



2018–19 Snapshot and Exit Report  
**Rail Manufacturing CRC**



# Message from the Chair and MD

This is an abridged Chair and MD letter. This snapshot report covers the Rail Manufacturing Cooperative Research Centre's fifth year of operation. To access the full annual report, visit [www.rmcr.com.au](http://www.rmcr.com.au)

Over the course of the last five years, the Rail Manufacturing CRC has continued to expand its programs to deliver excellence in research, technology and training for Australia's rail industry.

## Renewed optimism in rail R&D

With our Centre entering its last year of operation and a scheduled wind-up date of 30 June 2020, it is encouraging to see a resurgence of interest in collaborative research and development in Australian rail.

A renewed focus by the Federal and State Governments to build an efficient, nationwide rail system as the fundamental element to transport passengers, goods and services for the next century has re-energised the industry.

In the Centre's early years, the downturn in the heavy rail manufacturing and supply sectors severely impacted the ability of our Industry and Research Participants to pursue heavy rail related projects. In comparison, the recent upturn in the resources sector and the continuing growth in passenger rail infrastructure and rolling stock highlights market optimism.

With this substantial investment comes immense opportunities for Australia to build its blue and white collar workforce, to use future investment to support the creation and adoption of new domestic rail technologies, to build new supply chains based on emerging technologies, to fund domestic innovation initiatives, and most importantly, for rail to attract and retain a new and emerging workforce of highly skilled engineers and science professionals that will lead the industry into the future.

## Projects going strong

For the past 12 months, the Rail Manufacturing CRC has been actively engaged in workshopping, evaluating and implementing a variety of new projects by both existing partners and new Participants. In 2018–19 alone, our team has initiated seven new projects with a total cash funding of \$8.7 million, leading progressive research in battery back-up systems, predictive maintenance solutions, responsive passenger information technologies and defining future rail workforce needs.

The increase in project activity also mandated a required amendment to the Commonwealth Agreement, which occurred in January 2019. This included general updates to milestones and budget, plus the incorporation of terms and conditions to reflect new Commonwealth requirements relating to CRC funding agreements. As always, our interactions with the Department of Industry, Innovation and Science team have been constructive and positive, and we continue to acknowledge the support they provide and the key role they play with our Centre and Participants.

Furthermore, the successful outcomes of our projects could not have been achieved without the strong support of our Industry and Research Participants, working collaboratively to deliver shared goals.



Dr Stuart Thomson



Paul Johnson MBE

Indeed, in the past year, relationships between several of our Participant organisations are now considered to be at their most productive since our Centre began, including:

- » **Downer and UTS** developing the Dwell Track™ responsive passenger information technology which can monitor platform and causeway congestion in rail environments, with a Sydney Trains trial commencing in August 2019
- » **CRC and CSIRO** undertaking a range of projects primarily focussed on energy storage activities and metal processing
- » **Bombardier and University of Queensland** delivering projects in monitoring and modelling to better predict bearing wear and maintenance cycles
- » **Airlinx and RMIT University** developing computer aided design systems to understand airflow within rail carriages and designing more effective means to deliver and recirculate air.

The buoyant rail sector is also reflected in terms of our PhD student commitments. It's extremely encouraging to see the very strong cohort of students conducting highly challenging research for the rail industry, with a number of students beginning to submit their theses and planning to embark on a career in rail upon completion of their PhD studies.

## Rail R&D moving forward

Despite the best efforts of the Centre and its Industry Participants to realise the initial commitments made in 2014, some organisations are unlikely to meet their obligations to the Centre, with a shortfall in total project activity expected.

These shortfalls are due to an ongoing global rail industry consolidation witnessed by numerous recent mergers and acquisitions, management restructures, financial challenges, and subsequent changes to innovation strategies and priorities, all of which have contributed to the volatility within the sector for a number of our Industry Participants over the last five years.

Despite this, the Rail Manufacturing CRC's short tenure is best characterised as contributing not only to delivering new technologies and knowledge to the sector, but also building an awareness about the importance of R&D in a local manufacturing environment.

By fostering strong working relationships between Industry Participants and publicly-funded research agencies since 2014, it is hoped that these partnerships, formed by the Rail Manufacturing CRC, will serve the sector for many years to come.

## Thanks for your support

Our thanks and recognition go to our Board and Management teams for their commitment and drive this year.

Thank you to our Industry and Research Participants, many of whom who have been actively engaged since the Centre first commenced in 2014. It's been a pleasure working with you to identify innovation projects that provide key improvements to help grow the Australian rail sector.

We appreciate your continued support during our upcoming final year, and as always, thank you for working with us to build an Australian rail industry committed to innovation and R&D.



Paul Johnson MBE  
Chair – Rail Manufacturing CRC



Dr Stuart Thomson  
CEO – Rail Manufacturing CRC

## About the Rail Manufacturing CRC

The Rail Manufacturing Cooperative Research Centre (CRC) was established in 2014 to build a collaborative research and development program between Australia's rail manufacturing industry and world-leading Australian education institutions.

The Centre manages partnerships between key stakeholders, including rail manufacturing multinationals, Australian small-to-medium enterprises, research and development providers, industry peak bodies, and Australian State and Federal Governments.

Funded by participating rail organisations and the Business Cooperative Research Centres Program of the Federal Government's Department of Industry, Innovation and Science, the Rail Manufacturing CRC is now five years into its six-year lifespan. The Centre is scheduled to cease operations on 30 June 2020.

### Board



CHAIR - PAUL  
JOHNSON MBE  
INDEPENDENT  
DIRECTOR



BRONWYN  
CONSTANCE  
INDEPENDENT  
DIRECTOR



DR STUART  
THOMSON  
RAIL MANUFACTURING  
CRC



MICHAEL  
MILLER  
DOWNER



PROF GRANT  
STANLEY  
CQUNIVERSITY



MICHAEL  
MCLELLAN  
KNORR-BREMSE  
AUSTRALIA



JASBIR  
TUMBER  
SYDNEY TRAINS

### Management team



DR STUART  
THOMSON  
CEO



DR LARRY  
JORDAN  
RESEARCH  
DIRECTOR



SHARON  
SALPIGHIDIS  
FINANCIAL  
CONTROLLER AND  
COMPANY SECRETARY



KATIE RIZZO  
COMMUNICATIONS  
MANAGER



HEIDI KRASULAK  
FINANCE AND  
RECORDS OFFICER



PROF COLIN  
COLE  
PROGRAM  
LEADER



PROF PAUL  
MEEHAN  
PROGRAM  
LEADER

# Performance against activities

01 Power and Propulsion	02 Materials and Manufacturing	03 Design, Modelling and Simulation
<p>Energy and cost efficiency, and improved competitive performance in advanced rail manufacturing through research, development and commercialisation in:</p> <ul style="list-style-type: none"> <li>» Energy Regeneration and Storage</li> <li>» Advanced Braking Systems</li> <li>» Electronic Motors and Systems</li> </ul>	<p>Competitive cost, durability and performance in advanced rail manufacturing through research, development and commercialisation in:</p> <ul style="list-style-type: none"> <li>» High Performance Materials For Heavy Haul</li> <li>» Advanced Manufacturing</li> <li>» Advanced Lightweight Materials</li> <li>» Low Cost Manufacturing Systems</li> </ul>	<p>Safety and efficiency in advanced rail manufacturing to enhance industry competitiveness through research, development and commercialisation in:</p> <ul style="list-style-type: none"> <li>» Advanced Design and Simulation</li> <li>» Automated Health Monitoring</li> <li>» Advanced Data Analysis and Information Systems</li> <li>» Advanced Operations Management Systems</li> <li>» Energy Use Management Tools</li> </ul>



## Program 1 – Power and Propulsion

The relevance of the Centre’s focus on battery and supercapacitor systems was further supported at InnoTrans 2018 in Berlin, where leading rail businesses are starting to deliver different power solutions to the rail industry.

The benefits of hybrid systems for diesel locomotives include reduced emissions at stations, regenerative braking, and the ability to operate under diesel or electric power when needed. For electrified lines, a hybrid system offers the ability to operate in non-electrified sections such as line extensions or areas where overhead lines are not possible due to height limitations or environmental sensitivity.

Related to Rail Manufacturing CRC projects, this electrification challenge is extended to entirely catenary-free light rail systems where the overhead lines are replaced by charging stations at tram stop platforms.

During the year, the strong collaboration between China Railway Rolling Stock Corporation (CRRC) and CSIRO has continued through a suite of supercapacitor energy storage system projects, including:

- » Project R1.3.3 - **High energy supercapacitor development** (CRRC / CSIRO)
- » Project R1.3.4 - **Supercapacitor energy management system stage 2** (CRRC / CSIRO)

In particular, Project R1.3.3 - **High energy supercapacitor development** (CRRC / CSIRO) was completed during the reporting period, resulting in the testing of a supercapacitor that maintains good cycle life and power density whilst improving energy density compared with traditional supercapacitors.

As part of the PhD activity undertaken at Queensland University of Technology, lithium iron phosphate (LFP), one of the important commercial battery materials, was investigated to determine electrochemical, electrical and magnetic properties. In this study, the presence of iron phosphate was found to significantly improve the electronic conductivity.

Project R1.3.4 - **Supercapacitor energy management system stage 2** (CRRC / CSIRO) has continued progressing through laboratory tests at CSIRO, and is scheduled for completion following full-sized tests to be conducted at CRRC’s facility in China by CSIRO and CRRC technical staff in late 2019.

An additional two new battery-related projects look at the energy battery backup options provided by modern battery chemistries for trains – Project R1.3.5 - **Lighting and control battery backup** (Downer / CSIRO) and Project R1.3.6 - **Battery pack durability** (Knorr-Bremse / CSIRO).

In a similar theme, two battery and supercapacitor material-focused projects between the HEC Group and the University of Technology have also delivered promising laboratory results. In Projects R1.1.1 - **New generation lithium ion batteries with high energy density and long service life for rail industry application** (HEC Group / University of Technology Sydney) and R1.1.2 - **Hybrid supercapacitors with high energy and power densities for rail industry applications** (HEC Group / University of Technology Sydney), improved materials are showing promising increases in energy density while maintaining other required parameters of cycle life and power density.

One final project that addresses the advanced braking research component of Program 1 has also progressed well during the reporting period. Project R1.5.1 - **Aluminium matrix composite brake discs** (CRRC / CSIRO) involves the production of full-sized composite brake discs produced at the CSIRO facility. The composite brake disc seeks to address several operational considerations to achieve better in-service performance, with the CRRC division QSY (Qishuyan Institute Co. Ltd) to undertake ongoing testing of the brake disc in their facilities.

## Program 2 – Materials and Manufacturing

This program area incorporates a variety of projects primarily relating to maintenance and durability of rail track and rolling stock, which has emerged as a key focus for industry due to Australian build-maintain contracts granted for efficient maintenance and servicing of rail assets.

Two projects in partnership between Bombardier and the University of Queensland could significantly reduce the rail industry's maintenance and overhaul requirements.

For Project R2.3.2 - **Axle bearing maintenance optimisation** (Bombardier / University of Queensland), which completed in the last 12 months, this project developed and tested a new enhanced predictive maintenance system for axle bearings. This work has enabled Bombardier to progress commercial activities in optimising axle bearing maintenance.

The other project due to complete shortly is Project R2.3.4 - **Monitoring and control of false brinelling** (Bombardier / University of Queensland), which investigates the wear that can occur during the transportation of bearings due to vibration and/or load on the bearing.

In Project R2.3.1 - **Accelerated life testing and characterisation of critical components** (Knorr-Bremse / CSIRO), Knorr-Bremse is working with CSIRO to test the performance of air conditioning units in different atmospheric conditions.

In Project 2.1.1 - **Platform gap** (Downer / Monash University), this project is focused on the manufacture and testing of a dynamically-adjustable gap filling device between the train and platform.

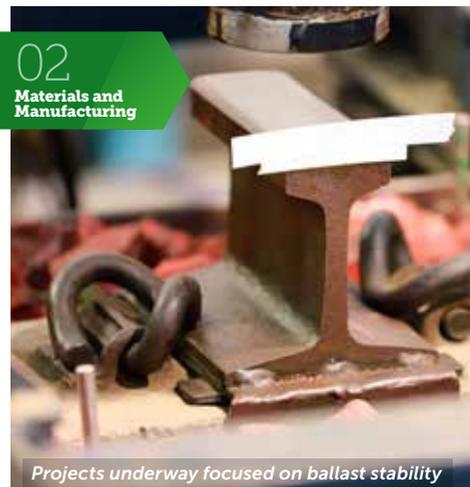
Another two projects focus on researching materials to enable rail ballast stability – Project R2.5.1 - **Performance of recycled rubber inclusions for improved stability of railway** (Tyre Stewardship Australia / Australasian Centre for Rail Innovation / University of Wollongong) and Project R2.5.2 - **Application of geogrids for minimising track deformation and degradation under high frequency cyclic and heavy haul loading** (Global Synthetics / Foundation QA / University of Wollongong).

Project R2.5.1 involves researching the use of recycled tyres as an alternate product for use in the rail ballast, while Project R2.5.2 is looking into the use of geogrids to stabilise the ballast foundation. A series of large-scale tests are currently in progress to investigate the behaviour of the rail ballast with and without geogrid reinforcement under cyclic loading conditions.

Project R2.1.2 - **Protection of cast steel coupler from corrosion by cold spray** (CRRC / CSIRO) is investigating the use of cold spray techniques to maintain and prolong coupler lifetime. Cold spray is an efficient and environmentally-friendly method of metal coating that uses a supersonic jet to spray metal particles to bond and form a protective metal layer.

In Program 2, one new project commenced during the year – Project R2.1.3 - **Laser repair of railway cast components** (CRRC / CSIRO). The project team is looking to develop a smart and reliable technology to repair steel casting defects without thermal damage in the surrounding regions. It is a robotic process which will reduce the rejection rate of cast parts by the rapid laser repair of defects.

One project was terminated during the Financial Year – Project R2.4.1 - **Advanced steel development for rail and sleepers** (OneSteel / Monash University), due to OneSteel's withdrawal from the project following its parent company, Arrium, being placed in voluntary administration and subsequently sold to new owners.



## Program 3 – Design, Modelling and Simulation

The potential of data analytics and predictive maintenance in rail has resulted in significant new activity during the year. Predictive maintenance offers the potential to implement technologies to monitor asset health, optimise maintenance schedules and gain real-time alerts to operational risks.

New projects commencing in the last 12 months include:

- » Project R3.1.3 - **Predictive maintenance models for Sydney Trains** (Sydney Trains / University of Technology Sydney): Identification of case studies and development of a proof-of-concept predictive maintenance demonstrator using an inhouse tool developed by UTS.
- » Project R3.1.4 - **Intelligent data fusion and analytics framework** (Downer / Deakin University): Developing a generic multi-modal data fusion and analytics framework using machine learning, statistical and other complementary models, to be assessed for predictive train maintenance services.
- » Project R3.2.2 - **Development of a responsive passenger information system for the Sydney Trains network (stage 2)** (Sydney Trains / University of Technology Sydney): This project builds upon outcomes from a previous project. Stage 2 will deliver a demonstrable information system at Town Hall station, allowing the collection of insights into customer movements from existing CCTV, Dwell Track™ and Wi-Fi in real-time.
- » Project R3.3.3 - **Reimagining the workforce: building smart, sustainable and safe public transport** (Department of Transport (Victoria) / Victoria University): Undertaking assessments to gain insights into future public transport sector resourcing needs.

Within this research area, Project R3.1.2 - **Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system** (Downer / University of Technology Sydney) was extended to trial the technology with Sydney Trains. Commencing in August 2019, the trial involves the installation of Dwell Track™ to monitor the movement of passengers.

Another project underway is Project R3.4.1 - **Arc welding modelling** (CRRC / CSIRO). CSIRO's arc welding software allows accurate prediction of the heat transfer to the welded metal, expected to greatly reduce the number of tests required in developing weld designs for rolling stock fabrication.

Project R3.6.1 - **Experimental and computational study on the key ventilation issues affecting air quality and thermal comfort in train cabins** (Airlinx / RMIT University) involves the development of a 3D computational fluid dynamics (CFD) model to predict thermal airflow and contaminant dispersion in train cabins.

The completion of Project R3.3.2 - **Development of a smart rail route map** (Australasian Railway Association / Deakin University) provides a framework for improving the rail industry's ability to adopt telecommunication and information-based technologies to improve standardisation, integration and harmonisation over the next 30 years. A Smart Rail Executive Committee has been established to guide the implementation of the Smart Rail Route Map.

Project R3.5.1 - **Battery HVAC feasibility study** (Knorr-Bremse / CSIRO) was also completed during the reporting period, enabling Knorr-Bremse and CSIRO to undertake future activities in heating, ventilation and air-conditioning battery use with much deeper insights into the technology involved.



# Current projects and milestones status

## Rail Manufacturing CRC Projects current during reporting period

Number	Project	Participants
<b>Program 1 – Power and Propulsion</b>		
R1.1.1	New generation lithium-ion batteries with high energy and long service life for rail industry applications	HEC Group / University of Technology Sydney
R1.1.2	Hybrid supercapacitors with high energy and power densities for rail industry applications	HEC Group / University of Technology Sydney
R1.3.3	High energy supercapacitor development	CRRC / CSIRO
R1.3.4	Supercapacitor energy management system stage 2	CRRC / CSIRO
R1.3.5	Lighting and control battery backup	Downer / CSIRO
R1.3.6	Battery pack durability	Knorr-Bremse / CSIRO
R1.5.1	Aluminium matrix composite brake discs	CRRC / CSIRO
<b>Program 2 – Materials and Manufacturing</b>		
R2.1.1	Platform gap	Downer / Monash University
R2.1.2	Protection of cast steel coupler from corrosion by cold spray	CRRC / CSIRO
R2.1.3	Laser repair of railway cast components	CRRC / CSIRO
R2.3.1	Accelerated life testing and characterisation of critical components	Knorr-Bremse / CSIRO
R2.3.2	Axle bearing maintenance optimisation	Bombardier / University of Queensland
R2.3.4	Monitoring and control of false brinelling	Bombardier / University of Queensland
R2.4.1	Advanced steel development for rail and sleepers	OneSteel / Monash University
R2.5.1	Performance of recycled rubber inclusions for improved stability of railways	Tyre Stewardship Australia / Australasian Centre for Rail Innovation / University of Wollongong
R2.5.2	Application of geogrids for minimising track deformation and degradation under high frequency cyclic and heavy haul loading	Global Synthetics / Foundation QA / University of Wollongong
<b>Program 3 – Design, Modelling and Simulation</b>		
R3.1.2	Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system	Downer / University of Technology Sydney
R3.1.3	Predictive maintenance models for Sydney Trains	Sydney Trains / UTS
R3.1.4	Intelligent data fusion and analytics framework	Downer / Deakin University
R3.2.2	Development of a responsive passenger information system for the Sydney Trains network (stage 2)	Sydney Trains / UTS
R3.3.2	Development of a smart rail route map	Australasian Railway Association / Deakin University
R3.3.3	Reimagining the workforce: building smart, sustainable and safe public transport	Department of Transport / Victoria University
R3.4.1	Arc welding modelling	CRRC / CSIRO
R3.5.1	Battery HVAC feasibility study	Knorr-Bremse / CSIRO
R3.6.1	Experimental and computational study on the key ventilation issues affecting air quality and thermal comfort in train cabins	Airlinx / RMIT University

## Commonwealth Milestone status as at 30 June 2019

Milestone number	Milestone	Due date	Status
<b>Program 1 – Power and Propulsion</b>			
R1.1.2	Design of system hardware and/or software confirmed. IP strategy (patents/know-how/designs/software) defined	30 Jun 2018	Achieved
R1.1.3	Demonstrator built	30 Jun 2019	Achieved
R1.3.4	Evaluation and validation report approved	31 Dec 2018	Achieved
R1.3.5	Scale up and commercialisation report approved. Conduct full scale trials	30 Jun 2019	Achieved
R1.4.3	Demonstrator built	31 Dec 2018	Achieved
R1.4.4	Report approved for evaluation and validation of Demonstrator	30 Jun 2019	Achieved
R1.5.2	Commencement of 4 PhD students	30 Jun 2017	Achieved
R1.5.3	Commencement of 3 PhD students	30 Jun 2018	Achieved
R1.5.4	Completion of 1 PhD students	30 Jun 2019	In Progress
<b>Program 2 – Materials and Manufacturing</b>			
R2.1.6	Test and evaluate component and manufacturing process completed	31 Dec 2018	Achieved
R2.1.7	Final report approved and release IPR for utilisation/commercialisation. Start of Production	30 Jun 2019	Achieved
R2.2.3	Software model to predict performance completed	30 Jun 2019	Achieved
R2.3.4	Validated model for physical and predicted data	31 Dec 2018	Achieved
R2.3.5	Design and develop component and manufacturing process completed	30 Jun 2019	Achieved
R2.4.6	Test and evaluate component and manufacturing process field trials completed	31 Dec 2018	Achieved
R2.4.7	Final report approved and release IPR for utilisation/commercialisation	30 Jun 2019	Achieved
R2.5.4	Completion of 1 PhD students	30 Jun 2018	Achieved
R2.5.5	Completion of 3 PhD students	30 Jun 2019	In Progress
<b>Program 3 – Design, Modelling and Simulation</b>			
R3.1.5	Design and develop component and manufacturing process completed	31 Dec 2018	Achieved
R3.1.6	Test and evaluate component and manufacturing process field trials completed	30 Jun 2019	Achieved
R3.3.2	Provisional patent/s/publications lodged for algorithms for rail applications	30 Dec 2018	Achieved
R3.3.3	Report approved for know-how for algorithms for rail applications	30 Jun 2019	Achieved
R3.3.4	Demonstrator algorithms for rail applications and commercialisation plan completed	30 Jun 2019	Achieved
R3.4.3	Software model to predict performance completed	30 Jun 2018	Achieved
R3.5.3	Software model to predict performance completed	30 Dec 2018	Achieved
R3.5.4	Validated model for physical and predicted data	30 Jun 2019	Achieved
R3.6.6	Computer simulation of train cabin completed	31 Dec 2018	Achieved
R3.7.4	Completion of 1 PhD student	30 Jun 2018	In Progress
R3.7.5	Completion of 3 PhD students	30 Jun 2019	In Progress

## Education and training

The Rail Manufacturing CRC has continued its commitment to delivering a strong education program by supporting its students to consider future employment in Australia's rail industry.

In the past 12 months, the number of PhD students supported by the Centre has risen to a high of 48 students commencing across the Centre's industry projects, PhD scholarships and rail industry internships.

### Industry projects

As of 30 June 2019, there are 12 students actively working on industry projects:

- » Tianyi Wang and Shuoqing Zhao, both working on Project R1.1.1 - **New generation lithium-ion batteries with high energy and long service life for rail industry applications** (HEC Group / University of Technology Sydney)
- » Pauline Jaumaux, Xiaochun Gao and Yi Chen, all working on Project R1.1.2 - **Hybrid supercapacitors with high energy and power densities for rail industry applications** (HEC Group / University of Technology Sydney)
- » Zhang Yin, working on Project R1.3.3 - **High energy supercapacitor development** (CRRC / CSIRO), studying at Queensland University of Technology
- » Matthew Pozzebon and Abdul Mannan, both working on Project R2.3.2 - **Axle bearing maintenance optimisation** (Bombardier / University of Queensland)
- » Osama Brinji and Vijayaragavan Raju, both working on Project R2.3.4 - **Monitoring and control of false brinelling** (Bombardier / University of Queensland)
- » Alexander Virgona and Julien Collart, both working on Project R3.1.2 - **Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system** (Downer / University of Technology Sydney)

Chaminda Jayasuriya, who worked on Project R2.5.1 - **Performance of recycled rubber inclusions for improved stability of railways** (Tyre Stewardship Australia / Australasian Centre for Rail Innovation / University of Wollongong) submitted her PhD thesis in March 2019 and is now employed as a Research Associate at the University of Wollongong.



### PhD scholarships

Since establishing its scholarship program in 2016–17, the Centre has grown its number of PhD student scholarship recipients, with 30 students now actively working on their PhDs.

The scholarships have been granted to select students working in rail research relating to one of the Centre's three key research areas – Power and Propulsion, Materials and Manufacturing, and Design, Modelling and Simulation.

### Industry internships

Across 2016–17 and 2017–18, the Rail Manufacturing CRC and TrackSAFE Foundation delivered a PhD internship program, where two PhD students from Queensland University of Technology participated in a 12-week paid level crossing-related internship with rail organisations Queensland Rail and Aurizon.

One of the interns, Zheshuo Zhang, has since completed his PhD thesis in April 2019.

### Encouraging the next generation of rail employees

With an ever-increasing number of students supported by the Centre, the Rail Manufacturing CRC has continued to deliver ongoing support and guidance to its student cohort.

In March 2019, the Centre hosted its second annual PhD Students' Forum in Melbourne. The forum provided two full days for the students to build relationships, learn more about Australia's rail industry and to participate in professional development activities.

The second day introduced the Grow Your Career program, a combined face-to-face and webinar training program delivered across 2019 to upskill students to understand their personality preferences, career goals and drivers, and to develop strong LinkedIn profiles, resumes and interview career readiness skills to prepare to find work in Australia's rail industry after graduation.

In addition to this program, the students have further been supported through:

- » Industry tours of rail headquarters and job sites
- » Participation in and presentations at key rail and industry events
- » Ongoing training support and guidance

## Current list of commenced PhD students – as of 30 June 2019

Student name	Project title	Expected completion date	Research institute
<b>Program 1 – Power and Propulsion</b>			
Tianyi Wang	New generation lithium-ion batteries with high energy and long service life	Aug 2021	University of Technology Sydney
Shuoqing Zhao	New generation lithium-ion batteries with high energy and long service life	Aug 2021	University of Technology Sydney
Pauline Jaumaux	Hybrid supercapacitors with high energy and power densities for rail industry applications	Aug 2022	University of Technology Sydney
Xiaochun Gao	Hybrid supercapacitors with high energy and power densities for rail industry applications	Feb 2020	University of Technology Sydney
Yi Chen	Hybrid supercapacitors with high energy and power densities for rail industry applications	Feb 2020	University of Technology Sydney
Zhang Yin (Yin)	High energy supercapacitor development	Jan 2020	Queensland University of Technology
Sundar Shrestha	Estimation of adhesion conditions between wheels and rails for the development of advanced braking control systems	Jul 2021	CQUUniversity
Esteban Bernal Arango	Smart axle transducer transmitter for freight wagon condition monitoring systems	Jul 2021	CQUUniversity
Minoo Oveisi	A static and dynamic loading assessment of structural-critical composite material rolling stock carbody shells	Oct 2022	RMIT University
<b>Program 2 – Materials and Manufacturing</b>			
Cameron Milne	Axle-bearing maintenance optimisation	N/A <sup>1</sup>	University of Queensland
Matthew Pozzebon	Axle-bearing maintenance optimisation	Oct 2019	University of Queensland
Abdul Mannan (Mannan)	Axle-bearing maintenance optimisation	Jul 2022	University of Queensland
Osama Brinji	Monitoring and control of false brinelling	Jul 2020	University of Queensland
Vijayaragavan Raju (Vijay)	Monitoring and control of false brinelling	Jun 2022	University of Queensland
Chamindi Jayasuriya	Performance of recycled rubber inclusions for improved stability of railways	Completed	University of Wollongong
Chuhao Liu	The performance of stabilised ballast in rail tracks	Oct 2020	University of Wollongong
Mahsa Taherimandarjani	Laboratory evaluation of laser cladding on rail wheel steels	Apr 2022	Swinburne University of Technology
Meng Wang	Manufacturing of lightweight panels	Jan 2022	Swinburne University of Technology
Fukun Xia	Evaluation of hybrid structures for impact performance in rail applications	Dec 2021	Swinburne University of Technology
Vu Trong Thien (Terence)	Automated assembly for rolling stock fabrication in rail industry	Aug 2020	University of Wollongong
Hang Su	Optimisation of rail welding process parameters to mitigate rolling contact damage	Sep 2020	Monash University
Pravin Urudra	Evaluating the suitability of laser clad rail steel in heavy haul application	N/A <sup>2</sup>	Monash University
Simon Wagner	Heavy haul train force control product	May 2022	CQUUniversity
Elias Salloum	Optimising friction-stir welding and alloy design to ensure the durability of light weight carriages in the rail fleet	Feb 2022	RMIT University

<sup>1,2</sup> This student withdrew from his PhD

Student name	Project title	Expected completion date	Research institute
<b>Program 2 – Materials and Manufacturing</b>			
Mohammad Adinehrand	Miniature crawling robots for rolling stock manufacture and maintenance	Nov 2022	RMIT University
Anthony Micheletto	Improvement of flashbutt welds in premium rails	Apr 2021	Monash University
Tommy Huynh	Fire-retardant and lightweight composite materials for rolling stock carriages	Dec 2022	RMIT University
Panahsadat Fasihi	Full-scale implementation of a new wheel-rail maintenance technology by using laser cladding	Nov 2021	Monash University
Don Kushlani Ranmal Ransinghe	Optimal design of raised rail - road crossing structure	N/A <sup>3</sup>	Queensland University of Technology
Zheshuo Zhang	Effect of raised rail - road crossing to the safety of road vehicles	Completed	Queensland University of Technology
<b>Program 3 – Design, Modelling and Simulation</b>			
Alexander Virgona	Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system	Oct 2019	University of Technology Sydney
Julien Collart	Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system	Jan 2020	University of Technology Sydney
Mahdi Saki	Ultra-reliable and cost effective communication infrastructure for future IoT-based railway applications	Sep 2023	University of Technology Sydney
Zhibin Li	Big data analytics for condition based monitoring and maintenance	Mar 2021	University of Technology Sydney
Huaxi Huang	Rail infrastructure defect detection through video analytics	Apr 2022	University of Technology Sydney
Amir Eslami	Drive-by bridge inspection: the use of instrumented revenue wagons for structural health monitoring of rail bridges	N/A <sup>4</sup>	Monash University
Yu Fung Lee (Joseph)	Nonlinear vibro-acousto-ultrasonic waves for fatigue cracking detection in key rail components	Jun 2020	Monash University
Chi Hei Vong (Calvin)	Control and navigation of micro UAV in small railway culverts and tunnels	Jul 2020	Monash University
Yong Pang	System for real-time monitoring and sensing railway conditions by laser light	Aug 2020	Monash University
Dongyu Zhang	Hybrid unmanned aerial system for railway inspection	Oct 2020	Monash University
Nalin Randeniya	Train maintenance training enhancements with transformative technologies for productivity and quality measures	Jun 2021	Swinburne University
Andrew Danylec	Develop and establish augmented reality tools in High Capacity Metro Train for productivity and quality enhancements	Jun 2021	Swinburne University
Wenhua Jiang	Short-term rail passenger flow forecasting application	Jan 2021	Monash University
Don Skerman	Efficient daily track monitoring system	Oct 2022	CQUUniversity
Jie Yang (Joanne)	Optimising railway carriage design for improved dispersion, capacity and safety	Jun 2022	RMIT University
Bibek Baral	FEM modelling of vacuum consolidation to alleviate visco-plastic strains in soft subgrade soils	Oct 2021	University of Wollongong
Peter Allen	Impeding pedestrian-train collisions using safety by design principles	Aug 2021	Swinburne University
Alejandro Tamani	Development of evacuation management tool for rail transport	Nov 2022	RMIT University

<sup>3</sup> This student withdrew from her PhD<sup>4</sup> This student withdrew from his PhD and reverted to Masters

# Exit report

The Rail Manufacturing CRC will wind-up on 30 June 2020 at the end of its six-year Commonwealth funding period. In the final months of operation, the Centre will actively work with its Research and Industry Participants to ensure the successful completion of activities.

During its lifespan, the Rail Manufacturing CRC has delivered new technologies and knowledge to the sector, and built an awareness about the importance of R&D in the Australian rail manufacturing environment.

By fostering strong working relationships between Industry Participants and publicly-funded research agencies, it is hoped that these partnerships, nurtured by the Rail Manufacturing CRC since commencement, will serve the sector for many years to come.

This exit report summarises the Rail Manufacturing CRC's impact to date. This report will be updated and finalised in the Centre's last Annual Report for the 2019–20 Financial Year.

## Direct economic benefits achieved

Since establishing in 2014, the Rail Manufacturing CRC has worked consistently to identify project opportunities that have the potential to provide tangible benefits to the rail industry. This has resulted in the development of the following four products to-date:

### Dwell Track™

Licensed by Downer and patented by the University of Technology Sydney, Dwell Track™ uses 3D imaging cameras, algorithms and software to track passenger numbers and movement at station platforms. The core application of Dwell Track™ is to reduce the length of time it takes passengers to embark and disembark from a train, optimising passenger flow through monitoring and automated actions. With a trial now underway with rail operator Sydney Trains, data collected will be used to further build upon the technology developed. Following this major trial, the aim is for Dwell Track™ to be commercially available to assist rail operators to improve platform management procedures, reduce train dwell times and potentially increase the capacity of their train services – see case study on page 18.

### Smart Rail Route Map

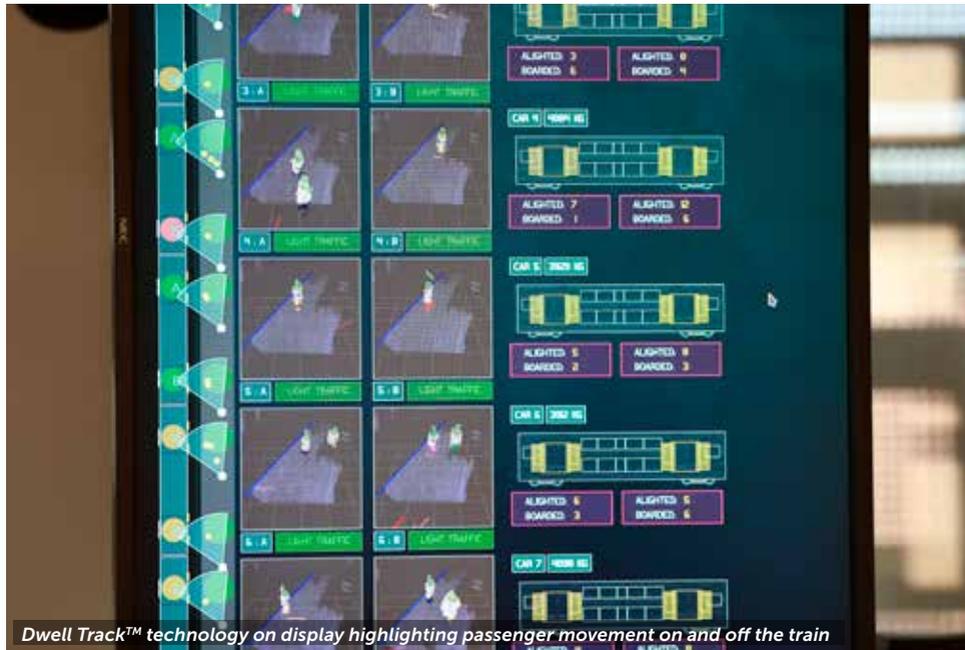
Working with the Australasian Railway Association and Deakin University, this technology road map provides priorities for the rail industry in developing initiatives and programs for the integration of the next-generation of digital and telecommunications technologies. Following the release of the Smart Rail Route Map, a Smart Rail Executive Committee has been formed comprising of key representatives from the rail sector to develop strategies for implementing the priorities.

### Axle bearing wear modelling software

The Rail Manufacturing CRC collaborated with Bombardier and the University of Queensland to predict the wear rates of axle bearings used in suburban passenger trains. The software model predicts bearing life through algorithms developed for lubrication and bearing wear. This enables Bombardier to optimise the bearing selection, lubrication and overhaul maintenance schedule with significant economic benefits due to bearing life management and integration with other overhaul activities – see case study on page 19.

### Arc welding modelling software for rail

This project was a partnership with CSIRO and CRRG to develop a user-friendly computer program to predict the properties of rail component welds. The software allows accurate prediction of the heat transfer to the welded metal for a wide range of parameters, which is expected to greatly reduce the number of experimental tests required in developing weld designs for rolling stock fabrication. The implementation of the software produced will result in large savings in staff time and result in significant productivity improvements. Moreover, optimised weld parameters can save expenditure on consumables such as shielding gases, while also providing assurance to the high quality of the weld.



*Dwell Track™ technology on display highlighting passenger movement on and off the train*



*Professor Paul Meehan working with a sample axle bearing from Bombardier*

## CASE STUDY

### Understanding passenger congestion

Efficient movement of passengers across a network is at the core of any transport network. Central to this is reducing dwell time, the total period the train remains stationary at the platform for door operations and passenger motion (embarking and disembarking).

In early 2015, the Rail Manufacturing CRC partnered with the University of Technology Sydney and Downer on Project R3.1.2 - **Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system** to fund the development of Dwell Track™, a tool capable of detecting key dwell events relating to train and passenger movements in crowded environments.

Using spatial data, Dwell Track™ leverages advances in 3D camera technology combined with algorithms to identify passenger movement and numbers in a crowd.

Dwell Track™ determines train door positions, door status, passenger counts and the direction passengers are moving, all of which supports the more efficient management of passengers. The technology also provides rail operators with the capability to generate and analyse data to influence passenger behaviour in real-time, while also further developing and testing strategies for long-term dwell time management.

## CASE STUDY

### Axle bearing wear

For operators and maintainers, effectively balancing maintenance requirements with operational availability and cost is an important aspect of asset management. Understanding bearing durability through informed bearing and lubricant selection, life prediction and maintenance practices can have considerable impact on operational performance.

Commencing in 2015, Bombardier and the University of Queensland started work on Project 2.3.2 - **Axle-bearing maintenance optimisation** to investigate the wear and degradation of the axle bearings used in a suburban fleet for passenger transport, with an aim to predict the wear and optimise the lifespan of the bearings.

In this project, a model and tool were created to predict bearing wear by selecting lubricant and operational parameters, with a goal to extend the life of bearings performing well below their fatigue threshold.

Due to the collaboration between academic researchers and the rail industry, facilitated by the Rail Manufacturing CRC, this work provided a validated predictive model to optimise axle bearing maintenance over rolling stock fleet lifetime.

Value statements from Rail Manufacturing CRC Industry Participants

“RMCRC has opened up multiple new opportunities for Airlinx to explore different Industries which have HVAC (heating, ventilation and airconditioning) demand. Throughout our project, the research has been monitored, and the milestones have been checked and reported. We know our investment in R&D has been professionally handled, and all of these events have helped Airlinx to progress and understand the trends of manufacturing, what data is useful and what is not. With the forum and conference meetings, RMCRC has enabled us to focus on our company’s bigger picture, which made decision making simpler.”

Joanne Xia, Accountant – Airlinx



“Our work with the RMCRC has connected Downer with highly capable experts in academia, helping us build long-term collaborative partnerships to solve complex problems in the rail industry. From increased efficiencies in maintenance with data analytics platform TrainDNA, to improving the customer experience by mapping dwell time at stations, the solutions developed through the RMCRC have resulted in real, tangible benefits to our business.”

Tim Young, Executive General Manager Rolling Stock Services – Downer



“Identifying suitable partners, developing and funding R&D can be a difficult task for companies, in particular for those without dedicated local functions to do this. The Rail Manufacturing CRC has been a success for Knorr-Bremse by helping connect us to appropriate research partners and supporting us to ensure projects are successfully completed. We have undertaken four projects that have added real value to our business, ranging from feasibility studies for new product concepts to product testing regimes, and new and innovative product development.”

Michael McLellan, Managing Director – Knorr-Bremse Australia



“The HEC Group is a multinational company, and we’re working with the Rail Manufacturing CRC on our first two R&D projects in Australia. From an industry perspective, the most important focus is always identifying those real research outcomes that can be commercialised. With our first fundamental research project to develop lithium batteries, we’ve done nearly two and a half years of a three-year long project. So far, the UTS and HEC research teams have worked very hard together and are now starting to see some commercialisation benefits. I think we’ve got a great relationship with the Rail Manufacturing CRC, who has provided a lot of connection, both with the strategic, overall push for projects, as well as the day-to-day monitoring and support.”

Steven Wan, CEO – HEC Group Australia



Participants



UNIVERSITY OF WOLLONGONG AUSTRALIA



## The impact of education

Since establishing in 2014–15, the Rail Manufacturing CRC has supported the commencement of 48 students, with two PhD thesis submissions so far.

### Number of PhD students

48 students supported through industry projects, scholarships or internships, with:

- » 42 PhDs currently underway
- » The submission of two theses
- » Four students withdrawn

### Industry employment

Of the two students who have completed their theses, the Rail Manufacturing CRC is aware that one student has taken a University Research Associate position and the other student is seeking a rail industry position in Australia.

Of the students who withdrew, three are currently employed in manufacturing/engineering positions in Australia.

### Student supervision

- » 32 university supervisors from nine universities
- » Mentoring and internship programs run with six industry organisations.

In the past five years, the Centre's PhD candidates have been diligently working on a wide range of cutting-edge rail research projects, including real-time condition monitoring, using drones for infrastructure assessment, laser cladding technologies, augmented and virtual reality for training, big data analytics and automated assembly of rolling stock fabrication.

With less than one per cent of scientists and researchers working in rail<sup>5</sup>, it is vital to promote the industry as an attractive employment prospect, while also recognising the innovative skills that these highly trained students could bring to Australia's future rail industry.

To encourage the Centre's students to consider a career in rail after graduation, a variety of supporting initiatives have been delivered by the Rail Manufacturing CRC. This has included annual PhD students' forums with guest presentations from senior rail industry representatives, student tours of industry headquarters in Melbourne, Sydney and Brisbane, the trial of a mentoring program to match students with rail industry representatives, and the rollout of a Grow Your Career job and research readiness training program to build the students' skills in communicating research results, using LinkedIn, developing resumes and cover letters, and conducting interviews.

<sup>5</sup> ACIL Tasman, Railway Manufacturing Industry: A profile of the Railway Manufacturing Industry, prepared for the Department of Innovation, Industry, Science and Research, July 2011.

## Education and training programs in areas of skills shortage

A strong, efficient and modern rail industry is an important element of Australia's transport infrastructure future. With Australia's vast geography and distance from the sites of resource production to ports, coupled with high levels of urban congestion in growing cities, the country's future prosperity and productivity is dependent on a strong rail industry sector.

The rail industry is facing significant technological challenges including new manufacturing processes, automation and advancements in materials technologies. The sector can take advantage of these challenges by:

- » forging new alliances and collaboration to increase the rate of domestic innovation
- » upskilling the rail industry to include managers and staff that have a broad understanding of the current Science, Technology, Engineering and Mathematics (STEM) landscape
- » working to attract a younger and more diverse workforce
- » collaborating with a broader cross section of the transport and research sectors to gain a more holistic view of future innovation and economic opportunities.



Students participating at Melbourne PhD Students' Forum in March 2019



University of Wollongong PhD student Chuhao Liu has achieved multiple awards for his PhD pitching

## CASE STUDY

### The power of pitching

A PhD student's ability to communicate their research clearly and powerfully can determine their future. Often brilliant in their field of research, this doesn't always show when communicating the topic to prospective employers, a funding body or even a colleague.

Working with external trainers, the Centre's PhD students participated in PowerPitch training to learn how to write and deliver an engaging three-minute pitch about their PhD research. Throughout 2018, six of the PhD students were also given the opportunity to deliver their pitches to industry and university representatives attending the Rail Manufacturing CRC Participants Forums held in Sydney and Melbourne.

The Centre's students also had the chance to enter the CRC Association's Early Researcher Showcase competition in 2018. University of Wollongong student Chuhao Liu was selected as a finalist to present a five-minute pitch about his research during the conference, alongside five other PhD students working on other CRC-related research.

Chuhao's passionate, energising and funny pitch was selected as the winner by the 200 strong audience, and he was awarded his prize at the CRC Association's gala dinner in May 2018. He was also crowned overall winner of University of Wollongong's Three Minute Thesis competition that year, going on to compete in the Asia-Pacific 3MT Competition finals at the University of Queensland in September 2018. In September 2019, Chuhao was also selected as a finalist in the AusRail Young Professionals pitching competition.

## Value statements from Rail Manufacturing CRC Research Participants

"CSIRO has been working with the Rail Manufacturing CRC on a variety of projects spanning many years. Our partnership with RMCRC has enabled us to better engage with the rail industry both locally and internationally and help to position Australia as a world leader in rail manufacturing research and development.

Through our projects together – and by harnessing the industry connections RMCRC has helped to broker – we have increased train network productivity, enhanced safety and improved performance. CSIRO and Australian industry are now well positioned to improve global rail operations for generations to come."

**Keith McLean**, Director Manufacturing – CSIRO



"UTS currently participates in eight CRCs, we see them as an excellent platform for delivering high impact from our collaborative research with industry. UTS enjoys a very productive relationship with the Rail Manufacturing CRC with a number of valuable research outcomes having been created through the collaborative research projects undertaken. It is particularly pleasing to note that these projects span across different discipline areas showing how the Rail Manufacturing CRC appeals to a wide range of industry interests and that UTS researchers work together to bring a diversity of expertise and perspectives to bear to meet those demands.

UTS strongly values the relationship it has developed with the Rail Manufacturing CRC. This can be attributed to having open channels of communication with the CRC team, so that irrespective of whether projects are progressing well, or if for some reason have stalled, it's always easy to have those helpful transparent and pragmatic conversations and to work together to deliver valuable outcomes. With the Rail Manufacturing CRC, those conversations are very easily facilitated, especially when they are done in a spirit of seeking solutions."

**Kate McGrath**, Deputy Vice-Chancellor (Research)  
– University of Technology Sydney



## Snapshot summary

**Major achievements**

- » Dwell Track™ passenger tracking technology patented, trademarked and trialled by the Sydney Trains rail network, commencing in August 2019
- » Projects between CSIRO and CRRC resulted in key gains in supercapacitor technologies and impending commercial trials of the developed energy management system
- » Arc welding software used by CRRC enabling optimised welding parameters to be determined
- » Bombardier and University of Queensland axle bearing projects providing the ability to understand wear and maintenance cycles of bearings, where optimised maintenance cycles are projected to provide a substantial return on project investment
- » The Smart Rail Route Map process brought together rail industry leaders to develop a digital roadmap for the next 30 years and to support the implementation of solutions through an industry-led steering committee
- » Airlinx has completed computational fluid dynamics modelling on air conditioning diffusers and airflow in train cabins to develop a model for improved thermal and air quality properties

**Research**

- » Research in the manufacturing processes and durability of rail components has focussed on protective coatings, stability of ballast, laser repair, new brake materials and enhanced welding processes
- » Development of new battery materials, cell properties and energy management systems to progress the commercial viability of energy storage systems in the rail sector
- » Technology, processes and design to reduce dwell time at train stations, including in the patent of Dwell Track™ technology
- » Advanced techniques for assessing rail infrastructure and rolling stock condition using unmanned aerial vehicles, sensors and predictive algorithms
- » Manufacturing and maintenance process efficiency using robotics, and virtual and augmented reality

**Commercialisation and utilisation**

- » All commercial outcomes and Intellectual Property terms and conditions are determined at project commencement, limiting any potential IP legacy issues in future years
- » Completion of projects in areas including supercapacitor development, axle bearing modelling, responsive passenger information systems and smart rail route mapping
- » Development of new battery and supercapacitor materials with far-reaching applications in rail, including potential use in the development of hybrid trains or catenary-free tram systems
- » Optimisation of maintenance and overhaul requirements for rolling stock by examining methods to model and predict lubrication needs, which may enable considerable financial and time savings for Australian passenger rail fleet operators
- » Following technology trial by Sydney Trains, it is anticipated that Dwell Track™ passenger tracking technology will be available to the Australian market through Downer
- » The use of cold spray to maintain and prolong coupler lifetime

**SME engagement**

- » Seven SME organisations participating in industry projects
- » Employment of a Business Development Manager in the Centre's early stages to specifically engage with SMEs
- » Proactive engagement with SMEs through Participants forums, key rail conferences, rail peak body events, and Federal and State Government forums
- » Regular strategic and tactical communications shared via recurring events, newsletters, website and social media updates, and face-to-face project meetings

**Education and training**

- » 48 PhD students supported in Centre lifetime across industry projects, scholarships and internships
- » To-date, two thesis submissions
- » Three students participating in an industry mentorship program trial
- » 40 students attending tours of industry headquarters across Melbourne, Brisbane and Sydney
- » Two PhD students' forums held
- » Six students pitching their research during rail industry events
- » Professional development training rolled out in Power Pitching and Grow Your Career job and research readiness program

**Spin-off companies and inventions**

- » Trademarked by Downer and patented by the University of Technology Sydney, Dwell Track™ dwell time technology trialled by Sydney Trains network
- » University of Queensland's development of a software model and tool to extend the life of bearings operating well below their fatigue threshold
- » CSIRO and CRRC arc welding modelling software to predict the properties of rail welds, where accurate predictions are expected to greatly reduce the number of experimental tests required when developing weld designs for rolling stock fabrication

**International engagement**

- » Meeting with leading international rail organisations during participation in two Australian contingent visits to InnoTrans in 2016 and 2018
- » Site visits to MTU Engines in Germany, Swiss company Stadler in Switzerland and the HEC Group in China
- » Regular visits between CSIRO in Melbourne and Sydney and CRRC in China to support information transfer and the testing of supercapacitor technologies
- » Involvement in international events representing Chinese, Spanish and Indian rail conglomerates
- » Ongoing engagement with new international entries to the Australian rail industry
- » Delivery of eight projects with leading Chinese manufacturer CRRC, and working with multinational company HEC Group on its first two R&D projects in Australia in battery and supercapacitor development projects
- » CSIRO Researcher Dr. Marzi Barghamadi awarded an Endeavour Research Fellowship to work at Münster Electrochemical Energy Technology in Germany for three months to learn about Li-ion battery manufacturing
- » Monash University PhD student Wenhua Jiang studying at Massachusetts Institute of Technology (MIT) for six months in her research focus area of passenger flow forecasting



**Rail Manufacturing CRC Ltd.**

ABN – 14 600 249 518

PO Box 273

Flemington Victoria 3031

Australia

Ph: +61 3 8589 7112

[www.rmcr.com.au](http://www.rmcr.com.au)