

Annual Report 2017–18
Rail Manufacturing CRC





Vision

To assist the Australian rail manufacturing sector to develop industry-led R&D solutions to industry-identified challenges, to encourage innovation and to foster increased engagement in the global supply chain.

Mission

To assist the rail manufacturing supply chain to develop new technologies and products to increase productivity and play a key part in attracting and supporting the next generation of highly qualified engineers and scientists to bring their skills and talent to the rail industry.

Strategic intent

To foster, sponsor and direct collaborative research and commercialisation partnerships between key stakeholders in the rail manufacturing sector.



Australian Government
**Department of Industry,
Innovation and Science**

Business
Cooperative Research
Centres Programme

Front Cover: Melbourne's trainline towards the CBD.

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Message from the Chair and MD

This annual report covers the fourth year of operation for the Rail Manufacturing Cooperative Research Centre (CRC).

During the past year, the Rail Manufacturing CRC has continued to deliver excellence in research, technology and capability improvements for the rail industry in collaboration with our research institutions and industry partners.

Australia's commitment to rail

Since commencing in 2014, the Rail Manufacturing CRC has witnessed many changes to the Australian rail sector. The plateauing of the heavy haul mining sector, the exceptional growth of passenger rail projects and the ongoing global restructuring of traditional and large rail manufacturing organisations (through mergers and acquisitions) have all influenced the demand for research and development (R&D) activities within Australia and subsequently within the Rail Manufacturing CRC's program of work.

Despite these changes in approach, the long term future for the rail sector continues to look positive. In its 2018 National Rail Program Budget, the Australian Federal Government committed to funding \$4.9 billion of rail projects, including:

- » a rail link to Melbourne's airport
- » support and further development of Perth's new Metronet transportation system
- » a variety of new line constructions, upgrades and business cases delivered across Victoria, Queensland, South Australia and New South Wales.

Investments are also strong at the state level, with the NSW Government to spend over \$648 million to improve the accessibility and capacity of state-wide train services, and the Victorian Government to invest \$1 billion in metropolitan public transport improvements and rail line upgrades.

These commitments provide Australian rail manufacturers with a sustainable pipeline of work to assist in long-term workplace and R&D activity planning, with the Rail Manufacturing CRC continuing its support by funding industry-led R&D projects and helping to develop the next generation of highly skilled, research-trained rail employees.

Project highlights this year

The 2017–18 Financial Year has again been one of continued growth for our Centre and the Australian rail manufacturing sector as a whole, resulting in strong progress for a number of the Rail Manufacturing CRC's inaugural projects, as well as the commencement of seven new projects in the last year.

Some of the Centre's projects starting to yield commercial outcomes include:

- » the development of a prototype energy management system to power supercapacitors, designed by CSIRO for industry organisation CRRC
- » the launch of DwellTrack, a passenger tracking system, delivered by the University of Technology Sydney and Downer
- » the ongoing development of bearing monitoring systems for Bombardier, undertaken by the University of Queensland
- » the expansion of our heating, ventilation, and air conditioning (HVAC) project portfolio with industry leader Knorr-Bremse Australia
- » the extension of our train cabin airflow modelling project with Airlinx and RMIT University.

We are especially fortunate to have the ongoing support and commitment from some of Australia's best research institutions. Throughout the rail industry's recent difficulties, our research institutions have provided unwavering support, first class performance and regular proposals for new R&D initiatives that have helped our Centre to continue to meet its commitments.

Our research remains of the highest quality from a scientific standpoint and continues to deliver real commercial impact for our industry partners. This, coupled with on-time and on-budget performance, provides us clear acknowledgement that we are providing the appropriate balance of outcomes for our participants.



Education is the future

The Rail Manufacturing CRC has continued to foster and grow our education program, with the Centre supporting 34 PhD students, through industry projects, scholarships and internships, since establishing in 2014.

This number of students now exceeds the originally agreed obligation of 30 students during the lifetime of the Centre, plus with two years still to go, opportunity still exists to increase student numbers further.

Our PhD candidates are working on a wide variety of industry-leading rail research projects, including real-time condition monitoring, using drones for assessment, laser cladding technologies, augmented and virtual reality for training, big data analytics and automated assembly of rolling stock fabrications.

These students are committed, keen and excited to engage with the rail industry during their studies, and many have expressed intent to join Australia's rail industry post-graduation. Our PhD scholarship program would not be possible without the continued support of our university participants, who we thank for their commitment and joint funding.

Determining the future of the Rail Manufacturing CRC

With the Rail Manufacturing CRC now more than halfway through its six year lifespan, this year has been critical in determining the future of our Centre. To identify next steps and to ensure a full set of projects are in place for the remaining two years, we have conducted an in-depth, strategic review of the projects in progress, expected follow-on business from current activities and prospects for new projects.

The review, which included an analysis of the current state of Australia's rail industry, also provided the basis for an examination of future options for continued activities.

We remain optimistic that the projects the Centre has in progress, and the anticipated renewed enthusiasm of the industry to invest in local R&D, will provide the basis for continued partnerships between Australian rail businesses and universities, alongside potential CRC-P opportunities in the future.

Recognition of our team and supporters

As always, thank you to our Board of Directors and the Rail Manufacturing CRC's Management team for their resolve, energy and dedication.

The Rail Manufacturing CRC also acknowledges the ongoing support of our industry participants who continue to engage with the Centre and our activities. The last six months have seen extensive growth in the approval of new projects and the development of new research proposals by a number of our major industry participants – it is heartening to see the increasing levels of collaboration between researchers, academia and industry.

Thank you also to industry peak bodies including the Australasian Railway Association, TrackSAFE Foundation, Rail Industry Safety and Standards Board and the Advanced Manufacturing Growth Centre for their ongoing support in providing invaluable information sharing, collaboration and participation throughout the year.

These combined efforts have underpinned our continued success and provided exciting new opportunities for Australia's rail manufacturing industry that we look forward to continuing to foster in the coming two years.

A handwritten signature in black ink, appearing to be 'P. Johnson'.

Paul Johnson MBE
Chair – Rail Manufacturing CRC

A handwritten signature in black ink, appearing to be 'S. Thomson'.

Dr Stuart Thomson
CEO – Rail Manufacturing CRC

Keeping the Centre *on track*



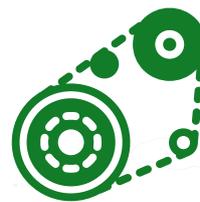
Fourth year
of operation



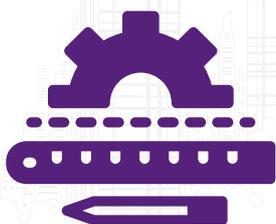
**25 Essential
and Other Participant**
organisations committed



41 Rail Manufacturing CRC
projects currently underway
– 18 industry projects and 23 scholarships



\$42M available to fund rail
innovation projects



34 students
supported in the Centre's lifetime

The Rail Manufacturing Cooperative Research Centre (CRC) drives the development of new products, technologies and supply chain networks to enhance the competitiveness, capacity and productivity of Australia's rail manufacturing industry.

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

The Rail Manufacturing CRC currently has 41 active projects underway, and five projects completed. These projects focus on work in areas such as battery and supercapacitor development, new braking technologies, bearing maintenance optimisation, the use of new manufacturing materials, integrated passenger tracking, train operations diagnostics and improvements to train cabin ventilation.

Funded jointly by participating rail organisations and the Australian Federal Government's Department of Industry, Innovation and Science under its Business Cooperative Research Centres Programme, the Rail Manufacturing CRC has a six year lifespan, finishing up at the end of the 2019–20 Financial Year.



Australian Government
**Department of Industry,
Innovation and Science**

Business
Cooperative Research
Centres Programme

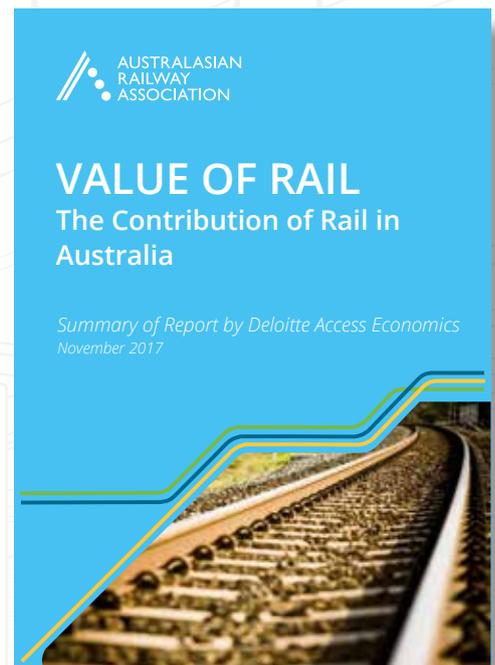
The value of Rail Manufacturing

"Rail manufacturing is an important component of Australia's rail industry, where it works as part of the global rail supply chain. The rolling stock manufacturing industry has revenue of just over \$3 billion a year and a value added of \$825 million.

This industry supports around 4,000 FTE workers. Rail manufacturing has a strong regional presence – a significant proportion of activity occurs in regional cities and towns.

According to the 2011 ABS census, 46 per cent of Railway Rolling Stock Manufacturing and Repair Services employment is outside of the eight capital cities. This is significant and makes rail the third most regionally concentrated industry in Australia – after agriculture and mining."

Excerpt from Value of Rail Report, prepared by Deloitte Access Economics for the Australasian Railway Association – available to view at ara.net.au/value-of-rail.



Executive summary

Achievements



Research and collaboration

In its fourth year of operations, the Rail Manufacturing CRC's research program has started to see commercial success across its projects, with a number of outputs now starting to be investigated or implemented by the rail industry.

The high degree of end-user collaboration within projects this year has been particularly pleasing, clearly highlighted in Project R1.3.4 - **Supercapacitor energy management system stage 2** (CRRC / CSIRO). For this project, CSIRO has developed and transported a prototype full-sized energy management system unit to China for the CRRC project team to replicate and test in their purpose-built facility.

Another key success is shown in Project R3.1.2 - **Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system** (Downer / University of Technology Sydney), where the commercialisation of the project's outputs has resulted in the development of a technology prototype for a responsive passenger information system called DwellTrack.

Seven new project agreements were executed in 2017–18:

- » Project R1.1.2 - **Hybrid supercapacitors with high energy and power densities for rail industry applications** (HEC Group / University of Technology Sydney):
With hybrid supercapacitors having the potential to eventually form a large part of the energy storage market, this project is looking to develop a supercapacitor with an enhanced energy density through changes to cell chemistry.
- » Project R1.5.1 - **Aluminium matrix composite brake discs** (CRRC / CSIRO):
This project enables the Rail Manufacturing CRC to develop expertise in the important area of advanced braking. For this project, advanced composite materials will be investigated to determine the potential for improved wear and heat dissipation from rail braking systems.
- » Project R2.1.1 - **Platform gap** (Downer / Monash University):
Focused on issues surrounding platform gaps at train platforms, this project is investigating the use of a dynamic polymer-based solution to bridge the gap between the train and the platform.
- » Project R2.1.2 - **Protection of cast steel coupler from corrosion by cold spray** (CRRC / CSIRO):
This project is researching the potential for cold spray technology to increase the durability of couplers.



Commuters travelling on the Sydney Trains network

- » Project R3.3.2 - **Development of a smart rail route map** (Australasian Railway Association / Deakin University):

This project is working to identify a long term vision for digital and communications technology in the rail industry over the next 30 years with a common view of priorities, themes, timelines and actions.

- » Project R3.4.1 - **Arc welding modelling** (CRRC / CSIRO):

The use of advanced algorithms to develop a user-friendly computer program that will predict the properties of metal inert gas (MIG) and tungsten inert gas (TIG) welding.

- » Project R3.5.1 - **Battery HVAC feasibility study** (Knorr-Bremse / CSIRO):

A feasibility study used to scope a larger potential project for heating, ventilation and air-conditioning (HVAC) systems.

Commercialisation and utilisation

The Rail Manufacturing CRC's model for commercialisation and utilisation was developed in close consultation with its industry and research participants, with an overarching principle to support and facilitate industry-led research outcomes in an independent manner.

The commercialisation model limits the number of organisations seeking input into commercial decisions, and ensures that industry and research participants investing in the project will receive benefit from any commercial returns.

Before projects commence, all commercial outcomes and Intellectual Property (IP) terms and conditions are determined through transparent contractual negotiations, which limits any potential IP legacy issues in future years.

As of June 2018, two Rail Manufacturing CRC projects were completed during the year:

- » Project R3.2.1 - **Development of a responsive passenger information system for the Sydney Trains network** (Sydney Trains / University of Technology Sydney)
- » Project R3.3.1 - **Detection and monitoring on trains - feasibility study** (Knorr-Bremse / University of Technology Sydney)

Both of these projects will enable the two participating industry organisations to undertake future activities with much deeper insights into the background technology involved.

To assist with potential commercialisation activities, Project R2.3.2 - **Axle bearing maintenance optimisation** (Bombardier / University of Queensland) was extended during the year to broaden the scope of work and bearings being assessed.

The Utilisation Plans developed during the reporting period for relevant projects have resulted in almost all Utilisation milestones being completed (see page 35).

Education and training

The Rail Manufacturing CRC has again delivered a strong effort in supporting the next generation of research-trained employees to join Australia's rail industry.

The past year has seen another large increase in the number of PhD students supported by the Rail Manufacturing CRC. Since commencing in 2014, 34 PhD students have now been supported by the Centre across three student programs – industry-led projects, rail PhD scholarships and internship placements.

At the end of 2017–18, there are now seven¹ PhD students participating in industry-led projects, 23² PhD scholarship students currently working on rail research projects and two PhD students who participated in a paid 12-week work placement at Queensland Rail and Aurizon in 2016–17 and 2017–18.

To encourage the Centre's PhD students to consider a career in rail after graduation, a variety of supporting initiatives have been delivered to provide information sharing, relationship building and induction into Australia's rail industry. This support includes:

- » hosting the inaugural Rail Manufacturing CRC PhD students' forum in January/February 2018
- » scheduling student tours of industry headquarters in Sydney and Brisbane
- » inviting PhD students to attend and present at Rail Manufacturing CRC Participants Forums
- » the rollout of a trial mentoring program to match students with rail industry representatives for support and guidance.

There are four active education-related milestones, all of which are currently in progress (see page 26).

¹ This total does not include one industry PhD student who withdrew from a project.

² This total does not include one scholarship PhD student who withdrew from a project.



University of Queensland researchers working on an axle bearing maintenance project



Speed networking underway at PhD students' forum

Risks and impediments



The Rail Manufacturing CRC continues to work with its current and prospective participants to develop projects that create positive impact for the rail organisations involved, as well as Australia's broader rail manufacturing industry as a whole.

During the last 12 months, the Rail Manufacturing CRC has continued to assess the Centre's participant list, review and grow the project portfolio, consulted with its participants, and sought to instigate new projects with current and new participants.

The key risks to the Rail Manufacturing CRC primarily relate to the slow uptake of projects by industry in the initial years of the Centre that were related to:

- » the downturn in commodity prices, thereby affecting demand for heavy haul equipment and supporting R&D
- » the increased demand in passenger rail manufactured products resulting from recently announced State Government tenders
- » organisational restructures that have occurred within the majority of industry participant businesses, subsequently resulting in delays or modification to their R&D strategies.

As detailed in last year's annual report, the Centre has focused on mitigating the risks associated with the abovementioned economic and corporate issues by:

- » developing new projects with current and potential participants
- » increasing the project portfolio focus on passenger rail projects
- » increasing engagement with the postgraduate community via specialised scholarships
- » working with industry peak bodies, such as the Australasian Railway Association, the Rail Industry Safety and Standards Board and TrackSAFE Foundation to engage and inform the rail manufacturing industry.

By continuing to focus on these strategies, the Rail Manufacturing CRC has been able to better meet its performance against Commonwealth Milestones, improve engagement with research and industry participants and develop closer ties with Australia's key rail industry peak bodies.



Waiting for a train at Melbourne's Flinders Street station

Recent achievements

By implementing the above strategies, the Centre's 2017–18 achievements include:

- » the increased financial support of additional PhD students, with 34 now supported since the Centre commenced operations in 2014
- » a second major project with the HEC Group commencing: Project R1.1.2 - **Hybrid supercapacitors with high energy and power densities for rail industry applications** (HEC Group / University of Technology Sydney)
- » three new projects with CRRC initiated in the last year, spread across the Centre's three research themes – *Power and Propulsion, Materials and Manufacturing, and Design, Modelling and Simulation*
- » the commitment of Downer to a new project focusing on disability access to metro train platforms: Project R2.1.1 - **Platform gap** (Downer / Monash University)
- » a number of new project agreements with Knorr-Bremse and Downer now being finalised and set to commence in 2018–19
- » Sydney Trains in negotiations to undertake a second research project with the Rail Manufacturing CRC.

The risks associated with any research and development entity in the manufacturing sector are typically dependent on the global economic environment, domestic and international demand for manufactured products, the nature of competitive global supply, the general level of confidence within the sector, and the capacity of domestic manufacturers to invest in research, innovation, capital equipment and human resources.

The Rail Manufacturing CRC has not been immune to such external factors, but has managed to navigate through these difficult times by changing focus from freight-related to passenger-focused projects, continuing to engage with companies during restructures to build and maintain long-term relationships, and assisting companies to identify their needs in securing the next generation of staff.

The Centre's capacity for flexibility and its close working relationship with its participants has enabled the Rail Manufacturing CRC to continue to gain momentum over the last four years and to progress the benefits of innovation within the rail manufacturing sector.

There have been some setbacks this year – following protracted contractual disputes, Simplex Factory Automation Pty Ltd was expelled as an Essential Participant of the Rail Manufacturing CRC in December 2017, resulting in the write down of their contributions to the Centre. Subsequently, the loss of this associated industry funding requires the Centre to find new projects and participants to meet this shortfall.

Impacts



CSIRO researcher Marzi Barghamadi was awarded the Australian Endeavour Research Fellowship

The Rail Manufacturing CRC has been active in developing new projects in 2017–18, with seven new project agreements executed:

- » Project R1.1.2 - **Hybrid supercapacitors with high energy and power densities for rail industry applications** (HEC Group / University of Technology Sydney)
- » Project R1.5.1 - **Aluminium matrix composite brake discs** (CRRC / CSIRO)
- » Project R2.1.1 - **Platform gap** (Downer / Monash University)
- » Project R2.1.2 - **Protection of cast steel coupler from corrosion by cold spray** (CRRC / CSIRO)
- » Project R3.3.2 - **Development of a smart rail route map** (Australasian Railway Association / Deakin University)
- » Project R3.4.1 - **Arc welding modelling** (CRRC / CSIRO)
- » Project R3.5.1 - **Battery HVAC feasibility study** (Knorr-Bremse / CSIRO).

In **Program 1 – Power and Propulsion**, two new projects have commenced.

Project R1.1.2 - **Hybrid supercapacitors with high energy and power densities for rail industry applications** (HEC Group / University of Technology Sydney) is studying improved supercapacitor technologies for rail applications by assessing new electrode chemistries.

Project R1.5.1 - **Aluminium matrix composite brake discs** (CRRC / CSIRO) is an advanced braking project which aims to develop new composite materials for brake discs.

There have also been positive impacts experienced on the suite of supercapacitor projects (R1.3.3 and R1.3.4) underway between CRRC and CSIRO during the year. Towards the end of 2017, CRRC Project Leader Ruijie Qin travelled to Australia to assist the CSIRO Clayton team for a number of months to work through end-user inputs on performance requirements.

Project R1.3.3 was also further supported when key CSIRO researcher Marzi Barghamadi was selected to receive an Australian Endeavour Research Fellowship at the Münster Electrochemical Energy Technology in Germany. Marzi took part in a four month placement between April to August 2017, and gained valuable insights into battery developments which she brought back to the research work being conducted at CSIRO.



In **Program 2 – Materials and Manufacturing**, two new projects began during the year.

Project R2.1.1 - **Platform gap** (Downer / Monash University) is focused mitigating issues surrounding the train platform gap, with a dynamic polymer-based solution to bridge the gap between the train and the station platform being investigated. The impact of the project has both economic and social benefits, with improved access for disabled passengers providing a positive impact on society.

Project R2.1.2 - **Protection of cast steel coupler from corrosion by cold spray** (CRRC / CSIRO) is investigating the use of cold spray to coat couplers and increase the parts' durability, which is otherwise prone to corrosion and cracking in certain circumstances.

Also in Program 2, Project R2.3.2 - **Axle bearing maintenance optimisation** (Bombardier / University of Queensland) was extended to study a broader range of bearings, following useful results generated in the project to date.

In **Program 3 – Design, Modelling and Simulation**, three projects commenced during the reporting period.

Project R3.3.2 - **Development of a smart rail route map** (Australasian Railway Association / Deakin University) involves the development of a Smart Rail Route Map for Australia's rail industry. The project will identify a long term vision for rail industry technologies over the next 30 years through the establishment of a common view of priorities, themes, timelines and actions.

The objective of Project R3.4.1 - **Arc welding modelling** (CRRC / CSIRO) is to develop a user-friendly computer program that will predict the properties of welds. The implementation of the software produced will result in significant productivity improvements. Moreover, optimised weld parameters can save expenditure on consumables and provide further assurance of the weld quality.

Project R3.5.1 - **Battery HVAC feasibility study** (Knorr-Bremse / CSIRO) is scoping a larger project based on the potential use of batteries for discrete applications.

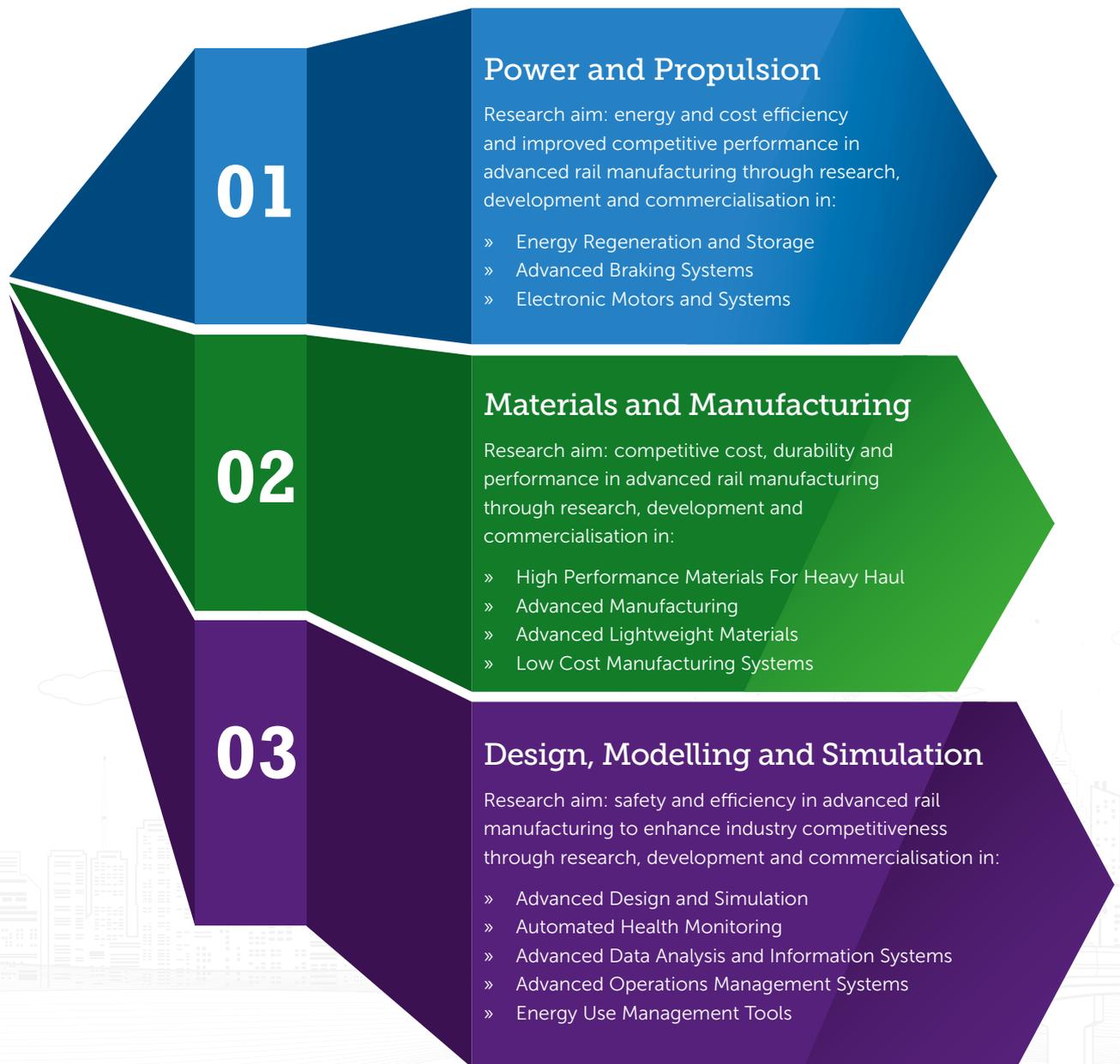
The research outputs of long-term Project R3.1.2 - **Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system** (Downer / University of Technology Sydney) have been developed into a commercial product called DwellTrack. The technology is a passenger monitoring solution for railway platform congestion, which received wide interest when demonstrated at the CeBIT Australia conference held at Sydney in May 2018. The next step for this project is likely further station trials in collaboration with a rail network operator.

Also in Program area 3, two project scoping studies were completed during the year:

- » Project R3.2.1 - **Development of a responsive passenger information system for the Sydney Trains network** (Sydney Trains / University of Technology Sydney)
- » Project R3.3.1 - **Detection and monitoring on trains - feasibility study** (Knorr Bremse / University of Technology Sydney).

Both of these scoping projects provided the two participating industry organisations with the ability to undertake future activities with in-depth insights into the background technology involved.

Performance against activities



Program 1 – Power and Propulsion

With an increasing focus on electrification and energy efficiency, this first research theme has the potential to significantly change the rail industry through energy storage solution development and implementation. The Rail Manufacturing CRC has a number of related projects in this program area that are looking to address the challenge of increasing the performance of energy storage devices for use in rail applications. This includes research to increase cycle life in high energy density lithium ion batteries and to increase the energy density of supercapacitors.

There is a variety of applications for energy storage in rail, including backup power and regenerative braking, but the largest application exists for catenary-free light rail systems where the overhead lines are replaced by charging stations at tram stop platforms.

During the year, the excellent collaboration between China Railway Rolling Stock Corporation (CRRC) and CSIRO continued in the following rail supercapacitor energy storage systems projects:

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

A prototype energy management system to power the supercapacitors was transported to China, with the CRRC project team now working to manufacture and test the design in a full-scale facility.

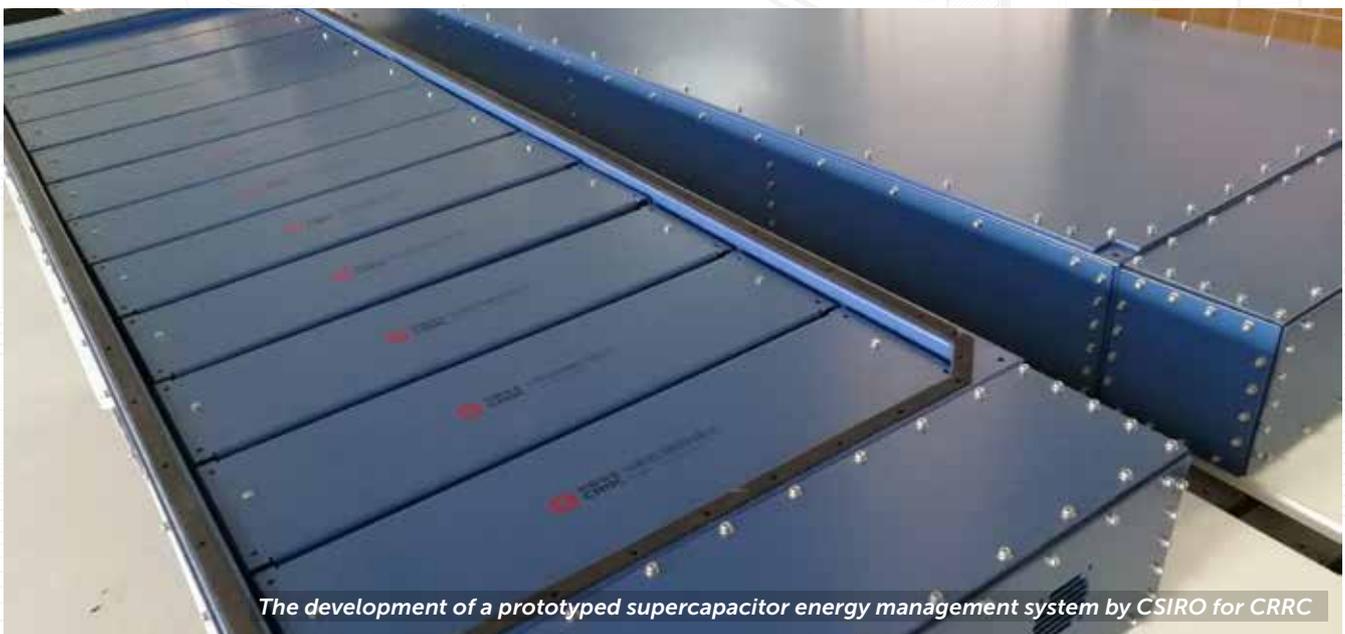
In a similar theme, the material-focused activities in partnership between the HEC Group and University of Technology Sydney have also delivered promising laboratory results for:

- » Project 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)
- » Project R1.1.2 - **Hybrid supercapacitors with high energy and power densities for rail industry applications** (HEC Group / University of Technology Sydney).

Within these two projects, efforts are now underway to scale-up some of the synthesis processes, with the manufacturing capacity of the HEC Group highly beneficial in directing these developments.

One final project that addresses advanced braking research also commenced during this Financial Year: Project R1.5.1 - **Aluminium matrix composite brake discs** (CRRC / CSIRO).

This project aims to develop novel materials and processing to fabricate high-performance aluminium matrix composite brake discs. The proposed composite brake disc seeks to address a number of operational considerations to achieve better in-service performance, with the CRRC division QSY (Qishuyan Institute Co, Ltd) to undertake testing of the brake disc in their facilities.



The development of a prototyped supercapacitor energy management system by CSIRO for CRRC

Program 2 – Materials and Manufacturing

This theme incorporates a variety of projects relating to maintenance and durability of rail track and rolling stock, supporting the need to efficiently maintain and service rail assets in a timely and cost-effective manner.

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.

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

- » Project R2.3.2 - **Axle bearing maintenance optimisation** (Bombardier / University of Queensland)
- » Project R2.3.4 - **Monitoring and control of false brinelling** (Bombardier / University of Queensland).

Project R2.3.2 involves the development and testing of a new optimised predictive maintenance system for bearings, while Project R2.3.4 is investigating wear that occurs during the transportation of bearings.

Progress on both of these projects was enhanced by the close involvement of Bombardier providing materials for testing. During the year, the vibrations and forces on bearings were also monitored by sensors in transit with the assistance of Bombardier.

Another two projects are focused on researching materials used 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)

- » 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 is focused on the use of recycled tyres as an alternate ballast material while Project R2.5.2 is investigating the use of geogrids to stabilise the ballast foundation. With Global Synthetics supplying geogrids, this has resulted in valuable commercial insights being shared.

Two new projects have also just commenced in Program 2 at the end of 2017–18:

- » Project R2.1.1 - **Platform gap** (Downer / Monash University):
The manufacture and testing of a dynamically adjustable polymer-based gap bridging device that fills the space between the station platform and the train door when passengers embark and disembark the vehicle.
- » Project R2.1.2 - **Protection of cast steel coupler from corrosion by cold spray** (CRRC / CSIRO):
Investigating the use of cold spray to spray metal particles to bond materials together.

Project R2.4.1 - **Advanced steel development for rail and sleepers** (OneSteel / Monash University) was put on hold in April 2016 due to OneSteel's parent company Arrium being placed in voluntary administration. In May 2018, rebranded organisation Liberty OneSteel gave notice of their intention to withdraw from the project.



Assessing the lubrication of axle bearings

Program 3 – Design, Modelling and Simulation

With Industry 4.0, automation, the Internet of Things and Virtual Reality beginning to take prominence in Australia's rail industry, the suite of projects underway within this program area are focused on the use of design and simulation techniques to model operations, develop more efficient processes and equipment solutions, increase efficiencies and extend rail systems' asset life.

Within this research theme, Project R3.1.2 - **Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system** (Downer / University of Technology Sydney) is well advanced. This project involves the development of an autonomous system capable of sensing and interpreting passenger behaviour and train events to monitor the movement of passengers on and off trains. In the last 12 months, a commercial prototype called DwellTrack has been delivered and a provisional patent and trademark has been lodged. The technology was also demonstrated at the CeBIT conference held in May 2018 at Sydney.

Another long-term project underway is 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). This project involves modelling airflow from the air vents within a train environment to determine optimum flow based on different passenger numbers. Researchers from RMIT University are experts in computational fluid dynamics modelling, so have been actively collaborating to establish a facility at Airlinx to test the modelling in.

A focused six-month project also delivered in the past 12 months was Project R3.5.1 - **Battery HVAC feasibility study**, (Knorr-Bremse / CSIRO).

An additional two new projects also began towards the end of 2017–18:

» Project R3.3.2 - **Development of a smart rail route map** (Australasian Railway Association / Deakin University)

This project is working to establish a common view of priorities, themes, timelines and actions for Australia's rail industry, which will be used to identify and deliver the most applicable technologies and services to the sector.

» Project R3.4.1 - **Arc welding modelling** (CRRC / CSIRO)

Advanced algorithms are the key component of a new project involving modelling of welding processes. This project will develop a software module specifically for CRRC to use for welding rail components.



DwellTrack camera hardware used to track passenger movements

Rail Manufacturing CRC Projects underway during reporting period

	Program	Project number	Project	Participants
1	Program 1 – Power and Propulsion	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
2	Program 1 – Power and Propulsion	R1.1.2	Hybrid supercapacitors with high energy and power densities for rail industry applications	HEC Group / University of Technology Sydney
3	Program 1 – Power and Propulsion	R1.3.3	High energy supercapacitor development	CRRC / CSIRO
4	Program 1 – Power and Propulsion	R1.3.4	Supercapacitor energy management system stage 2	CRRC / CSIRO
5	Program 1 – Power and Propulsion	R1.5.1	Aluminium matrix composite brake discs	CRRC / CSIRO
6	Program 2 – Materials and Manufacturing	R2.1.1	Platform gap	Downer / Monash University
7	Program 2 – Materials and Manufacturing	R2.1.2	Protection of cast steel coupler from corrosion by cold spray	CRRC / CSIRO
8	Program 2 – Materials and Manufacturing	R2.3.1	Accelerated life testing and characterisation of critical components	Knorr-Bremse / CSIRO
9	Program 2 – Materials and Manufacturing	R2.3.2	Axle bearing maintenance optimisation	Bombardier / University of Queensland
10	Program 2 – Materials and Manufacturing	R2.3.4	Monitoring and control of false brinelling	Bombardier / University of Queensland
11	Program 2 – Materials and Manufacturing	R2.4.1	Advanced steel development for rail and sleepers	OneSteel / Monash University
12	Program 2 – Materials and Manufacturing	R2.5.1	Performance of recycled rubber inclusions for improved stability of railways	Tyre Stewardship / Australasian Centre for Rail Innovation / University of Wollongong
13	Program 2 – Materials and Manufacturing	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
14	Program 3 – Design, Modelling and Simulation	R3.1.2	Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system	Downer / University of Technology Sydney
15	Program 3 – Design, Modelling and Simulation	R3.3.2	Development of a smart rail route map	Australasian Railway Association / Deakin University
16	Program 3 – Design, Modelling and Simulation	R3.4.1	Arc welding modelling	CRRC / CSIRO
17	Program 3 – Design, Modelling and Simulation	R3.5.1	Battery HVAC feasibility study	Knorr-Bremse / CSIRO
18	Program 3 – Design, Modelling and Simulation	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 2018

Milestone number	Milestone	Due date	Status
R1.1.2	Design of system hardware and software confirmed. IP strategy (patents/know-how/designs/software) defined	30 Jun 2018	In progress
R1.2.3	Second prototype delivered and report on optimising the system manufacturing and running costs approved	30 Dec 2017	Not achieved
R1.2.4	Third prototype delivered and report on various loading, control and power issues approved	30 Jun 2018	Not achieved
R1.3.3	Demonstrator built	31 Dec 2017	Achieved
R1.5.1	Report approved for feasibility study for advanced braking system for locomotives including patent and literature landscape, performance benchmark and confirm approach in terms of technical and economic feasibility	30 Jun 2017	Achieved
R1.5.2	Development and design of hardware and software completed IP strategy (patents/know-how/designs/software) defined	31 Dec 2017	Achieved
R1.5.3	Demonstrator built	30 Jun 2018	In progress
R1.6.2	Commencement of 4 PhD students	30 Jun 2017	In progress
R1.6.3	Commencement of 3 PhD students	30 Jun 2018	In progress
R2.1.4	Validated material-process-property relationship for physical and predicted data	31 Dec 2017	Achieved
R2.1.5	Design, develop component and manufacturing process completed	30 Jun 2018	Achieved
R2.3.2	Review of performance and design constraints completed Define IP strategy (patents/know-how/designs/software)	30 Jun 2018	Achieved
R2.5.3	Software model to predict performance completed	30 Sep 2017	Achieved
R2.5.4	Laboratory validation of model for physical and predicted data	30 Jun 2018	Achieved
R2.5.5	Design and develop component and manufacturing process completed	30 Jun 2018	Achieved
R2.7.4	Completion of 1 PhD students	30 Jun 2018	In progress
R3.1.3	Software model to predict performance completed	31 Dec 2017	Achieved
R3.1.4	Validated model for physical and predicted data	30 Jun 2018	Achieved
R3.2.4	Advanced detection technologies for rail applications demonstrator and commercialisation plan completed	30 Jun 2018	Achieved
R3.3.2	Provisional patent/s lodged for train handling algorithms for rail applications	30 Dec 2017	Achieved
R3.3.3	Report approved for know-how for train handling algorithms for rail applications	30 Jun 2018	Achieved
R3.4.2	Review of performance and design constraints completed Define IP strategy (patents/know-how/designs/software)	30 Dec 2017	Achieved
R3.4.3	Software model to predict performance completed	30 Jun 2018	In progress
R3.5.2	Review of performance and design constraints completed Define IP strategy (patents/know-how/designs/software)	30 Jun 2018	Achieved
R3.6.4	Validated model for physical and predicted data	31 Dec 2017	Achieved
R3.6.5	Design and develop component and manufacturing process completed	30 Jun 2018	Achieved
R3.7.4	Completion of 1 PhD student	30 Jun 2018	In progress

Publications list in 2017–18

Number of book chapters

Indraratna, B., Ngo, N. T., Nimbalkar, S., and Rujikiatkamjorn, C. (2018). Two decades of advancement in process simulation testing of ballast strength, deformation, and degradation. *Railroad Ballast Testing and Properties*, ASTM STP1605, T. D. Stark, R. Szecsy, and R. H. Swan, Jr., Eds., ASTM International, West Conshohocken, PA, 2018, pp. 1–28.

Articles in scholarly refereed journals

Ngo, N.T., Indraratna, B., Ferreira, F.B. and Rujikiatkamjorn, C. (2018). Improved performance of geosynthetics enhanced ballast: laboratory and numerical studies. *Proceedings of the Institution of Civil Engineers-Ground Improvement*, pp: 1-21. DOI: doi.org/10.1680/jgrim.17.00051

Yang, L., X.D. Li, J.Y. Tu. (2018). Effects of cough-jet on airflow and contaminant transport in an airliner cabin section. *The Journal of Computational Multiphase Flows* 10(2): 72-82.

Yang, L., X.D. Li, J.Y. Tu. (2018). The effects of diffuser type on thermal flow and contaminant transport in high-speed train (HST) cabins - A numerical study. *International Journal of Ventilation* 17(1): 48-62.

Full written conference paper – refereed proceedings

Farhood, H., He, X., Jia, W., Blumenstein, M. & Li, H., 2017, Counting People based on Linear, Weighted and Local Random Forests Appeared at the Proceedings of 2017 International Conference on Digital Image Computing: Techniques and Applications (DICTA 2017).

Indraratna, B., Ngo, N., Sun, Q., Rujikiatkamjorn, C. & Bessa Ferreira, F. (2018). Concepts and Methodologies for Track Improvement and Associated Physical Modelling and Field Monitoring. *Proceedings of the International Symposium on Geotechnics of Transportation Infrastructure (ISGTI 2018)* (pp. 24-36). India: Indian Institute of Technology Delhi. (Invited keynote paper)

Kasmani, S. A., He, X., Jia W., Wang, D. & Zeibots, M., 2018, A-CCNN: adaptive CCNN for density estimation and crowd counting, 2018 IEEE International Conference on Image Processing (ICIP2018), accepted on 5 May 2018.

Meehan, P.A., Milne, C.D. & Liu, S., Investigation of wear degradation of railway spherical roller bearings, *Dynamics of Vehicles on Roads and Tracks: Proceedings of the 25th International Symposium on Dynamics of Vehicles on Roads and Tracks (IAVSD 2017)*, 14-18 August 2017, Rockhampton, Queensland, Australia

Ngo, N. & Indraratna, B. (2018). Interface Behavior of Geogrid-reinforced Sub-ballast: Laboratory and Discrete Element Modeling. *Proceedings of the International Symposium on Geotechnics of Transportation Infrastructure (ISGTI 2018)* (pp. 475-481). India: Indian Institute of Technology Delhi.

Pozzebon, ML and Meehan, PA. Modelling of grease lubrication decay [online]. In: 9th Australasian Congress on Applied Mechanics (ACAM9). Sydney: Engineers Australia, 2017: [604]-[612].



Education and training



The Rail Manufacturing CRC has again delivered a strong result in supporting the next generation of potential employees joining Australia's rail industry.

The past year has seen a large increase in the number of PhD students supported by the Rail Manufacturing CRC. Since the Centre commenced in 2014, 34 PhD students have been supported across three student programs – industry-led projects, rail PhD scholarships, and internship placements.

Industry projects

In 2017–18, there are now seven³ PhD students participating in industry-led projects:

- » Tianyi Wang, 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)
- » Zhang Yin, working on Project R1.3.3 - **High energy supercapacitor development** (CRRC / CSIRO), studying at Queensland University of Technology
- » Matthew Pozzebon, working on Project R2.3.2 - **Axle bearing maintenance optimisation** (Bombardier / University of Queensland)
- » Osama Brinji, working on Project R2.3.4 - **Monitoring and control of false brinelling** (Bombardier / University of Queensland)
- » Chamindi Jayasuriya, working 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)
- » 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).

Based on contract numbers, the Rail Manufacturing CRC is also currently working with university participants to fill a further five positions for PhD students on industry-funded projects (one student on R1.1.1, two students on R1.1.2, one student on R2.3.2, and one student on R2.3.4).



Students Fukun Xia, Tianyi Wang, Calvin Vong and Sundar Shrestha practicing their PhD pitches

Scholarship students

Following the establishment of a scholarship program in 2016–17, the Rail Manufacturing CRC has continued to commit to funding a number of new scholarship students in the past 12 months. These scholarships are co-funded by the Rail Manufacturing CRC and participating universities, which include CQ University, Swinburne University of Technology, RMIT University, Monash University and University of Technology Sydney.

As of 30 June 2018, there are 23⁴ PhD Scholarship students currently working on a wide variety of industry-leading rail research projects, including real-time condition monitoring, using drones for assessment, laser cladding technologies, augmented and virtual reality for training, big data analytics and automated assembly of rolling stock fabrications.

Industry internships

Across 2016–17 and 2017–18, the Rail Manufacturing CRC worked with Australian not-for-profit organisation TrackSAFE Foundation to establish a PhD internship program, where two PhD students from Queensland University of Technology were selected to participate in a 12-week paid level crossing-related internship with rail organisations Queensland Rail and Aurizon. At the end of the work placement, the students were invited to present on their research and internship experiences to the National Level Crossing Steering Committee in Brisbane in November 2017.

There is the desire to continue delivering internship opportunities for PhD students working in rail research across Australia, but this is dependent on interested rail industry organisations and universities identifying and developing future programs with the Rail Manufacturing CRC.

³ This total does not include one industry PhD student who withdrew from a project.

⁴ This total does not include one scholarship PhD student who withdrew from a project.

Support for students

To encourage Rail Manufacturing CRC PhD students to consider a career in rail after graduation, a number of supporting initiatives have been delivered to provide information sharing, relationship building and general induction and introduction to Australia's rail industry.

In January and February 2018, the Centre hosted its first PhD Students' Forum in Melbourne. Eighteen of the Centre's PhD students were in attendance from universities including CQ University, Monash University, Swinburne University, University of Queensland, University of Technology Sydney and University of Wollongong.

The forum was split into two days, with the first day focused on teaching the students about the Rail Manufacturing CRC and the Australian rail industry, with guest presentations from ARA's Danny Broad and Bombardier's David Collomb. The day also included a thorough 90 minute speed networking session, where the students got the chance to meet each other and other industry representatives in attendance from Knorr-Bremse, SNC-Lavalin and Downer.

Day two was a full-day Power Pitch training course session, where the students were provided with the skills to write, finesse and present engaging three minute pitches about their PhD research topic – see more **In Focus: The power of pitching** (see page 28).

Other support activities have included student tours of rail industry headquarters in Sydney and Brisbane, inviting the students to attend Rail Manufacturing CRC Participants Forums, and the rollout of a trial mentoring program to match students with rail industry representatives for support and guidance. This trial connected three students with three industry mentors – Mark Carling from SNC-Lavalin, David Collomb from Bombardier and Joshua Pitcher from Knorr-Bremse. It is hoped that these initial 12-week mentoring relationships will continue, also ideally further supported by new industry mentors volunteering to connect with additional students.

Moving into 2018–19, it is planned to host another PhD students' forum to provide further networking and training opportunities, which will also be supplemented by other communication channels to keep the students connected, such as recurring video conference sessions and online networking tools such as Slack.

Status against milestones

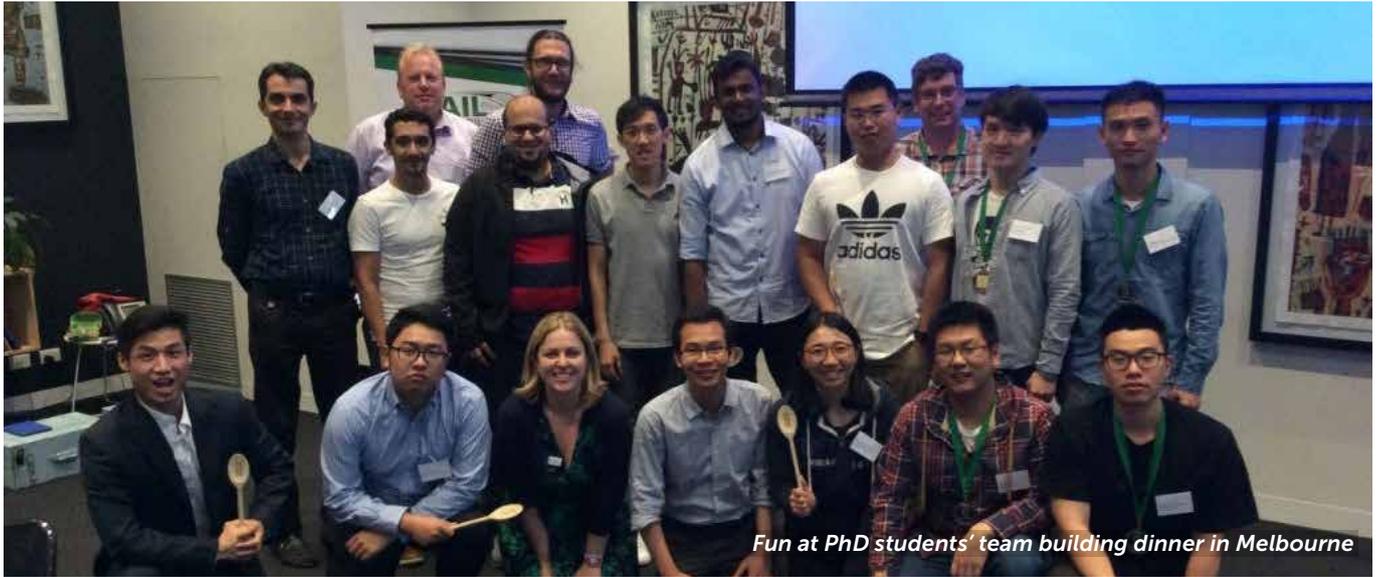
There are four milestones related specifically to the Rail Manufacturing CRC's Education program:

Milestone number	Milestone	Due date	Status
R1.6.2	Commencement of 4 PhD students	30 Jun 2017	In progress
R1.6.3	Commencement of 3 PhD students	30 Jun 2018	In progress
R2.7.4	Completion of 1 PhD students	30 Jun 2018	In progress
R3.7.4	Completion of 1 PhD student	30 Jun 2018	In progress

For milestones R1.6.2 and R1.6.3, three students commenced in 2017–18. An additional four students are expected to commence in the coming 12 months.

For milestone R2.7.4, three PhD students within the Materials and Manufacturing research area are expected to complete their PhDs in 2018–19.

For milestone R3.7.4, one PhD student within the Design, Modelling and Simulation research area is expected to complete his PhD in 2018–19.



Fun at PhD students' team building dinner in Melbourne



PhD interns Zhesuo Zhang and Don Kushlani Ranmal discussing the Queensland Rail network



Knorr-Bremse mentor Joshua Pitcher working with PhD student Esteban Bernal



Queensland-based PhD students participating in industry tour at Bombardier's Wulkaraka depot

In Focus: The power of pitching

A PhD student's ability to pitch 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 those people that matter - prospective employers, a funding body or even a colleague.

Working with trainers from Present with Intent in February 2018, the Centre's PhD students participated in a full day PowerPitch training session to learn how to engagingly write and deliver a three minute pitch about their PhD research to their audience. At the training's conclusion, the students each delivered their pitch to their fellow students and representatives from the Rail Manufacturing CRC.

In May 2018, three of the PhD students were given the opportunity to apply their learnings by delivering their pitches at the Rail Manufacturing CRC Participants Forum held in Sydney. With over thirty representatives from rail businesses and universities in attendance, the students delivered terrific insight into their PhDs, further supplemented by answering audience questions about their pitches.

The Centre's students also had the chance to participate in the CRC Association's Early Researcher Showcase competition. Held every year during the association's conference in May, the competition asked early researchers to submit a 30 second video introducing their research. Three of the Centre's students entered, with University of Wollongong student Chuhao Liu selected as a finalist to present 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 winner by the 200 strong audience, and he was awarded his prize at the CRC Association's gala dinner in front of representatives from CRC organisations, the Rail Manufacturing CRC and University of Wollongong.

Further to this, Chuhao was also crowned the overall winner of University of Wollongong's Three Minute Thesis competition. It's been over six years since an Engineering student won this award, and he will now go on to compete in the 2018 Asia-Pacific 3MT Competition finals at the University of Queensland this September.

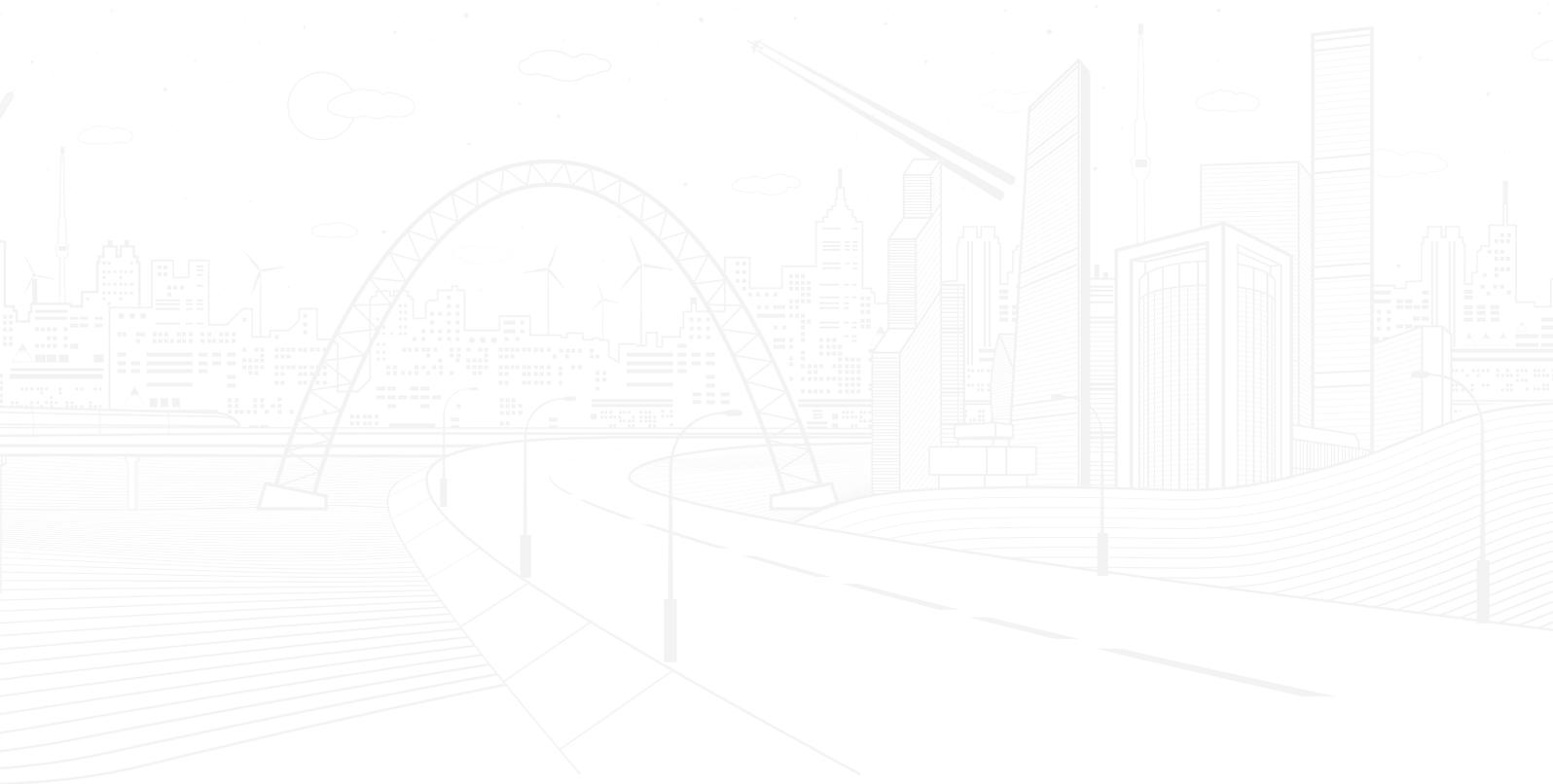
Recognising the benefit that this training has brought in improving students' confidence levels and delivery skills, the Rail Manufacturing CRC is now looking to book all of its new PhD students to attend PowerPitch training over the coming months.



PhD students hard at work at PowerPitch training with trainer Sandy McDonald



Chuhao Liu announced as winner at the CRC Association's Early Researcher Showcase competition



Current list of commenced PhD students – as of 30 June 2018

#	Student name	Degree	Start date *	Expected completion date *	Research program area	Project title	Research institute	Student's country of origin
1	Tianyi Wang	PhD	25/08/2017	25/08/2021	1 – Power and Propulsion	New generation lithium-ion batteries with high energy and long service life	University of Technology Sydney	China
2	Zhang Yin	PhD	2/05/2016	1/11/2019	1 – Power and Propulsion	High energy supercapacitor development	Queensland University of Technology	China
3	Sundar Shrestha	PhD	03/07/2017	02/07/2021	1 – Power and Propulsion	Estimation of adhesion conditions between wheels and rails for the development of advanced braking control systems	Central Queensland University	Nepal
4	Esteban Bernal Arango	PhD	03/07/2017	02/07/2021	1 – Power and Propulsion	Smart axle transducer transmitter for freight wagon condition monitoring systems	Central Queensland University	Colombia
5	Cameron Milne ⁵	PhD	12/01/2015	12/01/2018	2 – Materials and Manufacturing	Axle-bearing maintenance optimisation	University of Queensland	Australia
6	Matthew Pozzebon	PhD	28/04/2016	28/04/2019	2 – Materials and Manufacturing	Axle-bearing maintenance optimisation	University of Queensland	Australia
7	Osama Brinji	PhD	13/04/2017	13/04/2020	2 – Materials and Manufacturing	Monitoring and control of false brinelling	University of Queensland	Saudi Arabia
8	Chamindi Jayasuriya	PhD	22/08/2014	01/09/2018	2 – Materials and Manufacturing	Performance of recycled rubber inclusions for improved stability of railways	University of Wollongong	Sri Lanka
9	Chuhao Liu	PhD	18/04/2017	18/04/2020	2 – Materials and Manufacturing	The performance of stabilised ballast in rail tracks	University of Wollongong	China
10	Mahsa Taherimandarjani	PhD	30/04/2018	30/04/2022	2 – Materials and Manufacturing	Laboratory evaluation of laser cladding on rail wheel steels	Swinburne University of Technology	Iran
11	Meng Wang	PhD	25/01/2018	24/01/2022	2 – Materials and Manufacturing	Manufacturing of lightweight panels	Swinburne University of Technology	China
12	Fukun Xia	PhD	15/12/2017	15/12/2021	2 – Materials and Manufacturing	Evaluation of hybrid structures for impact performance in rail applications	Swinburne University of Technology	China
13	Vu Trong Thien (Terence)	PhD	27/02/2017	26/02/2020	2 – Materials and Manufacturing	Automated assembly for rolling stock fabrication in rail industry	University of Wollongong	Vietnam
14	Hang Su	PhD	27/03/2017	27/03/2020	2 – Materials and Manufacturing	Optimisation of rail welding process parameters to mitigate rolling contact damage	Monash University	China
15	Pravin Urudra ⁶	PhD	01/03/2017	01/03/2020	2 – Materials and Manufacturing	Evaluating the suitability of laser clad rail steel in heavy haul application	Monash University	Malaysia
16	Simon Wagner	PhD	14/05/2018	13/05/2022	2 – Materials and Manufacturing	Heavy haul train force control product	Central Queensland University	Australia
17	Elias Salloum	PhD	01/03/2018	28/02/2022	2 – Materials and Manufacturing	Optimising friction-stir welding and alloy design to ensure the durability of light weight carriages in the rail fleet	RMIT University	Australia
18	Anthony Micheletto	PhD	04/01/2018	04/04/2021	2 – Materials and Manufacturing	Improvement of flashbutt welds in premium rails	Monash University	Australia
19	Don Kushlani Ranmal Ranasinghe	PhD	27/06/2016	27/06/2019	2 – Materials and Manufacturing	Optimal design of raised rail - road crossing structure	Queensland University of Technology	Sri Lanka
20	Zheshuo Zhang	PhD	17/11/2015	16/11/2018	2 – Materials and Manufacturing	Effect of raised rail - road crossing to the safety of road vehicles	Queensland University of Technology	China

⁵ This student withdrew from the project as of 30 April 2017

⁶ This student withdrew from the project as of 21 February 2018

#	Student name	Degree	Start date *	Expected completion date *	Research program area	Project title	Research institute	Student's country of origin
21	Alexander Virgona	PhD	29/08/2014	27/10/2019	3 – Design, Modelling and Simulation	Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system	University of Technology Sydney	Australia
22	Julien Collart	PhD	05/02/2015	05/02/2019	3 – Design, Modelling and Simulation	Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system	University of Technology Sydney	France
23	Mahdi Saki	PhD	02/02/2016	03/09/2023	3 – Design, Modelling and Simulation	Ultra-reliable and cost effective communication infrastructure for future IoT-based railway applications	University of Technology Sydney	Iran
24	Zhibin Li	PhD	02/03/2017	02/03/2021	3 – Design, Modelling and Simulation	Big data analytics for condition based monitoring and maintenance	University of Technology Sydney	China
25	Huaxi Huang	PhD	03/04/2018	03/04/2022	3 – Design, Modelling and Simulation	Rail infrastructure defect detection through video analytics	University of Technology Sydney	China
26	Amir Eslami	PhD	05/06/2017	03/09/2020	3 – Design, Modelling and Simulation	Drive-by bridge inspection: the use of instrumented revenue wagons for structural health monitoring of rail bridges	Monash University	Iran
27	Yu Fung Lee (Joseph)	PhD	27/02/2017	28/05/2020	3 – Design, Modelling and Simulation	Nonlinear vibro-acousto-ultrasonic waves for fatigue cracking detection in key rail components	Monash University	China
28	Chi Hei Vong (Calvin)	PhD	27/02/2017	28/05/2020	3 – Design, Modelling and Simulation	Control and navigation of micro UAV in small railway culverts and tunnels	Monash University	Portugal
29	Yong Pang	PhD	30/05/2017	28/08/2020	3 – Design, Modelling and Simulation	System for real-time monitoring and sensing railway conditions by laser light	Monash University	China
30	Dongyu Zhang	PhD	01/03/2017	30/05/2020	3 – Design, Modelling and Simulation	Hybrid unmanned aerial system for railway inspection	Monash University	China
31	Nalin Randeniya	PhD	15/06/2017	15/06/2021	3 – Design, Modelling and Simulation	Augmented reality manufacturing and maintenance modules in High Capacity Metro Train for enabling effective engagement and faster learning curves	Swinburne University	Sri Lanka
32	Andrew Danylec	PhD	15/06/2017	15/06/2021	3 – Design, Modelling and Simulation	Develop and establish augmented reality tools in High Capacity Metro Train for productivity and quality enhancements	Swinburne University	Australia
33	Wenhua Jiang	PhD	17/10/2017	15/01/2021	3 – Design, Modelling and Simulation	Short-term rail passenger flow forecasting application	Monash University	China
34	Jie Yang (Joanne)	PhD	22/06/2018	21/06/2022	3 – Design, Modelling and Simulation	Optimising railway carriage design for improved dispersion, capacity and safety	RMIT University	Australia

*** Please note:** When reporting students' dates of commencement, the decision has been made to report against dates provided in each student's letter of enrolment from their university, rather than contract dates, as was previously reported in past annual reports. This accounts for any adjustments in commencement dates and expected dates of completion reported in previous annual reports.

SME engagement



In the rail transport sector, small-to-medium enterprises (SMEs) comprise 90 per cent⁷ of rail manufacturing and maintenance companies, so these organisations are an important element in the context of a devolved manufacturing supply chain. With SMEs playing such a large role in Australia's rail industry, engaging with these businesses is key to the Rail Manufacturing CRC's success.

As not all SMEs have the capacity or financial means to become participants in the Rail Manufacturing CRC's programs, the Centre looks at each research program theme and individual project to see how an SME's involvement can best be incorporated.

In 2017–18, methods of SME engagement have included:

- » delivery of two Rail Manufacturing CRC Participants Forums – held at Melbourne in December 2017 and at Sydney in May 2018
- » direct engagement with SME representatives by the Centre's CEO and key staff through participation in rail industry events and forums, university events, and Federal and State Government forums (see page 52)
- » regular communication about the Centre's activities and progress through the Rail Manufacturing CRC's Communications Strategy (see page 38).

⁷ ACIL TASMAN Railway Manufacturing Industry a Profile of the Railway Manufacturing in Australia 2011



Industry and researcher networking at the Sydney Participants Forum in May 2018

Current SME participants

During 2017–18, the Rail Manufacturing CRC had six SMEs participating in ongoing industry projects – Tyre Stewardship Australia, Australasian Centre for Rail Innovation, Global Synthetics, Foundation QA, Australasian Railway Association and Airlinx. In more detail:

- » 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):

This joint project is investigating the use of recycled rubber tyres for rail ballast applications, with two possible significant outcomes – firstly addressing and enhancing the rail ballast properties and secondly, exploring new sustainable uses for a problematic waste material.

- » 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):

This project aims to address a number of issues to solve unique challenges involving rail infrastructure by testing the use of geogrid technologies to stabilise and prolong the lifetime of rail ballast.

- » Project R3.3.2 - **Development of a smart rail route map** (Australasian Railway Association / Deakin University):

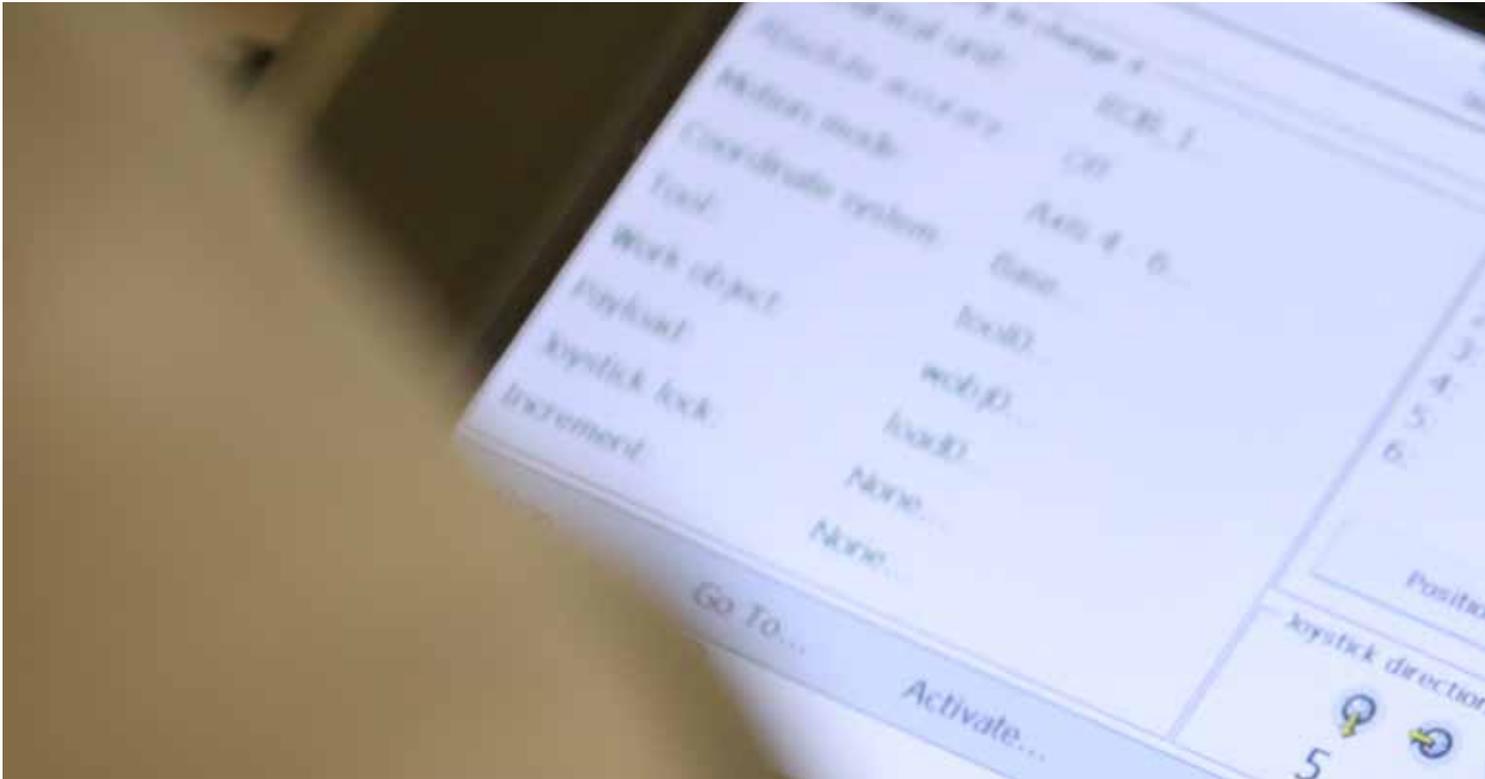
This newly commenced project will incorporate academic expertise in developing sector infrastructure and service provision modelling to establish a long term route map for the rail sector. Specifically, the project will seek to define industry goals, map the key challenges for the rail sector over the next 30 years relating to technology disruption, and identify focus area objectives and initiatives.

- » Project R3.6.1 - **Experimental and computational study on the key ventilation issues affecting air quality and thermal comfort in train cabin** (Airlinx / RMIT University):

Airlinx is deriving a greater understanding of its ventilation products through modelling and simulation research being undertaken in collaboration with RMIT University.

Another key SME engagement has been with TrackSAFE Foundation, who the Rail Manufacturing CRC has partnered with to deliver a work placement internship for two PhD students from Queensland University of Technology. These two students received a paid 12-week work placement at Queensland Rail and Aurizon. Dependent on future university and industry interest levels, it is hoped to run future cycles of an internship program for rail PhD students to participate in.

Commercialisation



The Rail Manufacturing CRC's model for commercialisation and utilisation was developed in close consultation with its industry and research participants, with an overarching principle to support and facilitate industry-led research outcomes in an independent manner.

This model is tailored to each project and is dependent on factors, including the:

- » capacity of the participants to use and commercialise project outcomes
- » research and commercial inputs to the project
- » benefit to Australia
- » contributions of parties to intellectual property
- » commercial viability of the research outcomes.

With the Centre playing an independent role in project decision making, the commercialisation model limits the number of organisations seeking input into commercial decisions, and ensures that industry and research participants investing in the project will receive benefit from any commercial returns.

Before projects commence, all commercial outcomes and Intellectual Property (IP) terms and conditions are determined through transparent contractual negotiations, which limits any potential IP legacy issues in future years.

Projects completed

As of June 2018, two Rail Manufacturing CRC projects were completed during the year:

- » Project R3.2.1 - **Development of a responsive passenger information system for the Sydney Trains network** (Sydney Trains / University of Technology Sydney):
This project was a scoping study for the development and implementation of a responsive passenger information system for the Sydney Trains network.
- » Project R3.3.1 - **Detection and monitoring on trains - feasibility study** (Knorr Bremse / University of Technology Sydney):
This project was a feasibility study for detection and monitoring on trains.

The outputs of these two projects will enable Sydney Trains and Knorr-Bremse to each undertake future activities with more detailed, in-depth insight.

Project extensions

To assist with potential commercialisation activities, Project R2.3.2 - **Axle bearing maintenance optimisation** (Bombardier / University of Queensland) was extended in May 2018 to broaden the scope of bearings being tested due to promising initial test results.

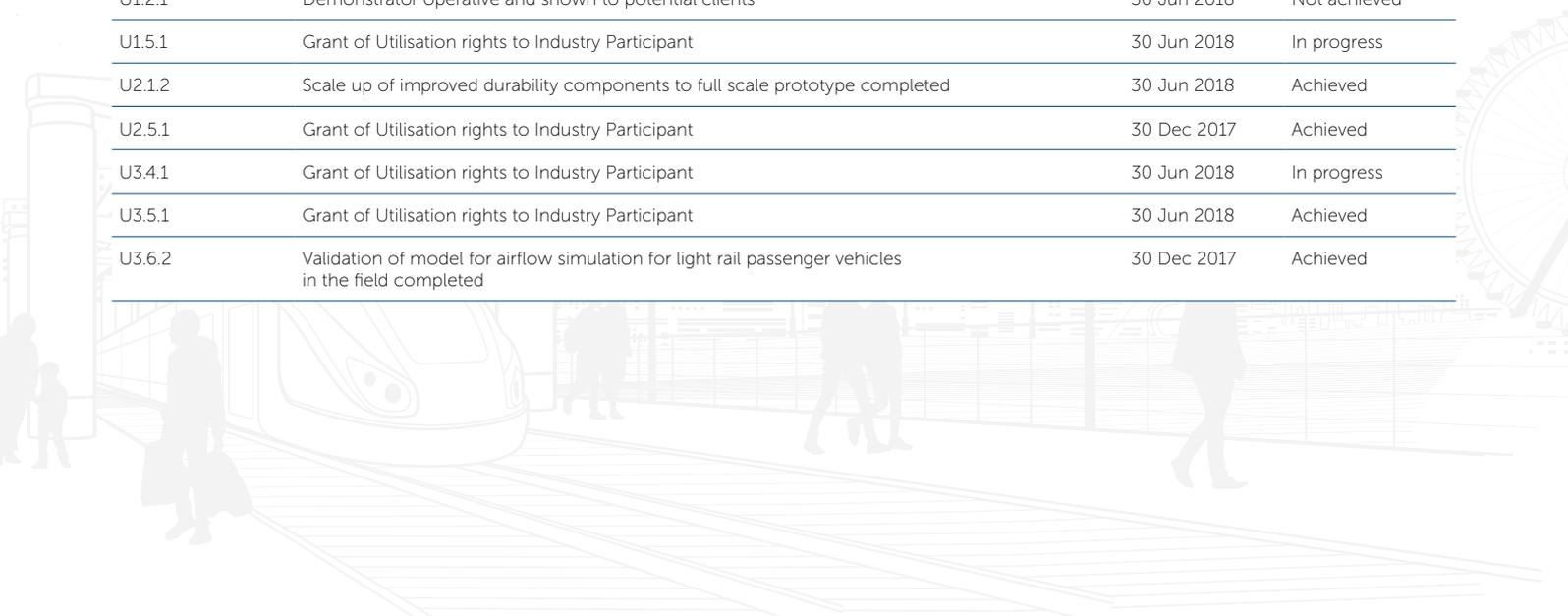


Automating robot assembly at University of Wollongong

Utilisation milestones

The Utilisation Plans developed during the reporting period for relevant projects have resulted in almost all Utilisation milestones being completed.

Milestone number	Milestone	Due date	Status
U1.1.1	Grant of Utilisation rights to Industry Participant	30 Jun 2018	Achieved
U1.2.1	Demonstrator operative and shown to potential clients	30 Jun 2018	Not achieved
U1.5.1	Grant of Utilisation rights to Industry Participant	30 Jun 2018	In progress
U2.1.2	Scale up of improved durability components to full scale prototype completed	30 Jun 2018	Achieved
U2.5.1	Grant of Utilisation rights to Industry Participant	30 Dec 2017	Achieved
U3.4.1	Grant of Utilisation rights to Industry Participant	30 Jun 2018	In progress
U3.5.1	Grant of Utilisation rights to Industry Participant	30 Jun 2018	Achieved
U3.6.2	Validation of model for airflow simulation for light rail passenger vehicles in the field completed	30 Dec 2017	Achieved



Intellectual property management



CSIRO Researcher Pon Kao testing supercapacitor cells

The Rail Manufacturing CRC Ltd is a company limited by guarantee, meaning it has members rather than shareholders.

As has been the case since its inception, the Rail Manufacturing CRC is focused on transferring the intellectual property that results from its projects in the most effective manner to its participants and to ensure maximum benefit and impact are derived.

The Rail Manufacturing CRC does not seek to own intellectual property nor seek royalties from the technology it develops. Instead, the Centre aims to ensure that the technologies its projects deliver will provide the maximum benefit to project partners.

Ownership and use of the project intellectual property is defined during the development of individual project agreements between the respective project participants to ensure that the process is transparent and beneficial to all parties.

Patent filed

In December 2017, a provisional patent was filed for Project R3.1.2 - **Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system** (Downer / University of Technology Sydney):

Official no.	Title	Priority date
2017904919	Monitoring systems, and computer implemented methods for processing data in monitoring systems, programmed to enable identification and tracking of human targets in crowded environments	6 December 2017



Communications



The Rail Manufacturing CRC recognises the importance in using a variety of communication channels to distribute information in a professional, timely and accurate manner to its participants, the broader rail industry and any interested parties.

Since June 2016, the Centre's communication function is run by a Communications Manager (0.6 FTE), who is responsible for developing the Rail Manufacturing CRC's Communications Strategy and rolling out key messages and communications collateral.

The Centre's Communications Strategy is to:

- » provide internal and external stakeholders with timely, consistent and informative communications about the Rail Manufacturing CRC's direction and activities
- » maintain strong and collaborative relationships with the Centre's industry and research institute participants and key external stakeholders
- » evaluate the communication channels used via surveys, feedback, website analytics, social media engagement and newsletter readership.

The communications function has two key audiences – **internal** and **external**.

Internal communications

Internal communications is focused on communication with the Centre's participant organisation representatives, project supervisors and students. This includes:

- » providing timely communications to ensure staff, students and industry participants are aware of the Centre's programs, projects and key initiatives
- » supporting effective collaboration and information sharing across the rail manufacturing industry
- » promoting key rail manufacturing industry news.

In 2017–18, a key communication channel was the Centre's monthly email newsletter, sent to over 500 subscribers. The newsletter's average open rate of 32.7 per cent during the last 12 months compares positively against the MailChimp manufacturing industry benchmark open rate of 16.6 per cent.

Another key communications channel during the year was hosting regular Participants Forum events, where representatives from the Centre's participant organisations, in addition to other interested attendees, came along to hear the latest news, engage with each other, participate in workshopping sessions and listen to guest speakers.



Students engaging with leading rail industry representatives during the PhD Students' Forum

An informal Christmas celebration forum was held in Melbourne in December, with 17 businesses represented. This was followed up with a full Participants Forum in Sydney at the beginning of May, with 30 attendees across the rail industry and universities – see more **In Focus: Forum networking success** (see page 41).

External communications

External communications is focused on communicating with all interested or related parties, working in rail manufacturing, transport, research, State and Federal Government, and the Australian general public. This includes:

- » promoting a positive outlook for the Australian rail manufacturing sector by sharing general news, key project updates and Rail Manufacturing CRC successes
- » raising the profile of the Rail Manufacturing CRC to identify the development of new projects and new participant organisations joining the Centre
- » encouraging representatives from other industries to apply their skills to the challenges faced in rail manufacturing.

Alongside the Rail Manufacturing CRC website, which is regularly updated with latest news, participants information and project listings, the Centre also manages LinkedIn and Twitter social media channels. The LinkedIn page is a publicly-facing company page where latest news, key successes and rail updates are posted to page followers. The Twitter account also provides the ability to communicate directly with interested organisations and individuals, and also actively engage with the Centre's participants to cross-promote key activities and support their successes.

Rating the effectiveness of the Centre

Following the establishment of an inaugural Participants Survey in 2016–17, this survey was again conducted at the end of 2017–18 to rate the effectiveness of the Rail Manufacturing CRC.

A link to an online survey was sent to one key representative per participant organisation, where respondents were asked to rate the Centre’s activities across a variety of functions. The 2017–18 Participants Survey received 18 responses in total – with 11 industry responses and 7 research institution responses (against a total of 25 organisations requested to respond).

In summary:

Questions (where 1= very unsatisfied, 3 = neutral, 5 = very satisfied)	2017–18 weighted average	2016–17 weighted average
... the Centre’s Board is effective	4.33	3.67
... the Centre’s Senior Leadership is effective	4.61	4.00
... administration is effectively managed	4.39	4.21
... research programs are effectively managed	4.44	4.08
... project outcomes meet the expectations of participants	4.06	3.71
... communications program is effectively managed	4.44	4.07
... education and training program is effectively managed	4.36	3.64
... level of satisfaction with the Centre’s Intellectual Property Model	4.11	4.00
Overall level of satisfaction with the collaboration between your organisation and the Rail Manufacturing CRC in 2017–18	4.33	4.07

It is planned for the Participants Survey to again be conducted at the end of 2018–19 to continue tracking the Centre’s performance, while also identifying further opportunities for improvement.

Alignment to CRC Program Branding

As required, all communications activities adhere to proper use of CRC Program Branding, as specified in the Funding Agreement. This has included the appropriate promotion of logos and inclusion of content used in presentations delivered, on printed communications collateral and online via the Centre’s website and social media channels.

In Focus: Forum networking success



In May 2018, the Rail Manufacturing CRC hosted its latest Participants Forum event, connecting together representatives from current participating industry businesses and research institutions, along with other interested attendees across the Australian rail industry.

On the day, 30 attendees represented industry groups Austrade, Central Japanese Railway Company, Downer Rail, Knorr-Bremse and SNC-Lavalin, joined by research representatives from CQ University, CSIRO, Deakin University, RMIT University, University of Technology Sydney, University of Queensland and University of Wollongong.

The session began with an intensive 90-minute speed networking session, followed by Stuart Thomson and Larry Jordan providing an update on the Centre's activities, funding opportunities and specific projects underway. Three of the Centre's PhD students were asked to deliver 5-minute PhD pitches about their research topics, and the forum concluded with a transparent look into Sydney Trains' future technology challenges and opportunities, delivered by General Manager Tony Eid.

Feedback was collected at the conclusion of the event, with participants expressing high praise for all of the sessions and considerable enthusiasm for the speed networking and Sydney Trains overview sessions. The next Participants Forum is scheduled to be held at Melbourne in October 2018.



Governance

The Rail Manufacturing CRC Limited (“RMCRC”; “Company”; “Centre”) is a public company limited by guarantee, incorporated and domiciled in Australia. The Rail Manufacturing CRC is registered as a charity with the Australian Charities and Not-for-profits Commission.

As a registered charity, the Australian Taxation Office granted income tax exemption, a Fringe Benefits Tax rebate on capped employee fringe benefits and certain GST concessions to the Centre. As a result, no provision for income tax has been made in the Centre’s financial accounts.

Directors’ Meetings

The Rail Manufacturing CRC Board met four times during 2017–18:

31 August 2017, 23 November 2017, 22 February 2018 and 22 May 2018.

During the year ended 30 June 2018, the number of Board meetings held while each Director was in office and the number attended by each Director was as follows:

Name	Role	Key skills	Independent / Organisation	Appointed (Resigned)	A ⁸	B ⁹
Current Directors						
Paul Johnson	Chair	Executive management, R&D, engineering, business administration, transport industry expertise, experience as a non-executive director	Independent	31/10/2014	4	4
Bronwyn Constance	Independent Director	Financial management, business administration, manufacturing industry administration, experience as a non-executive director	Independent	31/10/2014	4	4
Stuart Thomson	Executive Director (CEO)	Business administration, executive management, IP, commercialisation, R&D, experience as an executive director	Rail Manufacturing CRC	20/03/2015	4	4
Michael Miller	Industry Nominee	Financial management, business administration, manufacturing industry administration, IT, experience as non-executive director	Downer EDI Rail	14/10/2015	4	4
Grant Stanley	Research Nominee	R&D, commercialisation, higher education expertise, experience as a non-executive director	Central Queensland University	14/04/2016	4	3
Michael McLellan	Industry Nominee	Manufacturing industry administration, commercialisation, M&A, experience as a non-executive director	Knorr-Bremse Australia	26/09/2016	4	2
Former Directors						
Alan Beacham	Industry Nominee	Manufacturing industry administration, engineering, experience as a non-executive director	UGL	26/09/2016 (30/11/2017)	2	1

⁸ A = Number of meetings held while the Director held office

⁹ B = Number of meetings attended

The Board is responsible to its members and participants for the company's performance. The Board's election, composition, function and responsibilities are set out in the company's Constitution and in the Participants Agreement.

The filling of casual director vacancies is the responsibility of the Remuneration and Nominations Board Committee as follows:

- » **Nominee directors** - nominations are sought from the relevant industry or research Essential Participants (EPs), such that only industry EPs may nominate candidates to replace industry nominee directors and only research EPs may nominate candidates to replace research nominee directors. Likewise, voting is by nominee type EP only.
- » **Independent directors** - nominations are sought from suitable candidates, always keeping in mind the need to ensure that, collectively, the directors have skills and experience across a constitutionally established minimum set of fields.

The Board sets the Rail Manufacturing CRC company strategy and performance targets, it reviews and approves all company policies and it oversees the implementation of procedures to ensure that the Management team meets the Board's objectives. The Board meets at least quarterly for scheduled meetings.

The Chair is an independent director, and the Company's Constitution requires that the Board include:

- » up to four persons elected by a vote of the Industry Essential Participants
- » up to one person elected by a vote of the Research Essential Participants
- » up to three independent non-executive directors elected by a vote of Essential Participants
- » the CEO.

At the Annual General Meeting ("AGM") held 30 November 2017, four directors retired by rotation as required under the constitution. Three of the retiring directors were re-elected, namely Paul Johnson, Michael McLellan and Grant Stanley. Alan Beacham retired as a director and did not stand for re-election.

Board



CHAIR - PAUL JOHNSON MBE

DIPAIROCRRAFT DESIGN, MSC(AIRCRAFT DESIGN), MAICD.

INDEPENDENT DIRECTOR AND BOARD CHAIR SINCE 31 OCTOBER 2014.

CHAIR OF RMCRC RESEARCH AND DEVELOPMENT, AND REMUNERATION AND NOMINATIONS BOARD COMMITTEES.



BRONWYN CONSTANCE

FCCA, FAICD, FCIS.

INDEPENDENT DIRECTOR SINCE 31 OCTOBER 2014.

CHAIR OF RMCRC AUDIT AND RISK BOARD COMMITTEE.



CEO - DR STUART THOMSON

BSC, BSC(HONS), PHD, GCTMLP, GAICD.

EXECUTIVE DIRECTOR SINCE 20 MARCH 2015. CHIEF EXECUTIVE OFFICER SINCE 1 APRIL 2015.

MEMBER OF RMCRC RESEARCH AND DEVELOPMENT BOARD COMMITTEE AND RESEARCH AND DEVELOPMENT MANAGEMENT COMMITTEE.



MICHAEL MILLER

BEC, CA.

DIRECTOR SINCE 14 OCTOBER 2015 (INDUSTRY NOMINEE).

MEMBER OF RMCRC AUDIT AND RISK, AND REMUNERATION AND NOMINATIONS BOARD COMMITTEES

EXPERIENCE AND EXPERTISE:

After an extensive career in the Royal Australian Navy as an Aircraft Artificer and an Engineering Officer, Paul joined General Electric (USA) as the Australian Manager of Business Development. He was later assigned to Singapore as the ASEAN countries Regional Director for Business Development and in 1994 was promoted to regional President for South Asia and Australasia. In 2003, Paul was appointed as Managing Director and CEO of Lockheed Martin Australia, while also acting as Chairman of the Australian Industry Group's Defence Industry Executive Council.

Since retiring from Lockheed Martin in 2011, Paul has been involved as a director on the Boards of a number of institutions, currently including a member of the Air Force Board, Director of Aerospace, Maritime and Defence and Security Foundation of Australia Limited (AMDSFA) and Co-Chair Centre for Defence Industry Capability Advisory Board. Paul currently serves as an Independent Ministerial Advisor on Defence Innovation. He was awarded the MBE in 1980 in recognition of his contribution to the advancement of Naval Aircraft Engineering and is a Member of the Australian Institute of Company Directors.

EXPERIENCE AND EXPERTISE:

Bronwyn has held many senior executive positions including Finance Director of Kraft Foods Limited Australia and New Zealand, Vice President Finance of Kraft Foods Asia, Executive General Manager Finance and Administration of Pasminco Limited and Finance Director of Nylux Limited. She spent her early career with the ACI Group of companies. Bronwyn is an independent director of DMTC Ltd and chairs their Audit, Risk and Remuneration Committee. She is a former independent director of the Melbourne Market Authority, Plantic Technologies Limited, The Just Group Limited, CRC for Advanced Automotive Technology and CRC CARE Pty Ltd.

EXPERIENCE AND EXPERTISE:

Stuart received his PhD from the University of New South Wales ("UNSW"), and subsequently worked in various research roles at UNSW, the Max-Planck-Institut für Kohlenforschung and the Australian Nuclear Science and Technology Organisations (ANSTO). He has held numerous management roles in the manufacturing, mining, and agricultural sectors, including roles as Chief Operating Officer at CRC Mining and Executive Director and Board member of the Grape and Wine Research and Development Corporation. In 2015, he was appointed to the role of CEO and Managing Director of Rail Manufacturing CRC. He holds formal qualifications in Science, Trademark Law and Practice, and is a graduate of the Australian Institute of Company Directors.

EXPERIENCE AND EXPERTISE:

Michael joined Downer EDI Limited in 2011 and was appointed the CEO of Rail in 2016, having previously held the CFO position for both the Rail division and for the Waratah Train Project. Prior to joining Downer, Michael held executive positions within the IT and Telecommunications industry, including Hewlett Packard and Nortel Networks. Michael is a director of Downer EDI Rail and associated entities and a Director of the Australasian Railway Association.



PROF GRANT STANLEY

BENG(CHEM), PHD.
DIRECTOR SINCE 14 APRIL 2016 (RESEARCH AND DEVELOPMENT NOMINEE).
MEMBER OF AUDIT AND RISK, RESEARCH AND DEVELOPMENT, AND REMUNERATION AND NOMINATIONS BOARD COMMITTEES.



MICHAEL MCLELLAN

BENG, POSTGRADDIP.
DIRECTOR SINCE 26 SEPTEMBER 2016 (INDUSTRY NOMINEE).



ALAN BEACHAM

BENG(HONS), CENG, MIEE.
DIRECTOR FROM 26 SEPTEMBER 2016 TO 30 NOVEMBER 2017 (INDUSTRY NOMINEE).

EXPERIENCE AND EXPERTISE:

Grant holds undergraduate and postgraduate degrees from the University of Melbourne and has a background in Applied Microbiology/Biochemical Engineering, with ongoing research interests in biofuel production. He has experience in research and teaching and has published over 110 scientific papers, an international patent, has received a number of Commonwealth and Industry funding grants and supervised 15 PhD students. Grant was the Head of Molecular Sciences at Victoria University, he then joined Central Queensland University Australia as the Dean of Medical and Applied Sciences. In 2013 he became the Pro Vice-Chancellor (Research) and is currently the Deputy Vice-Chancellor (Research) at CQUniversity. Grant has sat on a number of Boards including the SmartWater Research Board and Queensland Cyber Infrastructure Board, and is currently a member of the Advance Queensland Expert Panel.

EXPERIENCE AND EXPERTISE:

Michael has been Managing Director of Knorr-Bremse Australia Pty Ltd since 2004. He was also appointed Managing Director of Sigma Air Conditioning Pty Ltd following Knorr-Bremse acquiring the business in 2010, as well as his appointment as non-executive director of Sydac Pty Ltd after leading the acquisition in 2009. Prior to joining Knorr-Bremse, Michael worked in a variety of management positions across organisations such as GUD Manufacturing, Honeywell and Caterpillar.

EXPERIENCE AND EXPERTISE:

Alan has extensive experience including leading the Rail & Defence businesses for UGL Pty Limited which he joined in 2010. Alan has spent most of his career in the transport industry. His early career started in aviation with Rolls-Royce Plc in the UK. He then moved to F1 working for Mercedes-Ilmor Ltd. After relocating to Australia, Alan returned to aviation working with Qantas before setting up a lean manufacturing consultancy KM&T Australasia supporting clients in the Rail, Marine, Automotive, Defence, FMCG and Healthcare sectors. Alan has served as a director on a number boards including Metro Trains Melbourne, Tracksafe Foundation, Australasian Railway Association (ARA) and was chair of the ARA's Rail Industry Group.

Committees



The **Audit and Risk Board Committee (ARBC)** is a subcommittee which reviews and provides recommendations to the Board on financial reporting, statutory audit functions, internal control functions, risk management, compliance and governance. The ARBC is chaired by an independent non-executive director and its membership includes an industry representative director and a research provider representative director. The Committee met on four occasions in 2017–18 and the current members are:

- » Bronwyn Constance (Chair)
- » Grant Stanley (Research representative member)
- » Michael Miller (Industry representative member).

The **Research and Development Board Committee (RDBC)** is a subcommittee which reviews and provides recommendations to the Board on project proposals and project progress and expenditure. Membership of the RDBC consists of an independent, non-executive director as Chair and a research representative director. The Committee met on one occasion in 2017–18 and also considered other projects by means of circular resolutions. The current committee members are:

- » Paul Johnson (Chair)
- » Stuart Thomson (Managing Director)
- » Grant Stanley (Research representative).



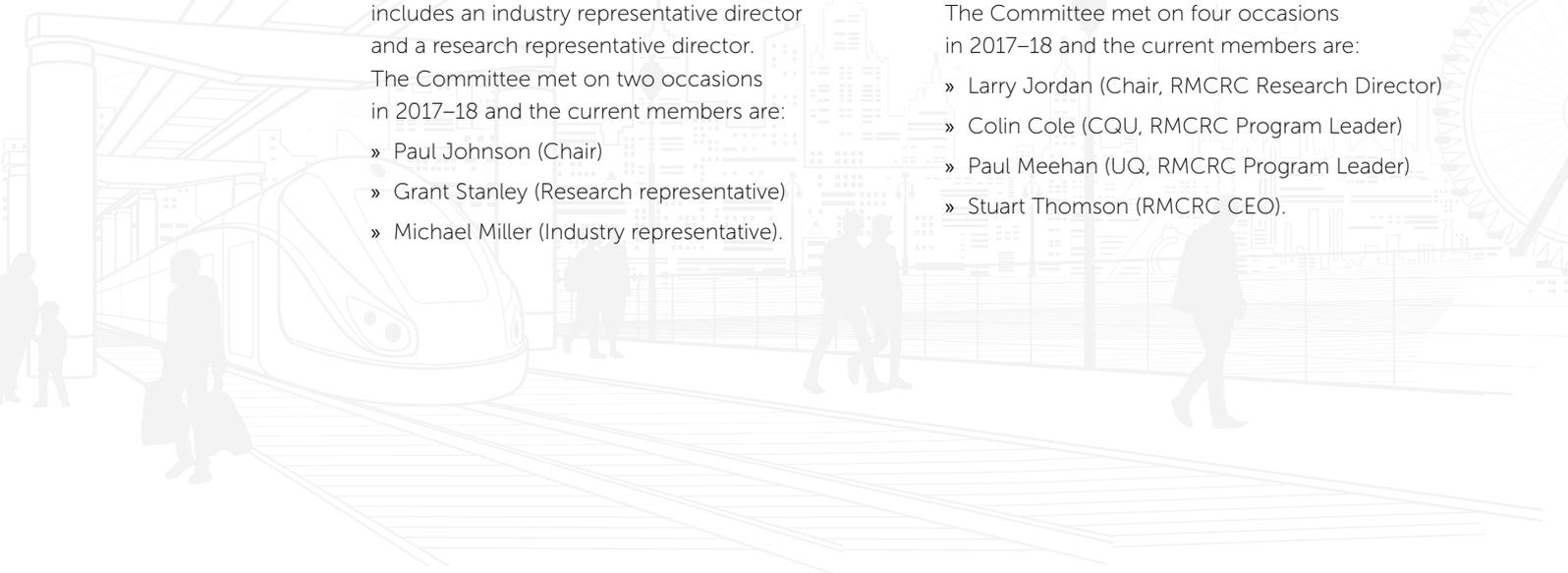
Heavy haul coal transportation

The **Remuneration and Nominations Board Committee (RNBC)** assesses nominations for the Board and reviews remuneration of the Centre's Management and Independent Directors. The committee is chaired by an independent non-executive director and its membership includes an industry representative director and a research representative director. The Committee met on two occasions in 2017–18 and the current members are:

- » Paul Johnson (Chair)
- » Grant Stanley (Research representative)
- » Michael Miller (Industry representative).

The **Research and Development Management Committee (RDMC)** provides advice to the CEO on technical research areas and meets quarterly to discuss the Rail Manufacturing CRC's project portfolio with the appropriate research and industry participant representatives. The Committee met on four occasions in 2017–18 and the current members are:

- » Larry Jordan (Chair, RMCRC Research Director)
- » Colin Cole (CQU, RMCRC Program Leader)
- » Paul Meehan (UQ, RMCRC Program Leader)
- » Stuart Thomson (RMCRC CEO).



Management team



CEO - DR STUART THOMSON

BSC, BSC(HONS), PHD, GCTMLP, GAICD.

CHIEF EXECUTIVE OFFICER SINCE APRIL 2015.

EXPERIENCE AND EXPERTISE:

Stuart has extensive experience in leading strategic research and development programs in both government and commercial organisations, having held senior management positions in the private and public sectors. His past roles have included technical development roles in manufacturing companies, Chief Operating Officer and Director of Research roles at CRCMining, and the Executive Director of the Grape and Wine Research and Development Corporation.



DR LARRY JORDAN

BSC, MSC, PHD.

RESEARCH DIRECTOR SINCE AUGUST 2015.

EXPERIENCE AND EXPERTISE:

Larry manages the delivery of the Rail Manufacturing CRC's research program to ensure high quality collaborative research is provided to the rail industry. With a background in materials science and experience in research, including electrochemical sensors, fuel cells and materials durability, Larry has worked in building construction, nanotechnology and automotive industries. Larry's past roles include Research Manager at the Advanced Manufacturing CRC and Chief Scientist at General Motors Holden.



SHARON SALPIGHIDIS

BCOM, DIPED, CPA.

FINANCIAL CONTROLLER AND COMPANY SECRETARY SINCE SEPTEMBER 2016.

EXPERIENCE AND EXPERTISE:

Sharon provides strategic and operational management of the Rail Manufacturing CRC's financial activities and ensures the Centre complies with its statutory obligations. Sharon has previously held senior management positions across both listed public companies and fast-growing private start-up enterprises, facilitating multiple mergers, acquisitions and divestments. She has previously worked both locally and overseas in diverse industries including healthcare, construction, education and most recently, telecommunications.



KATIE RIZZO

BARTS, GRADCERT.

COMMUNICATIONS MANAGER SINCE JUNE 2016.

EXPERIENCE AND EXPERTISE:

Katie is responsible for managing the communications function for the Rail Manufacturing CRC, which includes marketing, media engagement, event management and internal communications activities. Prior to joining the Centre, she worked in corporate communications, marketing and online communications roles across a number of sectors, including manufacturing, telecommunications, banking, energy and water.



MIETALI PANDIT

BCOM (INDIA), CPA (USA).
FINANCE AND RECORDS
OFFICER SINCE NOVEMBER
2017.

**EXPERIENCE AND
EXPERTISE:**

Mietali has experience in financial and management accounting and assists with the financial and contract management for the Centre, including reporting and the annual audit process.



PROF COLIN COLE

BENG, MENG, PHD.
PROGRAM LEADER SINCE
APRIL 2015.

**EXPERIENCE AND
EXPERTISE:**

Colin is the Director of the Centre for Railway Engineering (CRE) and also currently serves as a Program Leader in the Rail Manufacturing CRC. His work history in railway engineering started in 1984 in Queensland Railways, and he's spent the past 24 years working specifically in railway research. Colin has completed more than 20 rail research projects related to train dynamics, simulation and development of on-board intelligent systems and devices. He has published over 100 technical papers, one book, two book chapters and two patents.



PROF PAUL MEEHAN

BENG(HON1), PHD.
PROGRAM LEADER SINCE
MARCH 2017.

**EXPERIENCE AND
EXPERTISE:**

Paul is an expert in railway mechanics and noise, leading the University of Queensland research in rail mechanics as part of the Centre for Advanced Materials Performance and Manufacturing (AMPAM). He has initiated and led many successful large industry collaborative R&D projects totalling more than \$12 million in competitive research funding. He also teaches several intermediate and advanced level courses in mechanics including railway noise. He has authored over 120 internationally refereed publications and three international patents.

Name*	Organisation	Position title	Time committed
Stuart Thomson	Rail Manufacturing CRC	Managing Director and CEO	100%
Larry Jordan	Rail Manufacturing CRC	Research Director	100%
Mietali Pandit	Rail Manufacturing CRC	Finance and Records Officer	80%
Sharon Salpighidis	Rail Manufacturing CRC	Financial Controller and Company Secretary	60%
Katie Rizzo	Rail Manufacturing CRC	Communications Manager	60%
Paul Meehan	Rail Manufacturing CRC / University of Queensland	Program Leader	55%
Colin Cole	Rail Manufacturing CRC / CQ University	Program Leader	51%

*One additional employee during this time period was Shelley Bresick as Business Manager (working from September 2015 to November 2017).

Participants

BOMBARDIER

ACRI
Australian Centre for Rail Innovation

KNORR-BREMSE

CU university
AUSTRALIA

Transport
Sydney Trains

HEC

SWINBURNE
UNIVERSITY OF TECHNOLOGY

CSIRO

MONASH University

DEAKIN
UNIVERSITY

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Downer

onesteel
whyalla steelworks

RMIT
UNIVERSITY

UTS

trackSAFE
FOUNDATION

QUT

UNIVERSITY OF WOLLONGONG
AUSTRALIA

Global Synthetics

AIRLINX
AIRLINX INDUSTRY

TyreStewardship
AUSTRALIA

AUSTRALASIAN RAILWAY ASSOCIATION

中国中车
CRRC

UGL

Essential Participants

Participant name	Participant type	ABN	Organisation type
Bombardier Transportation Australia Pty Ltd	Essential	73 010 699 804	Large Industry
Central Queensland University	Essential	39 181 103 288	University
China Railway Rolling Stock Corporation (CRRC)	Essential	Not applicable	Large Industry
CSIRO	Essential	41 687 119 230	Australian Government
Deakin University	Essential	56 721 584 203	University
Downer EDI Rail Pty Ltd	Essential	92 000 002 031	Large Industry
Monash University	Essential	12 377 614 012	University
OneSteel Manufacturing Pty Ltd	Essential	42 004 651 325	Large Industry
Queensland University of Technology	Essential	83 791 724 622	University
Swinburne University of Technology	Essential	13 628 586 699	University
The University of Queensland	Essential	63 942 912 684	University
University of Technology Sydney	Essential	77 257 686 961	University
University of Wollongong	Essential	61 060 567 686	University

Other Participants

Participant name	Participant type	ABN	Organisation type
Airlinx Heating and Cooling Pty Ltd	Other	28 094 691 791	Individual SME
Australasian Centre for Rail Innovation (ACRI) Ltd	Other	52 164 764 167	Other
Australasian Railway Association	Other	64 217 302 489	Other
Foundation QA	Other	78 090 519 289	Individual SME
Global Synthetics	Other	71 120 519 520	Individual SME
HEC Group	Other	18 165 129 260	Large Industry
Knorr-Bremse Australia Pty Ltd	Other	31 092 562 671	Large Industry
Royal Melbourne Institute of Technology	Other	49 781 030 034	University
Sydney Trains	Other	38 284 779 682	State Government
TrackSAFE Foundation	Other	98 155 604 872	Other
Tyre Stewardship Australia Ltd	Other	44 164 971 939	Individual SME
UGL Rail Services Pty Ltd	Other	58 000 003 136	Large Industry

Third Party Participants

Participant name	Participant type	ABN	Organisation type
Aurizon Network Pty Ltd	Third Party	78 132 181 116	Large Industry
Austrade	Third Party	11 764 698 227	Government
Industry Capability Network Ltd	Third Party	85 068 571 513	Government
Queensland Rail Ltd	Third Party	71 132 181 090	Large Industry
The State of Queensland (Department of Transport and Main Roads)	Third Party	39 407 690 291	State Government

Simplex Factory Automation Pty Ltd was expelled as an Essential Participant of the Rail Manufacturing CRC in December 2017, resulting in the write-down of their contributions to the Centre.

Collaboration

The Rail Manufacturing CRC has continued to drive a variety of initiatives to grow its engagement with research institutions and rail industry organisations during the last 12 months.

The Centre's participation in multiple rail industry forums has enabled the development of stronger relationships with rail manufacturers, rail operators and Government groups across the world, while also working closely with local rail peak bodies such as the Australasian Railway Association (ARA).

In 2017–18, the Rail Manufacturing CRC participated in and promoted rail innovation at a number of key forums, including:

- » leading technical presentations at the AusRAIL conference held at Brisbane in November 2017
- » demonstrating DwellTrack technology at CeBIT Australia in May 2018
- » presenting at the Spain – Australia Rail Technology Cooperation Forum held at Melbourne's RMIT University in November 2017
- » participating in the Infrastructure Transport 2056 forum organised by Engineers Australia at CORE 2018
- » involvement in the Public Transport Authority Western Australia - METRONET Rolling Stock Procurement forum held in October 2017
- » chairing the Strategic Transport Asset Management conference held at Sydney in August 2017
- » participating in recurring ARA Rail Industry Group meetings, a forum with senior rail representatives aimed at supporting rail suppliers
- » participating in numerous State Government briefings and forums
- » attendance at the ARA Telecommunications & Technology Forum, the CRC Association annual conference, the Rail Manufacturing CRC's Participant Forums, and other academic and industry forums.

In 2017–18, the Centre initiated a third call for Rail Innovation Gateway proposals, where all interested businesses working in rail, or with the potential to do so, were invited to apply with rail R&D project proposals for funding. In response, four project proposals were received, three of which were selected to proceed and are now undergoing late stage contractual negotiations.

The Rail Manufacturing CRC has also continued to support its successful PhD scholarship program, where rail PhD students working on research that aligns to one of the Centre's three research themes (see page 16) are selected to receive a scholarship co-funded by the Centre and the participating university for the length of the student's PhD.

At present, there are currently 23 students actively working on rail PhD research topics across a number of Australian universities, including CQ University, University of Wollongong, Swinburne University, Monash University, RMIT University and the University of Technology Sydney.





Rail Manufacturing CRC's Larry Jordan and Paul Johnson attending the CRC Association conference in May 2018

Project collaborations

The Rail Manufacturing CRC's current suite of projects are providing considerable benefit to its participants, with a number of project examples underway showing commercial potential:

- » Project R1.1.1 - **New generation lithium-ion batteries with high energy and long service life for rail industry application** (HEC Group / University of Technology Sydney):

This research seeks to develop new battery technologies for rail applications by utilising new lithium-based chemistries. The materials being developed are to be used for propulsion and to enable regenerative braking of the train, signalling systems and auxiliary applications. Developing better battery materials have far-reaching applications in rail, with the potential for use in the development of hybrid trains.

- » Project R1.3.3 - **High energy supercapacitor development** (CRRC / CSIRO)

- » Project R1.3.4 - **Supercapacitor energy management system stage 2** (CRRC / CSIRO):

Energy storage control systems being developed jointly by CRRC and the CSIRO hold significant opportunities for the domestic and global rail sector. This suite of projects includes the development of high energy supercapacitors with new design and chemistry, and the prototyping of an energy management system which is currently being tested by CRRC in China.



Example CRRC trams using supercapacitor technology

- » Project R2.3.2 - **Axle bearing maintenance optimisation** (Bombardier / University of Queensland)

This project could potentially reduce maintenance and overhaul requirements for rolling stock by examining methods to model and predict lubrication needs for the maintenance of the axle bearings, which in turn could result in reduced operational costs.

- » Project R3.1.2 - **Integrated passenger behaviour, train operations diagnostics and vehicle condition monitoring system** (Downer / University of Technology Sydney):

This project has developed a prototype passenger monitoring system that was showcased at Sydney's CeBIT Australia conference in May 2018. The system continues to undergo trials with rail operators and will offer an array of benefits to rail operators, enabling them to better understand passenger movement within stations, to assist them to operate more efficiently and effectively, and to potentially reduce railway operation costs.

- » Project R3.2.1 - **Development of a responsive passenger information system for the Sydney Trains network** (Sydney Trains / University of Technology Sydney):

This work sought to study and identify key passenger information systems technologies for the rail sector. The outputs of this project will enable Sydney Trains to undertake future activities with in-depth insights into the background technology involved.

- » Project R2.3.1 - **Accelerated life testing and characterisation of critical components** (Knorr-Bremse / CSIRO)
- » Project R3.3.1 - **Detection and monitoring on trains - feasibility study** (Knorr-Bremse / University of Technology Sydney)
- » Project R3.5.1 - **Battery HVAC** feasibility study (Knorr-Bremse / CSIRO)

These three Knorr-Bremse projects focus on the key topics of real time heating, ventilation and air conditioning (HVAC) monitoring, battery technologies and HVAC accelerated lifecycle modelling, all of which seek to better understand and provide pertinent data for Knorr-Bremse's commercial benefit.

Financial management

For the year ended 30 June 2018, the Rail Manufacturing CRC expended its financial resources on:

- » contracting new research projects
- » managing and supporting existing research projects
- » awarding and managing student PhD scholarships
- » developing its pipeline of potential new research projects with both existing, and potentially new participants.

Financial performance

For the year ended 30 June 2018, the Rail Manufacturing CRC earned revenue of \$5.44 million and other income of \$0.17 million, and incurred expenses of \$5.61 million, resulting in a \$nil operating profit. Revenue of \$5.44 million comprised \$3.26 million of CRC Programme Funding from the Department of Industry, Innovation and Science and \$2.18 million from participants. Expenditure of \$5.61 million included \$4.21 million of research costs, \$1.01 million of employee benefits costs and \$0.39 million of administration and depreciation expenses.

Research expenditure has increased by \$935,000 or 29 per cent compared to last year, but was \$4 million lower than budgeted reflecting the loss of Faiveley and Simplex as Essential Participants and delays in some existing and anticipated projects.

Cash flows

During the year, the Rail Manufacturing CRC received \$5.68 million of operating cash inflows (inclusive of GST), consisting of \$3.39 million from the Commonwealth CRC Programme, \$2.13 million from participants and \$0.16 million in interest receipts. Operating cash outflows totalled \$4.59 million (inclusive of GST), consisting of \$2.98 million of research payments and \$1.61 million of administration payments. There were no investing cash flows this year.

In-kind contributions

Total in-kind contributions of \$8.18 million for the year ended 30 June 2018 comprised \$7.71 million of staff in-kind and \$0.47 million of non-staff in-kind contributions, being non-cash contributions to the Rail Manufacturing CRC's research programs by research and industry participants, representing contributions of people, equipment and facilities.

Financial position

As at 30 June 2018, total assets were \$13.67 million and total liabilities were \$13.67 million. Total assets are comprised predominantly of cash and cash equivalents of \$12.89 million, trade and other receivables of \$0.31 million, prepayments of \$0.45 million and non-current assets of \$0.02 million. Total liabilities comprised of deferred revenue of \$10.06 million, trade and other payables of \$3.54 million and provisions of \$0.07 million.

Financial issues

The key financial challenges, for the next and subsequent years, in order to meet the Centre's current obligations to the Commonwealth, are to:

- » source and secure additional funding to offset shortfalls due to Essential Participant changes
- » agree and finalise research projects to the value of approximately \$1 million with existing participants
- » source additional funding and projects to the value of approximately \$1.6 million.

CRC future plans and transition arrangements



The Rail Manufacturing CRC began operations in 2014, with a mandate to operate for six years, ceasing operations at the end of the 2019–20 Financial Year.

In January 2018, the Rail Manufacturing Board met to determine the Centre’s future plans to ensure an orderly transition of the CRC’s projects to completion.

Assessing future project opportunities

Ongoing restructuring within the rail manufacturing sector, coupled with shifting trends in Government policy regarding to rail infrastructure and rolling stock procurement, will impact on the domestic sector’s capacity to invest in long-term R&D initiatives for the immediate future. Hence, any future CRC bids should be considered once there is more clarity regarding these factors.

In preparing to close, the Centre is focusing on projects (current or proposed) that:

- » have Rail Manufacturing CRC commitments extending into the 2019–20 Financial Year
- » are of importance to Rail Manufacturing CRC in terms of possible industry funding, commercialisation or that can be readily transferred to a self-funding spin-off company (if applicable)
- » will be entirely industry funded beyond 2019–20 and can continue if funding is forthcoming (in consultation with industry participants), or
- » would be absorbed by the research provider (in consultation with research provider participants).

All other projects are planned to be completed by 31 March 2020.



Train entering level crossing in Melbourne's south

Activities for wrap-up

In the wrap-up of the Rail Manufacturing CRC, the Board and Management team will need to plan and implement shutdown activities covering the Centre's employees, students, existing contracts, Intellectual Property, assets, document archiving and insurance.

Prior to 31 October 2019, the Rail Manufacturing CRC will prepare a schedule, in consultation with the Centre's solicitors, for deregistering the business. The process will take into account the Centre's obligations to its Essential Participants, Members and Other Participants and will incorporate discussions with both the Australian Charities and Not-for-profits Commission and the Australian Securities and Investments Commission to ensure the Rail Manufacturing CRC legal entity is appropriately wound up.

Relating to final year budgets, while at the present time it is not possible to provide an accurate budget for the 2019–20 Financial Year, contingencies have been made

to reserve funds for the necessary legal, financial and auditing services that will be required. It is intended to furnish the Commonwealth with a more substantial final year budget in the latter years of the Centre's operations as further information becomes available.

Other matters for consideration

During its wrap-up post the 2019–20 Financial Year, the Rail Manufacturing CRC will also deliver:

- » an end of funding report provided to the Commonwealth in 2019 in accordance with any future guidelines
- » a post completion report provided to the Commonwealth post 30 June 2020 in accordance with any future guidelines
- » a final Annual Report to the Commonwealth, covering the last Financial Year of the grant period – prior to 31 October 2020.

Performance review

A review of the Rail Manufacturing CRC was conducted by the CRC Advisory Committee in July 2017. Feedback from this meeting was that the Committee was satisfied with the progress of the Centre and that issues raised during the first review in 2015 had been addressed.



Other activities

In 2017–18, no other activities to report.





Glossary of terms

ACRI	Australasian Centre for Rail Innovation
ACNC	Australian Charities and Not-for-profits Commission
AMGC	Advanced Manufacturing Growth Centre
ARA	Australasian Railway Association
ARBC	Audit and Risk Board Committee
ASIC	Australian Securities and Investments Commission
CQU	Central Queensland University
CRC	Cooperative Research Centre
CRRC	China Railway Rolling Stock Corporation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Essential Participant (EP)	Those persons, bodies and organisations who provide essential support (including cash or in-kind contributions) for the activities of the CRC
HVAC	Heating, ventilation and air conditioning
ICN	Industry Capability Network
IP	Intellectual Property
Other Participant	A participant who is not an Essential Participant who has signed an agreement with the CRC
QUT	Queensland University of Technology
R&D	Research and Development
RDBC	Research and Development Board Committee
RDMC	Research and Development Management Committee
RISSB	Rail Industry Safety and Standards Board
RMCRC (or 'the Centre')	Rail Manufacturing CRC
RNBC	Remuneration and Nominations Board Committee
SMEs	Small-to-medium enterprises
TSA	Tyre Stewardship Australia
UQ	University of Queensland
UTS	University of Technology Sydney
UoW	University of Wollongong



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