Institute of Railway Technology

A N I N S T I T U T E O F M O N A S H U N I V E R S I T Y
The Institute of Railway Technology (IRT) at Monash University is the premier track and vehicle railway research centre in Australia, and enjoys an international reputation for excellence in railway research. IRT is one of the main technology service providers to heavy haul railway operations and leading mass transit railway systems, and provides a "one-stop" technology access point for the railway industry. 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 45 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 Institute of Railway Technology is continuously developing new technologies to support increasing productivity and safety requirements at the same time as reducing risks and costs, ultimately improving the bottom line for their clients.

"Institute of Railway Technology at Monash University 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 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 academic staff, in conjunction with post-graduate researchers, enhance IRT’s broader industry-focused capabilities.

Over the past 45 years, 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 and passenger 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 dynamics 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 track condition monitoring and assessment of ride quality index
- 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)
- Personnel training.

**CAPABILITIES**

Primary areas of expertise include vehicle and track instrumentation, vehicle and train performance, condition monitoring, component testing, failure analysis, quality control and auditing, wheel-rail interface, rail welding, track structure design and maintenance, standards development and personnel training.

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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 IRT have been aimed at improving the reliability of flashbutt and aluminothermic welds across all sectors in the rail industry.

IRT personnel are internationally recognised for their expertise in rail welding. Key areas of expertise:

- 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.

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.

The Institute of Railway Technology has significant experience and expertise in the area of 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 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.

IRT’s involvement in rail management and maintenance activities has provided clients 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.

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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.

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.

ROLLINGSTOCK PERFORMANCE

The Institute of Railway Technology has substantial expertise in the area of rollingstock performance covering comprehensive engineering programs including dynamic simulation modelling, laboratory testing, 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-RAIL INTERFACE

The 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.

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.
The 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 tool manufactured by Greenwood Engineering A/S. It is widely used for research, planning and evaluation of maintenance activities such as rail grinding, rail milling and wheel machining.

PROFILE MEASUREMENTS – MINIPROF

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 computer or PDA 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, switch, wheel and brake profiles.

Railway maintenance task will often require the visual inspection of components, which may include difficult to access infrastructure such as bridges and culverts. In many cases this will require special conditions relating to access. Placing a human within the rail corridor exposes the person to significant risk due to the presence of hazards such as oncoming trains and electrification equipment within confined spaces.

IRT’s small-scale multi-rotor unmanned aircraft are capable of inspecting rail as well as railway tunnels and culverts. These unmanned aircraft are deployed at the entrance of a railway tunnel, a cutting, a culvert or confined space, and the aircraft traverses the space. Using Light Detection, and Ranging (LiDAR) to collect data, the interior surface of confined spaces as well as the condition of the track infrastructure can be mapped. This map allows an engineer to conduct an inspection without needing to enter either the rail corridor, or the confined space itself.

Operating small scale unmanned aircraft in confined spaces with computer controlled stability algorithms is now feasible. These systems are designed to centre themselves within the confined railway corridor, and allow an operator to control the exact position in which the UAV is located within the confined space.
The Institute of Railway Technology personnel have significant experience in the performance of couplers and other draft gear components, including the manufacturing specifications for these components to meet demanding applications, the analysis of failures and manufacturing plant audits.

The Institute introduced innovative non-destructive phased array technology inspections to the heavy haul industry to meet the need for rapid assessment of the integrity of couplers and yokes, which has dramatically reduced the incidence of in-service failures of these components.

The combination of coupler force measurements from instrumented revenue vehicles (IRVs), as well as strain measurements on key components in the drawgear assembly provides critical information required to take the next step in realising further reductions in the incidence of draft gear component failures.

COUPLERS AND YOKES

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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.
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 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.

The Instrumented Revenue Vehicle (IRV) technology 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 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 Institute of Railway Technology has considerable experience in modelling the dynamic response of various rail vehicle types. 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.

MULTI-BODY DYNAMIC MODELLING WITH UNIVERSAL MECHANISM

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.

PERFORMANCE ASSESSMENT AND COMPUTER SIMULATION

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.
Evidence based decision making is essential to progressive railway operations. The Institute of Railway Technology provides innovative data solutions for complex railway engineering problems. The Institute of Railway Technology team has considerable experience in the utilisation of data to draw out insights from "big data" 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 regimes where condition based maintenance is conducted in a planned and coordinated fashion ahead of time.

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.

Data Analytics and Visualisation
IRT ACHIEVEMENTS

1972
Railway Research activities commenced at IRT’s predecessor BHP’s Melbourne Research Laboratories (MRL)

2000
Established IRT at Monash University

2002
Engineers Australia’s Railway Technical Society of Australasia (RTSA) Rail Engineering Industry Award for Excellence in Railway Research

2002
Introduction of first heavy haul autonomous Instrumented Revenue Vehicle (IRV)

2006
Introduced Phased Array Technology into the railway industry

2010/11
Rio Tinto commissioned state of the art IRV Technology throughout its fleet

2012
Celebrated 40 Years of Excellence in Railway Research

2013
One of the most successful business units at Monash University, generating highest industry funded research income

2014
IRT was identified as the Premier Track and Vehicle Research Centre in Australia

2015
BHERT Best Research & Development Collaboration Award

2016
Australian Academy of Technological Sciences and Engineering (ATSE) Clunies Ross Award for IRT senior staff

2018
IRT celebrated 50 Years of Research Excellence in Railway Research

2022
IRT's research continued to drive innovation and development in the railway industry.
The Institute of Railway Technology has provided technical support to over 150 different businesses within the railway industry both nationally and internationally, including:

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

**International Mass Transit & High Speed Rail:**
- MTR Corporation (Hong Kong)
- SMRT (Singapore)
- MMC Gamuda (Malaysia)
- 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
- Brookfield Rail
- Taile Beach Railway
- KiwiRail (New Zealand)
- Queensland Rail
- North West Rapid Transit
- Metro Trains Melbourne
- Pacific National
- VL-ine

**Light Rail:**
- Yarra Trams
- Gold Coast Light Rail

**Suppliers & Contractors:**
- Railtech Australia
- Rocla
- Comsteel
- Bradken
- Amsted
- OneSteel
- Thermit Australia
- Voestalpine
- Valdunes
- New York Air Brake
- Speno Rail Maintenance
- Emrail
- John Holland
- Gemco
- Downer EDI Rail
- Delkor Rail
- McConnell Dowell
- Laing O’Rourke

**Government:**
- Victorian Government Department of Transport
- South Australian Government ODEI (TransAdelaide)

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