components
- Damage tolerance analysis of railway components
- Simulation of wheel-rail contact conditions including the influence of friction modifiers
- Machine and deep learning and artificial intelligence





PROFESSIONAL TRAINING

With continued investment into new, uprated and expanding railway assets, there is an essential need for a highly skilled and future proofed workforce. Monash IRT leads the way in professional training, with dedicated short courses, focussed in key railway areas. Using its 50 years of applied research and industry experience, IRT delivers knowledge and practical skills to give railway workers the real-world grounding they need. Targeted at both new entrants to the railway industry, and those seeking more in-depth knowledge, these courses offer dynamic learning and networking building opportunities.

Monash IRT offers courses in:

- Track Infrastructure
- Rollingstock
- Aluminothermic and Flashbutt Welding
- Wheel-rail Interface
- Rail Adhesion Management

FIELD TESTING, LABORATORY CAPABILITIES AND METALLURGICAL SERVICES

- Servo-hydraulic, dynamic testing machines with load capacity 10–70 tonnes
- Twin-disc test rig for simulation of wheel-rail contact conditions
- Comprehensive range of data recording, analysis and computing equipment
- Fatigue testing of components including rail welds, couplers, yokes, sleepers, fasteners and rail clips.
- Rail surface friction measurements
- Noise measurements
- Wheel load measurement systems
- Wheel and rail profiling
- Rail corrugation measurements and analysis
- Strain gauge instrumentation
- Ballast and formation testing
- Mechanical testing
- Weld qualification testing
- Materials characterisation and failure analysis
- Comprehensive metallurgical analysis capabilities.
- Imaging systems including photogrammetry





PROFILE MEASUREMENTS – MINIPROF

The Monash Institute of Railway Technology is the exclusive representative for MiniProf® in Australia, New Zealand, Hong Kong and Singapore.

MiniProf is a high precision, lightweight and portable profile measuring device manufactured by Greenwood Engineering A/S. It is widely used for research, optimised profile development, planning and evaluation of maintenance activities such as rail grinding, rail milling and wheel machining.

The MiniProf instrument uses a full contact measurement system in order to capture a highly accurate electronic cross sectional profile, which is then saved onto a laptop, tablet or mobile phone for further analysis. It is equipped with Bluetooth, which enables the user to perform fast and wireless measurements as well as the option for cable connection. Combined with a user-friendly and versatile software package which can be easily configured from basic use to in-depth post measurement analysis, MiniProf can be used for numerous purposes on all types of rail, turnouts, wheel and brake profiles.

SUSTAINABLE DEVELOPMENT GOALS

Monash Institute of Railway Technology supports sustainable development by aligning with the UN goals for:

- Good health and Wellbeing
- Quality Education
- Industry, Innovation and Infrastructure
- Reduced Inequalities
- Sustainable Cities and Communities
- Responsible Consumption and Production
- Climate Action



Through research supporting the Circular Economy, delivering an accessible rail system for all and training the next generation of railway workers, Monash IRT is enabling future proof solutions



CIRCULAR ECONOMY

There is a drive towards a more sustainable economy mode, namely the 'circular economy' to maximise the economic value of resources through reuse and recycling of waste materials.

Monash IRT is leading targeted research to address the recycling crisis through high performance innovative railway products manufactured using recycled waste material such as plastics, polymers and rubbers to support net-zero emission targets.

Research to contribute to the Circular Economy includes:

- Improved recycled plastic railway sleepers
- Recycled plastic structures for low impact tram stops
- Processing waste plastics and tires into fuel
- Replacing conventional diesel with fuel alternatives
- CO₂ capture and conversion

ACCESSIBILITY

Equal accessibility for all to the rail network is not only a key criterion for customer satisfaction and usability, but a critical legal requirement. Urban railways, especially those with legacy infrastructure and rollingstock, require novel solutions to help customers navigate to and access their services. Monash Institute of Railway Technology has drawn together a wide set of expertise from Monash University, including robotics, civil engineering, design, communications, accident research and occupational health to form the Rail Accessibility Research Group. This group is delivering real world applied research to help railways solve the accessibility conundrum.

Research deliverables in this area have included:

- Assessment of station infrastructure and connectivity to rank accessibility to aid investment for asset owners and travel decisions for users
- Design of improved boarding devices integrated into rollingstock
- Analysis of tram boarding and alighting accident statistics



The Monash Institute of Railway Technology has provided technical support to over 160 different businesses within the railway industry both nationally and internationally, including:

Heavy Haul:

- BHP Iron Ore
- Rio Tinto Iron Ore
- Fortescue Metals Group
- Roy Hill Holdings
- Companhia Vale do Rio Doce (Vale, Brazil)
- Aurizon
- Cliffs Natural Resources Inc.
- SNIM (Mauritania)

International Mass Transit & High Speed Rail:

- MTR Corporation (Hong Kong)
- SMRT (Singapore)
- Bangkok Express Metro (Thailand)
- Taiwan High Speed Rail Corporation (Taiwan)
- Dubai Roads and Transport Authority (Dubai Metro)
- PT Kereta Api Indonesia

General Freight and Passenger:

- Australian Rail Track Corporation
- Arc Infrastructure
- TasRail
- KiwiRail (New Zealand)
- Queensland Rail
- Metro Trains Melbourne
- Metro Trains Sydney
- Pacific National
- V/Line

Light Rail:

- Yarra Trams
- Gold Coast Light Rail
- Canberra Metro

Suppliers & Contractors:

- Railtech Australia
- Rocla
- Comsteel
- Bradken
- Amsted
- OneSteel
- Thermit Australia
- Alstom
- Pandrol
- Speno Rail Maintenance
- John Holland
- Gemco
- Keolis Downer
- Delkor Rail
- McConnell Dowell
- Laing O'Rourke

Government:

- Victorian Government Department of Transport
- South Australian Government DIT (TransAdelaide)
- Public Transport Authority Western Australia

CONTACT DETAILS

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