



Annual Report 2013

Platform Technologies
Research Institute







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Director's Report



Director
Professor Xinghuo Yu

The Institute fosters a dynamic research culture at RMIT through the establishment of disciplinary strategic initiatives across the three RMIT Colleges - Science Engineering and Health, Business and Design and Social Context.

The objective of the Platform Technologies Research Institute (PTRI) has been to take a leading role in research in the integration of smart materials and systems into technology platforms for future industry requirements. An integrated approach is central to the way PTRI undertakes research, focusing on total system performance via a multi-disciplinary approach through coordinated design and fusion of smart materials and systems. The Institute's focus on high impact platform technologies research is reflected in its three key research programs, namely, Informatics and Networks, Innovative Engineering Systems, and Nano Materials and Devices. The key projects within these three programs are concentrated on emerging areas of national and international significance such as aged care, sensing technologies, advanced materials and big data.

The Institute has continued its successes in 2013. For example, PTRI key researchers won 8 ARC Linkage grants (out of 15 RMIT grants) contributing \$2.6m to the total of \$4.7m awarded to RMIT in 2013 - and 10 ARC Discovery

grants (out of 16 RMIT grants) representing \$3.6m out of the \$6.1m RMIT received in this year's round. Furthermore, RMIT was a recipient of 3 Future Fellowship grants and 4 DECRA grants – 1 and 2 respectively involve research aligned with PTRI's focal areas. In addition, two Victorian Postdoctoral Research Fellowships were awarded to PTRI researchers. PTRI researchers also participated in six CRC bids with a successful one in the CRC for Space Environment Management. Participation in six ARC CoE bids led to one successful bid – Nanoscale BioPhotonics led by the University of Adelaide. Two successful Industry Innovation Precinct bids led to the establishment of the Space and Spatial Industry and Sports Technology Industry Precincts.

A number of high impact publications appeared in prestigious journals such as Nature Photonics, Applied Physics and Advanced Materials - an article on 2-dimensional materials also featured as a frontispiece in Advanced Materials. The article received international media attention and was featured in more than 70 media outlets including The Australian and Phys.org.

PTRI researchers and students have also contributed to high impact research. For example, Professor Franz K. Fuss and PhD student Robert Smith from School of Aerospace, Mechanical and Manufacturing Engineering filed a provisional patent on a prototype for a new advanced gym machine - Smart Gym, which is a muscle diagnostics and exercise machine that records muscle data without any sensor. They have been working with Australian Sports Technology Ventures, which commercialises Australian sports technology, on finding investors for the project.

PTRI has in place an outstanding External Advisory Board which assists the Institute in strategic planning and management. The PTRI External Advisory Board meeting was held on 1 October 2013, which was to inform the Board of the progress on the 2012 research proposals and the overall Institute performance over the past year, but also provided a forum for Board members and researchers to work together to establish a more strategic direction for their research.

The Institute has also played an important role in assisting the University to recruit talented new researchers to strengthen critical mass in focal research areas, e.g. Institute Directors participated on the selection panels for the 2013 Vice-Chancellor's Research Fellowships and the Vice-Chancellor's Senior Research Fellowships to ensure the highest quality candidates are appointed

in the relevant areas. Four Vice-Chancellor Research Fellows were appointed to PTRI as a result of this scheme.

In addition, to conduct research that is relevant to industry, builds capacity and has high impact, PTRI appointed two Managers, Commercialisation & Industry Linkage. Their business development activities focused heavily on helping PTRI researchers connect to industry, commercialise their research results and look for new R&D opportunities. Successes include the award of a grant from the Technology Voucher Program of Business Victoria to a project with Breville and Pride Mobility in aged care areas.

PTRI is committed to celebrating its members' research performance, not only through the quarterly Platform Technologies News Newsletter and the Annual Reports but in 2013 PTRI developed the PTRI Research Performance Awards in 14 categories. The award recipients were announced at the Planning Day and details on recipients are available on the website http://rmit.edu.au/browse;ID=3w6etz5nsgzdz#_Awards_and_achievements

In 2013 PTRI introduced the inter-institute project scheme which funded 8 projects which promised to deliver on providing a platform for future research developments and industry funding opportunities in 2014 and beyond.

Another initiative PTRI introduced in 2013 is the Bi-Monthly Networking Seminar Series where young researchers are invited to present on their research and engage with their peers to discuss and establish collaborations for future endeavours. This network has so far been very well received by RMIT's young researchers who also encouraged PhD students to attend and engage in discussions. This activity establishes a research environment which promotes a culture of sharing ideas and collaboration between young researchers and their peers.

2014 promises to build further on our past achievements as the Institute is consolidating its new direction for 2015-2020.



Professor Xinghuo Yu
Director

Research Programs

Informatics and Networks Program



Program Leader
Professor Andrew Eberhard

Program summary

The objective of the Informatics and Networks research program is to develop innovative platform technologies in big data, bioinformatics, network modelling, optimization and dynamics, logistics, media and communication and space science. We aspire to improve the management and systems performance of structured processes to meet surging demands for efficiency, quality and safety in an integrated and environmentally sustainable way.

Key research activities

- Develop tool for big data: research and development for supporting prediction, decision-making and visualisation systems for complex problems. The development of effective and efficient techniques to address the multiple dimensions of Big data. In particular, this group's activities overlap with the work of a number of other themes within the Informatics and Networks program. We explore five main research areas with multiple applications in the field of health, resource management, smart cities, and finance, to mention a few.
- Develop ICT technology platforms for quality ageing that complements what the medical field has done to extend longevity.
- Develop solutions to dynamic logistics problems and create smarter cities and optimized logistics networks.

- The emergence of natural interface technologies, applications that engage with human motivations for competition and fun and ubiquity of cloud based storage which is structuring and diffusing the information with which people work.
- Severe weather event monitoring, modelling and prediction, space environment management and multiple platform earth observation systems. We are working towards developing new methods, new algorithms and frontier technologies for satellite positioning, navigation and timing, space situation awareness (including space object and debris monitoring and tracking, precise satellite orbit determination), space weather and climate change modelling.
- Applied research in network modelling and the optimisation of electricity, transport/distribution, health systems, information, social and economic networks. Applications include epidemiology and biosecurity, e-crime, ecological networks and natural disaster modelling and optimisation and complexity.
- Global collaborative engineering of automation software, cloud-enabled test service for embedded software on physically distant platforms, and architectural design of such globally distributed software-intensive platforms.

The Informatics and Networks program focuses on automation solutions and processes using its strengths across areas combining tools from Big Data, mathematical techniques for analytics, network models, optimisation, computer and software architecture, software engineering, information retrieval, space science and global positioning.

No aspect of human life has escaped the impact of the Information Age, and computers have become available for all aspects of human endeavours, encompassing issues from the personal to global.

This program aims at establishing a world-leading centre of excellence recognised internationally for its cutting edge applied research in 'next generation' informatics and network platform technologies.

Projects and centres

- Australia-India Research Centre for Automation Software Engineering (AICAUSE)
- Applied Logistics
- Big Data Infrastructures - Data Analytics
- Network Modelling, Optimisation and Dynamics (NetMOD) Satellite Positioning for Atmosphere, Climate and Environment Centre (SPACE)
- RMIT Technologies Initiative for Ageing

Informatics and Networks Projects and Research Centres

Australia-India Research Centre for Automation Software Engineering (AICAUSE)

Director: Professor Heinrich Schmidt

Laboratory Manager: Dr Ian Peake

Software Engineer: Lasith Fernando

Research Fellows: Dr Jan Olaf Blech,

Dr Huai Liu, Dr Maria Spichkova

PhD Students: Mohsen Laali, Terry Zhou

The Australia-India Research Centre for Automation Software Engineering (AICAUSE) is a joint initiative of RMIT University, the ABB Group (India and Australia) and the Victorian State Government. Under AICAUSE, RMIT is an ABB partner university in ABB's global research network. The purpose is to incubate AICAUSE as an unincorporated venture and as a lasting research capability in RMIT focused on global collaborative engineering of automation software, cloud-enabled test services for embedded software on physically distant platforms, and architectural design of such globally distributed software-intensive platforms.

Research context

Research is now globally organized and increasingly connected with industry. Deployment of highly skilled and qualified personnel to remote locations for industries such as resources, manufacturing and power generation is an expensive and difficult issue to manage for large organisations. As such there is an emerging trend toward equipment and testing being controlled from a central but remote site. It is ideal if these remote sites are established in a suburban area where the relevant personnel wish to locate themselves and their families.

Remote automation is increasingly software-intensive, however software can be risky and costly to maintain. This is due to complex and non-standardised plant and subsystem requirements, long-

lived systems with changing needs and globally distributed software development, amongst others. The Australian economy in particular is heavily reliant on such industries, yet suffers from remoteness and skills shortages and thus will depend on and increasingly be driven by innovation in automation software.

Although there are already some examples of these technologies deployed in the field, such as for example driverless trains and mobile mining equipment, they are restricted in their scope and functionality, while the technology for remote automation is advancing at a rapid pace. As communications and automation technology evolves, there are increasing opportunities for more impactful industrial remote site-controlled technologies to be put in place in Australia. Eventually this will lead to technology 'trickle down' for the remote community at large. One of the key challenges that faces increased field deployment of more complex remote controlled technology is the integration of software, the overall structure of the software architecture, and the agile collaborative engineering process especially for software development. The Centre is training a number of PhD and post-doctoral staff and these staff are rotated to both ABB Melbourne and India through internships with ABB. The Centre contributes to the development of expert employees for ABB, their customers and other VITELab users. In addition, multiple links with Indian academic institutions have been established to enhance the teaching and research at RMIT.

Research themes

Beside PhD research projects, AICAUSE research is organised in projects either funded by industry partners and/or competitive grants or pre-studies aiming at grant proposals targeting government or industry funding. Current and future specific grant projects and PhD projects focus on the following broad research program themes described in more detail below:

- Parallel and Distributed Platforms Architecture Design
- Cyber-physical Systems

- Verification and Testing
- Virtual Collaboration, Platforms and Agility

Parallel and Distributed Platforms Architecture Design (PADx2)

CPS are widespread in safety-critical domains such as vehicles, production machinery, aircraft or medical devices. Failures of these systems may lead to considerable loss of money or even endanger human lives. This is one of the most challenging areas of system engineering because of the complexity of computing and physical dynamics, especially in distributed control of interconnected systems. The main challenge is to combine two worlds - the physical and the virtual one - to ensure that software components operate in discrete program steps. Meanwhile, the physical components evolve over time intervals in line with physical constraints. Control is increasingly distributed and decentralised requiring the coordination of systems with physical and virtual resources spread across devices and across sites. CPS architecture is concerned with structure and design of these kinds of systems and to develop and improve architecture-centric development processes, which can be adapted and scaled to specific needs of projects.

Areas of specific interest include: software product lines, reuse and evolution roadmaps for self-adapting or fault-tolerant component and service-based architectures, with emphasis on deploying new components in running service-oriented ecosystems.

Cyber-Physical System Verification and Testing (CPSVT)

Current activities include spatial aspects of cyberphysical systems (CPS) and cloud-enabled statistical testing of CPS.

The focus on efficient and effective distributed and remote testing for cyber-physical automation systems (robotics) over clouds is associated with:

- novel testing methodologies for the cost-effective test case selection and light-weight test

- result verification for parallel execution from the cloud;
- enabling testing as a service over the cloud with the aim of improving the testing performance and reducing its cost; and
- the development of cloud-enabled testing reference model to inform CPS design for testing and to increase testability of deployed systems by design.

Research interests in this program include software safety and reliability monitoring for robotic or automated physical systems directly co-operating with humans, operating on humans, or in closest proximity around humans with risks of injury or endangering human lives. The research also focuses on spatio-temporal aspects of model-checking and model-driven testing in addition to novel cloud-enabled statistical testing methods. Furthermore, it looks at cost-effective test case selection and light-weight test result verification for widely distributed systems as well as high-efficacy testing-as-a-service in the cloud for cyber-infrastructure and the architectural design for testability.

Virtual Collaboration, Information Architecture and Agility (VCI2A)

Research on software architecture and its intertwining with multi-domain development processes is central to this research program. Particularly in relation to quality and evolution designed to reduce life cycle costs and increase quality (maintainability, performance, reliability) of similar large scale/legacy automation software systems. Product line architecture is the lingua franca and reference for the views of different stakeholders and formal domain-specific documentation and artefacts from different phases, projects and parties that come together to deliver the overall software-intensive automation project.

Points of interest for this research program include empirical global software engineering research, cloud-enabled virtualisation of laboratories and collaboration, tele-presence and visualisation infrastructures. It also develops agile teams and methods

for rapid software-enabled innovation and productivity gains, with larger numbers of smaller teams operating across time zones, and with very short incremental design-build-and-deploy cycles (measured in hours or days rather than months or years).

Selected research projects

The Centre proposed seven specific projects in 2012 and 2013, two of which were funded by ABB Corporate Research Center India and the global corporate software engineering research program of ABB, contributing to funding both our collaborators in Bangalore and research at RMIT in Melbourne:

- Engineering Tools Product Line Architecture Requirements
- Collaborative Engineering

In addition, for platform architecture aspects, Professor Schmidt is co-investigator in a successful multi-disciplinary USAID grant Decision support tool kit for climate-smart seaports in the Pacific with researchers of the Climate Change Adaptation Program of the RMIT School of Civil, Environmental and Chemical Engineering (SCECE).

Furthermore, the architectural design of our distributed collaboration platform Virtual Interoperation Testing Laboratory and the analysis of various use cases overlaps all three major themes.

Engineering Tools Product Line Architecture Requirements

Work on this project (at RMIT) was completed in 2013 with a final review during an October 2013 visit to Bangalore and final acceptance and approval by the sponsor in 2014. This project provided methodological research support for an ABB product line case study, gathered resources and delivered a vision/concept for a longer term research activity. Approaches included reverse architecting systems of systems from sparse documentation and measurements of binary executions to capture various functional and non-functional properties of such systems relevant to consolidating reusable architecture elements.

Collaborative Engineering

The Collaborative Engineering project explores means for supporting digital collaboration between distributed sites such as production plants for development, operation, maintenance, and services. The RMIT portion of the project has started in late 2013 and is currently funded until August 2014 with AUD 80,000 by the ABB Corporate Research Centre in Bangalore, India. Scientific challenges addressed in collaborative engineering comprise security and confidentiality issues, which are targeted using semantic interpretation and visualisation of collaboration data and formal plant models and exploratory means. In addition to this, the project develops a collaboration show case based on open system software.

Virtual Interoperation Testing Laboratory – Architecture

Stage 1 of the development was largely completed and the requirements and design of Stage 2 started at the end of 2013. T

The architectural design of this platform in collaboration with IT Services and other relevant stakeholder inside and outside RMIT provided a hands-on case across all three programs of the Centre in two ways:

1. application of our research expertise in the analysis and architectural design of this eResearch collaboration platform;
2. tailoring this eResearch platform from requirements gathering to deployment and operation, for use in short-term to long-term industry-focused and industry-driven research.

Achievements

The Australia-India Research Centre for Automation Software Engineering (AICAUSE) was established as a University Centre in 2012 and began its ramp-up in the second half of 2012.

The team has spent most of 2013 establishing an operational structure, resources and facilities. In addition, we completed one and started

two further research projects. Furthermore, we consolidated the research group by hiring postdoctoral research fellows, technical staff and awarding a PhD scholarship.

In December 2013, the Centre held its official launch. The team demonstrated the Stage 1 implementation of the VITELab core capability of cloud support, robotic testing, visualisation and monitoring control facility at the City campus, connecting with sites at ABB Australia and India.

The launch provided guests with an opportunity for networking but also to join a tour of the facilities including our Global Operations Visualisation (GOV), Advanced Manufacturing Robot Interoperation Test (AMRIT) and Cyber-Physical Simulation Rack (CSrack) laboratories located in different places on the RMIT City Campus and in RMIT's Noble Park data centre, respectively.

Through VITELab, RMIT labs are physically connected to labs in ABB Australia and India. Currently, the latter connection relies on ISDN and standard internet, only. It will be upgraded by shaped-bandwidth networking in Stage 2 to support machine-to-machine data and control links and also collaborative visualisation. This will give researchers and students access to ABB's Bangalore testing facility – the largest such facility world-wide in the ABB Group of companies – and provide a world-class platform for global collaborative technology and design projects in research and

teaching. Once fully operational, for research and teaching, the lab will be transitioned into the College of Science Engineering and Health, which will sustain its operation on behalf of the University, like other major University facilities. This will also provide opportunities for full utilisation and a tighter research and teaching nexus around this advanced eResearch facility.

The global research connection of the AICAUSE Centre is demonstrated by its links into the global research network of ABB with headquarters in Zurich, Switzerland, six major R&D labs globally and a large number of university partnerships world-wide.

The AICAUSE research program concentrated existing distributed systems and software architecture research including ongoing PhD projects in distributed service-oriented architecture, safety and time analysis, and fault-tolerance for parallel (cluster and cloud) systems. The latter also dovetail with some hands-on externally funded platform developments in RMIT's eResearch, suitable for empirical studies and evaluations in PhD projects relevant to the Centre.

The Centre's future direction is to consolidate our research program, spin out VITELab into the College of Science Engineering and Health, once it is operational for research and teaching, and to engage with other industries outside ABB. These directions aim at sustainability beyond its incubation funded under the current ABB and State Government grant ending late 2016.



The AICAUSE team at the official launch in December

Applied Logistics

Project leader: Professor Caroline Chan

Research team: Professor Prem Chhetri, Associate Professor Colin Arrowsmith, Professor Brian Corbitt Associate Professor Booi Kam, Dr Victor Gekara, Dr Ahmad Abareshi Professor Shams Rahman

Research context

The objective of the Applied Logistics project is to develop analytical tools and Business IT systems to enhance work place productivity, improve supply chain performance, ameliorate transportation provisions and augment operational efficiency of logistics systems.

In this era of globalisation, demand for unprecedented volumes of business and consumer products and services is creating vast transnational supply chains and logistics networks. Meanwhile increasing urbanization is overstressing the capacities of our cities' infrastructure, landside transport networks, air and sea routes. With increasing trade and growing population come urban planning issues, transportation constraints, engineering challenges and spatial decisions.

Finding solutions to the upgrading of ageing logistics infrastructure and ascertaining the optimal location and development of decisions for creating new urban centres and logistics hubs drives the research agenda for the Applied Logistics projects. In addition, the capacity of Emergency Services Agencies, such as Fire, Police, and Ambulance, to respond effectively is enhanced when these agencies have appropriate information about the likelihood and spatial distribution of emergency calls. Such information can be used to guide optimal resource allocation in anticipation of likely load, and to identify conditions of increased risk, so that preventive strategies can be implemented. The use of technologies such as real time database access and mobile phone provides unhitherto access to information required in the right

place at the right time. While working with many government departments and industry associations, the research project provides research infrastructure to develop applied business solutions to their logistics and supply chain problems. Using RMIT's global presence and its international networks, the research activities of this project are being expanded to resolve various logistics problems internationally.

Research themes

Emergency services management

The aim of this research theme is to use innovative advanced methods of geographic visualisation and spatially based temporal modelling of urban fires to demonstrate the utility of this approach, and to inform response strategies to be developed by Fire Services in the Queensland Department of Emergency Services.

This theme is founded on the basis of two ARC linkage grants with the Queensland Fire and Rescue Services. This research theme develops a better understanding of the vulnerability of critical seaport infrastructure (structural and functional), and to develop new knowledge and methodologies for enhancing port resilience to future climate change. It also incorporates issues on supply chain sustainability.

Skills, Training and Innovation Research Group (STIRG)

This research theme contributes to the skilling and workforce development knowledge base. In liaison with the Transport and Logistics Industry Skills Council (TLISC), which develops national training packages for the sector, training providers and industry employers and employees, the study explored the relationship between skilling and workforce productivity. This research provided an evidence base for the development and focus of skills enhancement and training in the industry.

Data quality in e-supply chain

This research theme focuses on data quality in e-supply chain. The study investigates data quality and standard used in electronic trading

and e-supply chain, particularly in food and healthcare industry. It contributes to the industry through the identification of benefits and savings to relevant industry through the whole supply chain approach ensuring correct information are used and delivered to the right party in the right place at the right time.

Achievements

In 2013 the Applied Logistics project has completed a number of externally funded research projects including:

The Australian healthcare industry data crunch was commissioned by industry under the auspices of the National E-Health Transition Authority (NEHTA) Supply Chain Reform Group (SCRG), and developed in partnership between GS1 Australia, the Medical Technology Association of Australia, NEHTA and RMIT. Three business processes i.e. Procurement, External logistics and Reimbursement of Prostheses, were analysed in regard to data exchange between suppliers and jurisdictions themselves. The report highlights the outcomes that can be gained from an in-depth study about data quality, using analysis of key business processes to identify potential benefit (Project team: Professor Caroline Chan, Associate Professor Booi Kam).

Transport and Logistics Industry Skills Council (TLISC) *Assessing the situation and implications of ageing workforces in the Australian transport and logistics industry*. This study has been commissioned by the Transport and Logistics industry Skills Council (TLISC) to investigate the nature and implications of ageing workforces in the industry (Project Leader: Dr Victor Gekara).

AURIN VicHealth Project: This project developed a set of aggregation and analytical tools capable of integrating VicHealth Indicators Survey data with objective spatial contextual data. This project was funded by Australian Urban Research Infrastructure Network. (Project Leader: Professor Prem Chhetri).

Australian Mathematical Sciences Institute supported a project to develop a conceptual data model to manage flood in the Bass Coast Shire area, to store, retrieve and manipulate drainage asset datasets (Project leader: Associate Professor Colin Arrowsmith).

Research Project supported by the Australian Coal Association Research Program (ACARP) Grant in collaboration with Central Queensland University on *The cumulative impact of growth on regional transport infrastructure: Central Queensland case study* (Project Leader: Professor Prem Chhetri).



Staff recognition and achievements:

Professor Prem Chhetri has been invited to be member of the International Panel of Expert on the EC-funded research project MOWE-IT – Management of Weather Events in the Transport System.

Dr Ferry Jie has received the 2014 Endeavour Award – Research Fellowship (Australian Government), one of five awarded to RMIT. With this award, Dr Jie will conduct research project in Indonesia with Diponegoro University, Semarang, Central Java, Indonesia – as host institution. The project will focus on Australian and Indonesian Dairy Supply Chain Innovation Practices.

Big Data Infrastructures – Data Analytics

Research project leaders: Professor Timos Sellis, Professor Mark Sanderson

Research team: Associate Professor Xiaodong Li, Associate Professor Tao Gu, Associate Professor James Thom

Research context

Big Data is changing the way we solve problems that deal with multiple data dimensions – volume, velocity, veracity, variety and value. In 2013, Big data has been chosen by the Australian government and other organisations as one of the underpinning technologies to take on the challenges of massive data and its multiple dimensions.

The RMIT Big Data project focuses on research and development for supporting prediction, decision-making and visualisation systems for complex problems. We aim to strengthen such an activity by building the infrastructure and technologies behind the analytics capability.

We develop effective and efficient techniques to address the multiple dimensions of Big Data. In particular, our group explores five main research areas with multiple applications in the field of health, resource management, smart cities, and finance, to mention just a few.

Research themes

Complex networks and data analytics: Data analytics is the cornerstone to get insights from data by identifying trends and presenting these findings in an easy and simplified way that everyone can understand. By complex data analytics, the group is providing not only analysis, but also developing algorithms and techniques to handle large and interconnected data sets (graphs). In particular, we investigate efficient indexing techniques, machine learning approaches to assist decision making systems, anomaly detection, and data mining.

Highly streaming data: Current information systems are challenged by processing data that arrives at high speed from sensors, networks, or log files. For example, streams can be generated by users of social networks (tweets, posts), or coordinates provided by tracking devices. Typically, streaming data is volatile, as it rapidly varies. The Data Analytics group designs algorithms that efficiently manage data streams in contexts that require fast response and monitoring.

Data fusion: Data is stored by organisations with different purposes. This fact makes data take up a different format or level of detail (specificity), and at the same time be re-usable or incompatible with other organisations. In order to get insights from data among different repositories and formats, we focus on seeking novel approaches to unify these sources of information.

The Data Analytics group is investigating methods to handle structured and semi-structured data from social network data, scientific papers and geospatial data.

Data access: Security and privacy have been the onus of centralised or distributed information systems, and in the era of Big Data this is not an exception. We study how to safely treat information, how to trace the source of data and ensure its integrity (provenance), how to safely preserve data, or how to efficiently query data sources.

Infrastructure and architectures:

Data is distributed in different locations and new technologies are being investigated to store and communicate large repositories. In addition to this, the Data Analytics group conducts research in cloud computing technologies.

Achievements

The Data Analytics group had a prolific year by collaborating with local and global industry partners, and successful outcomes in ARC programs. Our new projects include:

Real-time analysis systems

In collaboration with the Mornington Peninsula Shire Council, we have developed a learning method to recognise risky driver behaviour from smart-phone sensor input to create a personalised driver advisory system. Other research efforts have focused on creating efficient algorithms to assist location-based applications, in particular of data collected from positional sensors.

Efficient access to data

Dr Shane Culpepper was granted an ARC Discovery Early Career Research Award. The project *Beyond keyword search for ranked document retrieval* investigates efficient algorithms to index and search massive data collections.

Structured and semi-structured data

Professor Timos Sellis and Associate Professor James Thom received a Google Faculty Research Award to investigate mechanisms to enable users to search, combine and interpret tabular data found in collections of scientific papers.

We also design novel approaches to seamlessly integrate location and geospatial information into web search. This research effort is funded by an ARC Discovery Project on *Efficient and effective ad-hoc search using structured and unstructured geospatial information* led by Professor Timos Sellis and collaborating with Dr Shane Culpepper.

In December 2013, Professor Timos Sellis, Dr Jenny Zhang and Dr Lawrence Cavedon participated in RMIT's symposium *Big Data: Good Data, Bad Data* presenting on current research in data analytics.

Professor Timos Sellis also participated in March 2014 in a panel discussion: *Big Data and Analytics - Building Better Businesses, Communities and Lives* as part of the Industry Summit organized by Engineers Australia and Infotech Enterprises.

Network Modelling, Optimisation and Dynamics (NetMOD)

Research project leader: Professor Lewi Stone

Research team: Professor Andrew Eberhard, Professor Kathy Horadam, Professor John Hearne, Professor Liuping Wang, Professor Xinghuo Yu, Associate Professor Vic Ciesielski, Associate Professor Xiaodong Li, Associate Professor Asha Rao, Associate Professor Sergei Schreider, Dr Babak Abbasi, Dr Stephen Davis

Research context

Networks exist as structures in almost all natural and human designed systems including industrial, critical infrastructure, social, biological and economic areas. All these involve global and connected human activities; many are urban. Networks can be designed and their behaviour optimised, predicted, repaired and recovered.

Industrial networks should be designed using smart technologies. Efficient use of water and power networks is critical to climate adaption strategies. These systems need to be optimised for efficiency and robustness. Future cities must better understand and use their distribution and information networks. Health infrastructures and processes can be managed as networks.

Computer networks and the internet control the spread of information across the planet. Social networks facilitate this spread further and have enormous political and social implications. Global security issues, whether it be the threat of terrorist groups, money laundering or computer and infrastructure take-downs, may only be understood and apprehended through the development of methods for studying complex network structures and dynamics.

The objective of the NetMOD research project is to achieve national and international recognition in the field of network modelling, optimisation and dynamics of high-value real networks through research, collaborative partnerships and publication. Applications are made in disaster management and response, management of critical distribution networks (blood supplies), the study of epidemics and disease propagation, the study of computer networks and security and the study of social and economic networks.

Research themes

Based on existing strengths, a set of key NetMOD research directions have been identified for the coming years. These include:

Network theory

Fundamental to the study of networks is the field of mathematical graph theory. Graphs are the most primitive mathematical descriptions of complex networks, and are comprised of a collection of nodes (say players) and edges connecting pairs of nodes if there is some identifiable between them. Graph theory is a systematic study of the structural properties of such networks including questions of connectivity, resilience, cycles, clustering, communities and small world and scale-free features. Powerful mathematical theories built around these properties, and developed at RMIT, are being harnessed for studying real world applications.

Mathematical modelling

In addition to the static underlying graph, many network systems have their own changing complex dynamics. Mathematical modelling techniques are exploited to study and optimise the flow of traffic through a network of roads, or the spread of an epidemic through a population of individuals. Nonlinear mathematical models may be used to fit the dynamical complexities observed in real-world datasets and forecast the future under different scenarios.

Applications currently under investigation:

Computer networks and information security

The spread of malicious computer viruses over networks is viewed as a major threat to global infrastructures. We study mathematical approaches for securing computers/ networks e.g. authentication and cryptography), controlling the spread of computer viruses and maintaining the integrity of the network.



E-crime

Money laundering activities and terrorist network activities both operate actively via the internet, and as such can be traced through the study of large on-line datasets. We are developing sophisticated network tools to locate anomalous activities in typical data sets gathered from banking exchanges and internet activities.

Epidemiology and biosecurity

There is a very active group of theoretical biologists researching the manner in which human diseases spread through population contact networks. We are at the forefront of modelling global pandemics which have the potential to wipe out tens of millions of the human population (as in 1918). The models are being used for exploring mitigation strategies and health policies.

Another ongoing and successful project involves developing new network technologies for improving BioSecurity and BioSurveillance (as funded by the Gates Foundation).

Ecological networks and natural disaster modelling

Advanced environmental modelling requires careful attention to ecological networks. Our research groups are using modern optimisation techniques and Bayesian statistical methodologies to design nature reserves and assess conservation practices under different climate scenarios. Similar spatial network methodologies are required for modelling fire damage scenarios, a major hazard for Australian landscapes. RMIT has a strong group of resource modellers working in these activities.

Optimisation and complexity

Networks that deliver critical infrastructure such as power, telecommunication, transport and water networks are man made and hence need to be designed for efficiency and stability. As these networks change, critical decisions need to be made to optimise these changes subject to constraints imposed by the existing network structure and demands on the systems' operational parameters.

Not only are these systems complex but the algorithms used to optimise these changes have an inherent complexity measure that governs their numerical performance. The ill conditioning of models need careful handling if large scale methods are to be successful. Often these problems are multi-objective and involve integer decision variables. We are developing a new group in the area within the School of Mathematical and Geospatial Sciences and hope to collaborate more with the School of Computer Science and Information Technology's optimisation group in this domain.

Achievements

Victoria Police research grant on *Algorithms for quality assessment of forensic ridge patterns to develop mathematical algorithms and corresponding software close to the proof-of-concept stage that will assess the pattern quality of fingerprints* (Project leader Dr Stephen Davis).

ARC Discovery grant on *Structure inference and adaptive intervention of evolving complex networks to develop a new theory and methodology for the dynamic analysis, structure inference and adaptive intervention of evolving complex networks*. It will place Australia in the leading position of this research (Project leader: Professor Xinghuo Yu).

Research visitor (2013-2014): Dr Lance Fiondella, Assistant Professor, Electrical and Computer Engineering, University of Massachusetts, Dartmouth, USA. Dr Fiondella is a specialist on road and power networks.

Workshops and Conferences

NetMod staff attended a number of national and international conferences:

The Mathematics of Planet Earth 2013 nation-wide conference was held over the entire week 7-12 July 2013. The conference was organised by the Australian Academy of Science. The RMIT NetMod group was highly visible with six presentations at the conference.

Professor Kathy Horadam was invited speaker at the ATN Industry Doctoral Training Centre Research Methods Workshop, Brisbane, 24 January 2013

Professor Kathy Horadam presented on *Influence neighbourhoods in CiteSeer: a case study* at the Complex Networks 2013, Kyoto Japan, December 2013.

Dr Stephen Davis presented at the AMSI Workshop on *Infectious disease modelling*, Newcastle, Australia, 25-27 September 2013.

Associate Professor Serdar Boztas attended the Erdos Centennial Conference in Budapest, Hungary, from 1-5 July 2013.

Associate Professor Serdar Boztas delivered a paper which was published in the Transactions of IEEE International Symposium on Information Theory, Istanbul, Turkey, from 7-12 July 2013.

Associate Professor Serdar Boztas delivered an invited plenary talk at the IEEE International Workshop on *Signal design and its applications*, in Tokyo, Japan, from 27 October to 1 November 2013.

Professor Andrew Eberhard presented on *An interpretation of feasibility algorithms in Integer programming* at the 26th Euro Conference on OR in Rome from 1-4 July 2013.

Professor Andrew Eberhard presented a memorial speech at the Charles Pearce Memorial Symposium in Adelaide on 17 June 2013.

Professor Andrew Eberhard presented in the Optimization of Planet Earth session at the 2013 AustMS meeting at Sydney University from 30 September to 3 of October 2013.

Professor Andrew Eberhard presented on *Augmented Lagrangian dual for integer programming* at the 6th Australia-China Workshop on Optimization: Theory, Methods and Applications at Federation University on 28-30 November 2013.

Professor Lewi Stone presented a plenary talk on *Digital epidemiology* at the Epiwork International Workshop, Turin, Italy, 30-31 May 2013.

Professor Xinghuo Yu presented an IEEE Distinguished Lecture on *Smart grids* at Stellenbosch University and the University of Pretoria, South Africa, 26 February-1 March 2013.

Professor Xinghuo Yu presented on *A new method for DFIG fault ride through using resistance and capacity crowbar circuit* at the 2013 IEEE International Conference on Industrial Technology (ICIT), Cape Town, South Africa, 25-28 February 2013.

On 28 May he gave an IEEE Distinguished Lecture in Ho Chi Minh and also visited the Institute of Applied Mechanics and Informatics of Vietnam Academy of Science and Technology to discuss potential collaborations.

Professor Xinghuo Yu attended the 2013 IEEE International Symposium on Industrial Electronics in Taipei, Taiwan, 29 May - 2 June 2013.

Professor Yu attended the 2013 Asian Control Conference and assisted running the conference as a Technical Program Co-Chair, Istanbul, Turkey, 23 - 26 June 2013.

Professor Xinghuo Yu and Dr Wenwu Yu presented a talk on *A complex networks based approach for modelling and control* at the University of Ballarat, 30 August 2013.

Satellite Positioning for Atmosphere, Climate and Environment Centre (SPACE)

Director: Professor Kefei Zhang

Research team: Dr James Cameron Bennett, Dr Brett Carter, Mr Lucas Holden, Associate Professor Chunsun Zhang, Professor John Le Marshall, Professor Gottfried Kirchengast, Professor Craig Smith, Dr Robert Norman, Dr Witold Rohm, Dr David Silcock, Dr Tzu-Pang Tseng, Dr Carl Wang, Dr Suqin Wu, Dr Shaocheng Zhang, Dr Xingwang Yu, Dr Dongju Peng, Associate Professor Songhua Yan, Dr Falin Wu, Sujun Zhang, Professor Prem Chhetri, Dr Suelynn Choy, Dr Gang-Jun Liu, Dr Yuri Kuleshov

Research context

The Satellite Positioning for Atmosphere, Climate and Environment (SPACE) Research Centre at RMIT University is committed to advancing the global competitive status of the Australian space industry. The main function of the Centre is to perform cutting-edge research into platform technologies for space, atmosphere and climate applications.

The Australian Government has identified Space and Astronomy as one of its National Innovation Priorities, focusing on three core areas; earth observation, satellite communication technologies and commercial precision Position, Navigation and Timing (PNT).

In 2010 the SPACE Research Centre was established at RMIT University to develop new and enhance existing Australian space science capabilities. The Centre's research focuses on the development of platform technologies for space, atmosphere and climate research. The Centre draws together a strong team of national and international experts, with a plenitude of skills and research experience.

The Centre is committed to becoming a serious player in the global space community, conducting world-class and

cutting-edge research, education and innovation activities. The RMIT SPACE Research Centre is working towards developing new methods, new algorithms and frontier technologies for satellite positioning, navigation and timing, space situation awareness (including space object and debris monitoring and tracking, precise satellite orbit determination), space weather and climate change modelling. Research is conducted in the context of new generation global navigation (GNSS) and geo-environmental satellite systems, to support a wide range of applications.

Research themes

The current research themes focus on four main streams:

GNSS/geodesy/surveying

The GNSS/ Geodesy stream aims to investigate platform technologies and innovative algorithms for satellite positioning and tracking, geospatial science, geodesy and industry applications.

Atmospheric modelling

The atmospheric modelling stream explores the nuances and chaotic pattern systems that are an integral part of space weather, climate science, environmental monitoring and precise positioning.

Space debris and tracking and satellite orbit determination

The space debris and tracking stream focuses on the space environment management issues related to the efficient operation and use of space vehicles using precise orbit determination techniques, satellite laser ranging and navigation for debris surveillance, space weather and atmosphere modelling and conjunction analyses.

Smart people mobility and object tracking (Ubiquitous Positioning)

The smart people mobility and object tracking stream aims to develop innovative seamless mobile tracking solutions using GNSS, WiFi, RFID, INS, magnetometers and smart phones etc. These advanced positioning and tracking

platforms will have a wide range of applications including, for example, Olympic competition/ sports activities, location-based services, health care, emergency management and intelligent transportation systems.

Achievements

The SPACE Research Centre has continued to work in collaboration with meteorologists at the Australian Bureau of Meteorology (BoM). This work has been extremely successful and as a direct result of our collaborative research the accuracy in weather forecasting in the Australian region shows that it has improved. This research combines Global Positioning Systems (GPS) and other geo-environmental satellites technologies to enhance the accuracy of weather forecasting models and climate monitoring.

This GPS Radio Occultation research work has been extended into Antarctic weather and climate research using the state of the art earth observation systems.

In the recently released report 'Excellence in Innovation: Research impacting our nation's future – assessing the benefits', the RMIT SPACE Research Centre's case-study submission of 'Improving weather forecasting and climate modelling for the Australian Region

using GPS Radio Occultation' was one of 20 case studies - out of a pool of 162 - classified as having an 'outstanding impact'. The report evaluated research impact case-studies from across the Group of Eight, Australian Technology Network, Charles Darwin University, University of Newcastle and University of Tasmania. The report's findings show that achieving a significant impact from research activities may be harder than achieving an ERA rating of 5.

The SPACE Research Centre has been working with EOS Space Systems Pty Ltd to improve orbit determination and prediction of low-Earth orbit space debris using optical and laser tracking data. Debris objects are uncontrolled and pose a significant threat to future space operations and accurate orbital state information is needed to accurately predict impending collisions with space assets.

Significant advancements have been achieved in orbit determination and prediction accuracy from sparse tracking data for low-Earth orbiting space debris. The data availability for debris objects is usually sparse. The orbit prediction accuracy required for next-generation debris tracking capabilities has been realised, such as unaided debris laser ranging -- where the ground-based tracking laser is fired without the aid of an optical system track.



This will extend operation time of the tracking station which is currently limited to a few hours per day where the object is visible from the ground tracking station and lit by the sun. The results are achievable through the highly accurate tracking data and the availability of an accurate ballistic coefficient which is estimated using long-term two-line element data. The results also have important implications in accurate collision assessments and contribute to an enhanced space situational awareness.

The amount of tracking data needed from individual passes was analysed and it was found only a fraction of each pass was required to obtain similar orbit prediction accuracy than when using full passes. In fact, only 5 seconds of optical and laser tracking data from two passes separated by a day is sufficient to maintain a debris object tracking catalogue. Usually an individual tracking pass is in the order of a minute so the advancements represent a saving of around 92% on tracking time, freeing the tracking station to track more objects in a session.

This research working with EOS Space Systems Pty Ltd has been very successful and we are a major part of a collaborative team that has been awarded more than \$19 million for the establishment of the new Space Environmental Management CRC (SEM-CRC) from the Federal Government.

A dedicated RMIT indoor positioning laboratory was established in 2013 at the Design Hub in collaboration with the University of Melbourne. The lab is the first of its kind in Australia to support ubiquitous positioning and tracking. It is arguably the best indoor positioning laboratory in Australia - RMIT Indoor Positioning Laboratory. A range of up-to-date sensors/systems, such as a fully controlled Wi-Fi network environment, commercial Ekahau System, passive and active RFID, UWB, ZigBee, IMU, USRP, magnetometers, and MiniMax S4 tracking systems, have been set up and tested. Recently these testing facilities were used for a simulation test of customer tracking for a global large shopping mall company who is a research partner of our recently awarded ARC project.

SPACE Researchers have been working with the Victoria-based GPS engineering company GPSat Systems Australia on the topic of GPS scintillation.

This project, which has now been successfully completed, was a key part of the multi-million dollar Australian Space Research Project 'Platform Technologies for Space, Atmosphere and Climate'.

Plasma waves in the ionosphere are known to adversely affect radio waves that transit the ionosphere by inducing random fluctuations in the amplitude and phase of the transmitted signal; this is commonly known as 'scintillation'. The scintillation induced by the ionosphere results in an inability of the receiver to maintain lock on the GPS signal, which reduces the number of 'visible' GPS satellites at any given time. Maintaining lock on a reduced number of satellites significantly affects the receivers' accuracy and performance in precise positioning and timing; two applications used, and heavily relied upon, by many Australian and international industries.

Researchers from SPACE have been studying the statistical occurrence of GPS scintillation events around the globe using the method of satellite-based GPS Radio Occultation, and have developed a global empirical scintillation probability model based on their results. This scintillation probability model is now being used operationally by engineers at GPSat Systems Australia to better understand the environments within which they operate.

Following this project, a key researcher (Dr Brett Carter) in this area has won a prestigious 3-year Victorian Postdoctoral Research Fellowship, and has commenced his overseas assignment at the Institute for Scientific Research at Boston College on the topic of the equatorial ionosphere and its effects on radio applications. It is expected that the knowledge acquired in this project will enable reliable day-to-day predictions of GPS scintillation events, particularly in the Southeast Asian region.

To summarise, 2013 was a very successful year for the RMIT University SPACE research centre. We have taken on a number of major initiatives and the two highlights of our achievements are the successful completion of the large ASRP project and being awarded the new SEM-CRC. This is in addition to our 'outstanding' ranking in the Excellence in Innovation Australia (EIA) trial, ARC application and research fellowship successes.

Further information is available on the website: www.rmit.edu.au/SPACE

RMIT Technologies Initiative for Ageing (TIA)

Research initiative leader: Professor Athman Bouguettaya

Research team: Professor Dinesh Kant Kumar, Professor Mark Sanderson, Professor Timos Sellis, Professor Zahir Tari, Professor Nilmini Wickramasinghe, Associate Professor Tao Gu, Associate Professor Lina Shawan-Akl, Dr Ibrahim Khalil, Dr Caspar Ryan

Research context

The ageing of Australia's population will call for the provision of aged care services to much larger numbers of people over the next few decades. Services will also need to meet the challenges posed by the increasing diversity of older people in terms of their care needs, preferences and affluence. It is clearly important that our aged care sector is able to meet these challenges in ways that promote the wellbeing of the oldest generation, while being cost effective for the community as a whole.

The Australian Government's cost for aged residential care is fast rising from \$8.7 billion in 2011-12 to \$9.2 billion in 2012-13. Government deregulation provides tremendous opportunities for the private sector to substitute part of the aged care with technology solutions. However, this is still limited to fragmented solutions which are unable to address the multitude factors of a holistic approach.

The RMIT Technologies Initiative for Ageing (TIA) is focused on developing the future generation of IT solutions for the well-being of older persons through multidisciplinary research for age-care services. TIA focus on emerging technologies and platforms, drawing on expertise from RMIT's capabilities in service computing, security and privacy, design, sensor networks, and aged care studies, intelligent systems, and business models. It explores new modes of interactions in multi-faceted environments where senior citizens naturally and non-invasively interact with the healthcare system through multiple channels.

Research themes

Preventive health

The preventive health stream aims to develop physical wellness and cognitive fitness technologies to maintain and improve both physical and cognitive

health, with emphasis on preventing or delaying chronic diseases and aged related frequent diseases.

Assistive technologies include a wide range of sensors, devices, information and communication technology to deliver customized care enabling the increasing numbers of dependent older people to continue living in their own homes, rather than in nursing homes or hospital settings, and social networking technologies to secure active ageing and avoid isolation.

Recovery health

The recovery health stream aims to develop technologies such as remote monitoring, m-health, telemedicine, data management, and data analytics to manage and monitor a range of health conditions that extend the reach of services, reduce the need for face-to-face consultations, enhance proper and timely diagnosis and treatment (use of protocols) and thereby contribute to maintaining older people’s independence and safety.

Achievements

During 2013-2014 fundamental multi discipline research dynamics from across RMIT have invested in the development of novel ‘Gerontechnology’ ideas. Discussions with government and private organisations such as Benetas, National Ageing Research Institute (NARI), CSIRO, Council on the Ageing (COTA) as well as with local councils and communities have led to the development of a State of The Art of the Ageing Era framework with the Mornington Peninsula Shire (MPS) as the leading strategic partner. The RMIT Technologies Initiative for Ageing (TIA) through the partnership with MPS aims to become a role model for Technology for Aged Care, with national and international accreditation.

During 2013-2014 summer semester, student projects were focused on the development of mobile apps for the ageing with a user friendly interface in the following areas:

Fall Detection

Supervisors: Andy Song, Flora Salim, Margaret Hamilton

This is a smartphone app that detects falls and alerts people around them with an auditory signal. If there is no response received on the app after a fall event is detected, the app sends a notification to carers or their family members. Users of the app are also able to view how

active they are as the app monitors daily activities, such as walking and running.

Sleep Well

Supervisors: Flora Salim, Andy Song, Margaret Hamilton

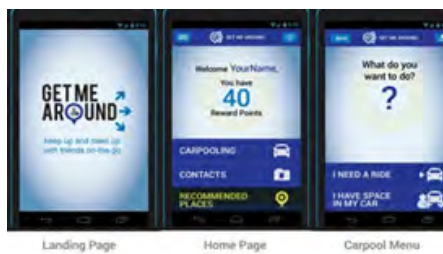
This technology is a non-invasive sensor module to monitor your sleep patterns based on the movement and vibration analysis from the sensor readings. The sensors are designed to be placed on top of a bed, under a bed sheet. The results of the analysis can be visualized on a web portal.



Get Me Around

Supervisors: Margaret Hamilton, Flora Salim, Andy Song

This is a smartphone app to help elderly users to plan their journey either by using public transport or carpooling. Using the app, elderly users can also find their friends to arrange catch ups at nearby cafes or restaurants, or plan their journeys together.



Further collaboration has been initiated between three of the four research institutes at RMIT, including Platform Technologies, Health Innovations and Design on various research topics including a) Digital Transportation b) Digital Social Inclusion and c) Digital Wellness Tools.

The RMIT Health and Ageing Forum which was held in February 2014 identified a number of digital health related research, patents and/or devices available at RMIT (not necessarily related to aged care), which may find new markets through the RMIT Technologies Initiative for Ageing and the related industries. These include contributions from:

- **The School of Computer Science and Information Technology** (cloud software architectures, service computing, data management, information retrieval, search engine, distributed systems, mobile and pervasive computing, sensor networks, machine learning, healthcare applications): Professor Athman Bouguettaya, Professor Timos Sellis, Professor Mark Sanderson, Professor Zahir Tari, Associate Professor Tao Gu, Associate Professor Xiaodong Li, Dr Ibrahim Khalil, Associate Professor Margaret Hamilton, Dr Flora Salim, Dr Andy Song
- **School of Business IT and Logistics** (healthcare technology, computer education, digital business, information and knowledge management, systems, models and strategies): Professor Caroline Chan, Professor Nilmini Wickramasinghe, Professor Mohini Singh, Dr France Cheong, Dr Christopher Cheong, Dr Say Yen Teoh, Dr Sasan Adibi
- **School of Electrical and Computer Engineering** (biomedical engineering): Professor Dinesh K. Kumar, Dr Sridhar Arjunan, Dr Dean Cvetkovic, Dr Heiko Rudolph, Professor Hong Ren Wu, (medical and rehabilitation devices) Dr John Fang, Dr Hans Permana, Mr Xie Xiang, Mr Yinjun Tu
- **School of Aerospace, Mechanical and Manufacturing Engineering** (sports engineering): Professor Franz K. Fuss, Professor Aleksandar Subic, Professor Sabu John, Associate Professor Firoz Alam, Associate Professor Lachlan Thompson, Dr Monir Takla, Dr Pang TohYen, Dr Milan Simic
- **School of Fashion and Textiles** (body centric lab: functional clothing and human environments), Associate Professor Olga Troynikov

RMIT’s partnership with MPS seeks to develop technologies to support all Ageing challenging topics as expressed by MPS.



Innovative Engineering Systems Program (IES)



Program Leader
Professor Franz. K. Fuss

Program summary

The objective of the Innovative Engineering Systems program is to develop an interdisciplinary approach to design, development and operation of large scale systems effectively in the areas of advanced manufacturing, sports engineering technology, advanced energy systems and innovative structures. The program is focused both on fundamental (modelling and simulation) and applied (design, development, testing and manufacturing) research leading to advanced and innovative technologies and products, with impact in various areas such as medicine, health, life style, architecture, production, aerospace, sport, defence and energy.

Key research activities

- Fundamental research into new multifunctional materials and structures and their applications, including energy absorption.
- Development of sustainable energy focusing on fundamental energy science, applied technologies and systems and sustainable energy design, policy and assessment research.
- Sports engineering and smart technology, human movement and sports science, customised design and sustainability of sports products, with focus on smart equipment for health and sport, and sports aerodynamics
- Design, operational, optimisation, manufacture, and applications of Unmanned Aircraft Systems.

Projects and centres

- Advanced Polymeric and Metallic Structures
- Centre for Innovative Structures and Materials (CISM)
- Sports Technology
- Sustainable Electrical Energy
- Unmanned Aircraft Systems (UAS)

Innovative Engineering Systems Projects and Research Centres

Advanced Polymeric and Metallic Structures

Research project leader: Professor Milan Brandt

Research team: Professor Mark Burry, Professor Mark Easton, Professor Dougal McCulloch, Professor Ma Qian, Professor Aleksandar Subic, Professor Mike Xie, Professor Irene Yarovsky

Research context

The objective of the Advanced Polymeric and Metallic Structures research project is to undertake innovative fundamental research into new multifunctional materials and structures and their applications towards technologically and socially important problems, in particular for the defence, medical and automotive sectors.

To remain competitive, Australia must focus on manufacturing products at the high value end of the market such as knowledge rich products. To facilitate this, the manufacturing enterprises of the future will be small to medium sized with a focus on exporting goods at a global level. The global market for additive manufacturing will reach US\$3.5 billion by 2015.

RMIT has established the Advanced Manufacturing Precinct (AMP), a world class research facility with a focus on additive manufacturing delivering research outcomes in the areas of advanced digital product design and advanced materials manufacturing analysis (RMIT Microscopy and Microanalysis facility).

These facilities enable the research group to provide strategic support for new industry capabilities which includes industry relevant project based learning (integrating all levels from Vocational Education to postgraduate) and training tomorrow's designers, engineers and technicians.

Research themes

The current research themes focus on three streams:

Metal composites

The metal composites stream aims to develop novel metal composite structures which are high impact damage tolerant and energy absorbing and also have the ability to carry structural loads due to a significant system-level weight reduction. The relevant research focus areas are materials and manufacturing optimisation, surface interface/bio integration and structure property optimisation.

Polymeric composites

The polymeric composites stream aims to develop novel low cost, high volume polymeric composite structures which are high impact damage tolerant and energy absorbing and also have the ability to carry structural loads due to a significant system-level weight reduction. The relevant research focus areas are resin science (renewable, rapid cycle-time) and the ability to manufacture low cost technologies.

Multifunctional composites

The multifunctional composites stream aims to develop novel multifunctional composite structures which are light-weight, feature conformal load bearing antennas and wireless strain sensing. The relevant research focus areas are structural-electrochemical and electromagnetic structural optimisation.

Achievements

We continue to build momentum in 2013 in additive manufacturing through the appointment of new professors Ma Qian and Mark Easton and research staff and the procurement of equipment at the Advanced Manufacturing Precinct. New industry based projects supported by BAE Systems and DSTO were initiated to investigate fundamental aspects of manufacturing and topology optimisation of aluminium alloy structures using the Selective Laser Melting equipment and the repair of aircraft components using

the new TRUMPF laser additive equipment at the Precinct. The PhD projects on the manufacture of hybrid composite/metal bio inspired structures for aerospace applications and just in-time patient specific implants involving St Vincent's hospital are progressing well. A provisional patent on the just in-time implants was lodged.

The group has submitted a proposal for a new RMIT Centre on Additive Manufacture to further strengthen RMIT's position in this area. The Advanced Manufacturing CRC rebid for a new CRC on additive manufacture was not successful however the team was advised to merge with a competing bid Manufacturing Industry Innovation CRC (MIICRC) and resubmit the application by end of May 2014 for further consideration. Professors Aleksandar Subic and Milan Brandt have been involved in the discussions on the new bid.



Centre for Innovative Structures and Materials

Director: Professor Mike Xie

Researchers: Professor Chun Qing Li, Professor Sujeeva Setunge, Dr Xiaodong Huang, Dr Jie Yang, Dr Gang Ren, Dr Ricky Wing Ki Chan, Dr Shiwei Zhou, Dr Jianhu Shen, Dr Zhihao Zuo

Research students: PhD candidates: Mr Arash Ghaedizadeh, Hadi Latifi, Yan Li, Sen Lin, Mr Dingjie Lu, Mr Arash Radman, and MEng candidates: Xuran Du, Mr Mohammad Yazdanpanah

Research context

The objectives of the Centre for Innovative Structures and Materials (CISM) are to conduct internationally leading research on techniques for creating innovative and efficient structures and materials, to develop novel structural systems and alternative materials for a sustainable future, and to combine research excellence with industry engagement. CISM was established in July 2012 following significant research outcomes achieved by its predecessor, the Innovative Structures Group.

Members of CISM have conducted pioneering work on the theoretical development and practical application of various structural optimisation techniques. These techniques have been widely used around the world by engineers and architects to design innovative buildings and bridges, and to create new microstructures of materials and composites.

CISM researchers have been awarded 17 major grants by the Australian Research Council (ARC). Recent projects funded by the ARC include topology optimisation of load-carrying structural systems with periodic geometrical patterns, optimisation of building structures considering wind loading, design of microstructures for materials and composites with exceptional functional properties, and topology optimisation for advanced

engineering nanostructures.

Financial support to the research team has also been provided by various companies such as Boeing, Arup, and Felicetti.

Research themes

The Centre's research themes are as follows:

- Shape and topology optimisation of a wide range of engineering structures.
- Conceptual design of buildings and bridges using topology optimisation techniques.
- Design of microstructures of materials and composites for enhanced performances.
- Static and dynamic testing of biological and man-made materials.

Achievements

During 2013 the Centre was engaged in a range of research projects. Several examples are given below.

Concurrent topology optimisation of structures and materials

We have developed a hierarchical concurrent design approach to maximising the stiffness or natural frequency of a structure. Multiple material phases are considered in the topology optimisation which is performed on both macro and micro scales. The design of the macro structure and the material micro structure is coupled. The effective material properties of the periodic micro structure are integrated into the analysis of the macro structure. In turn, the micro sensitivity makes use of the macro structure displacement field so that the global static and dynamic properties such as the stiffness and frequency are taken into account in the local topology change on the micro scale. Various design problems of cellular and composite structures and materials have been solved which demonstrate the capability and advantages of the approach.

Design of materials with exceptional properties

In this project, we have developed a series of new materials with unusual mechanical properties. We have extended the concept of buckling-induced-pattern-switch to the design of novel three dimensional metamaterials with negative Poisson's ratios over a large strain range. The highlight of this work is that our designs are based on very simple initial geometric shapes. Using topology optimisation techniques, we have also obtained metamaterials with negative linear compressibility, negative area compressibility, zero linear compressibility, and zero area compressibility.

Application of structural optimisation techniques to the design of bridges and buildings

Structural optimisation techniques have reached a certain level of maturity and their applications in architecture and civil engineering practice have increased in the past decade. In this project, we have applied the Bi-directional Evolutionary Structural Optimisation (BESO) technique to the design of bridges and buildings. The design applications aim to find the stiffest form of bridges and buildings under different geometric, constructional and loading conditions. A series of innovative bridge and building design concepts have been obtained.

This research has clearly demonstrated the benefits and potential of using topology optimisation in engineering and architecture.

The work shown below was part of a joint project between Professor Mike Xie's team and BKK Architects for a proposed footbridge in Suzhou, China.

Further information is available on the website:
www.rmit.edu.au/research/cism

Example - a structurally optimised bridge



Sports Technology

Research project leader: Professor Franz Konstantin Fuss

Research team: Professor Aleksandar Subic, Professor Stephen Bird, Professor Aaron Smith, Associate Professor Olga Troynikov, Associate Professor Anthony Bedford, Associate Professor Noel Lythgo, Associate Professor Firoz Alam, Dr Florian Mueller, Dr Amanda Benson, Dr Michael Azari

Research context

The global sports business is worth US\$800 billion annually and is as big as the global aerospace industry. Participation in sport is becoming more important for prevention and treatment of chronic diseases such as type II diabetes, cardiovascular diseases and obesity, and thus is expected to have a positive impact on national and global health budgets.

The global sports industry is growing faster than the overall GDP, between 1.6 - 8.2 times as fast, depending on the country. The Sports Technology research project 'SportzEdge' hinges on three complementary areas in which RMIT University is world leading: sports engineering and technology; human movement and sports science; design, customisation and sustainability of sports products. The aim of the project is to develop innovative sports products for performance enhancement and optimisation of training such as smart or customised equipment, with impact on health, participation and injury prevention.

Research themes

The collective research experience at RMIT extends to three different, yet complementary areas of sports science and technology:

1. **Sports technology:** engineering design, customisation, optimisation, manufacturing and testing of sports equipment; sports aerodynamics, smart and instrumented sports equipment, training devices, sports statistics.
2. **Sports science:** exercise physiology, biomechanics, motion analysis and kinesiology, sports nutrition.
3. **Sports design:** sports garments design and engineering, textile materials and composites, exertion games, stadium design.

Due to research and development carried out in different schools, the holistic, multi-, inter- and trans-disciplinary approach to Sports Research at RMIT is world leading. The sports technology and sports apparel branch is represented by the 'SportzEdge' project.

Achievements

Customised wheelchair design

The Customised wheelchair design for disabled athletes project has four interconnected projects:

- The Customisation of sporting wheelchair for individual athletes project identifies the key geometric parameters in customising a sport wheelchair to suit the specific needs of individual athletes and proposes a tool that can be used to drive a parametric design platform.
- The Customisation platform for rugby wheelchairs project involves research and development of suitable equipment that can be used to measure and record relevant wheelchair performance data in a laboratory environment.
- The Advanced wheelchair ergometer project combines customised rugby wheelchair design and a wheelchair ergometer for performance diagnostics and optimisation of wheelchair athletes, by adjusting the geometry of the modular wheelchair and measurement of performance with the wheelchair ergometer.
- The Customised design of lightweight and low-cost racing wheelchairs project aims to research and develop lightweight and cheap racing wheelchairs by applying aerospace design principles and materials in order to improve the performance of wheelchair athletes and to make the wheelchairs affordable to disabled athletes. In addition, the wheelchairs will be instrumented with wireless sensor technology, capable of recording, identification and visualisation of relevant wheelchair performance data in a field environment, based on an advanced software package.

Dynamics of sports balls

The Dynamics of sports balls project involves research of solid mechanics and aerodynamics of sports balls such as: cricket balls, rugby balls, AFL balls, baseballs, tennis balls and golf balls. The project serves various purposes,

e.g. to increase the speed of a ball game (by improving the grip and reducing the aerodynamic drag), to identify and measure performance parameters of balls, to quantify the consistency of manufacturing, and to develop new construction- and performance-based standards for sports balls.

The SportzEdge team tested all World Cup and Euro Cup soccer balls in the RMIT Industrial Wind Tunnel and found that the 2014 world Cup Ball – Brazuca – is better designed than the balls of the two previous world cups, as it exhibits less of a knuckling effect.

Smart Sports Equipment

The RMIT Smart Cricket Ball

The smart cricket ball was CNC machined, such that three gyros, a data logger and a battery fit into the ball without compromising the standard mean mass of 159.5 g for men's cricket games after balancing the ball. The data was processed with a program incorporating newly developed signal processing techniques for this particular purpose. Signal processing is based on new mechanical and mathematical principles developed as part of the project.

The following performance parameters were graphically visualised in 4D in AutoCAD: location of the instantaneous spin axis, magnitude of spin rate, direction and magnitude of the spin axis' precession (finger and impact), direction and magnitude of the torque imparted to the ball (finger and impact), location of the centre of pressure (point where resultant force is applied to the ball) of the fingers and of the impact point. The second prototype is wireless and re-chargeable inductively, and equipped with customised 4D software for data analysis. It is currently used in collaboration with the University of Sydney for classification of slow bowling deliveries.

The Smart Gym

The smart gym project anticipates the future of exercising at different levels, from elite athlete over recreational sports person to elderly citizens and rehab patients. The project involves research in and development of electronic muscle exercise machines capable of automatic adjustment to any exercise level, of muscle performance and fatigue diagnostics, and measurement and recording of muscle exercise data. The system allows electronic data management and storage via sophisticated software.

The Smart AFL Ball

The smart AFL ball was instrumented with three gyros, a data logger and a battery, and was designed to establish a kick precision index, for ranking the precision of drop- and torpedo punts. Even in top AFL players, the drop punt was far from being kicked accurately, as it exhibited considerable ball wobble.

The Smart RMIT Insole

The smart insole measures the pressure distribution across the foot sole at a high resolution (currently 150 sensor nodes) and data sampling frequency, and costs as little as \$3. The customised software returns high precision at not only the pressure distribution but also the centre of pressure, and is validated with a conventional force plate. The insole is used for establishing a fall index for real time measurement with biofeedback, and for management of diabetic foot sole ulcers (prevention, diagnosis, treatment). RMIT University joined the Wound Management Innovation CRC in February 2014, and one of their projects is utilising the insole for wound management.

The RIZMIK Insole

The RIZMIK Insole converts pressure to sound, thereby encouraging physical activity as well as musical performance. The musical art behind the system is produced by a famous Melburnian composer.

Friction and Sports Equipment

Friction between hands, gloves and sports balls is essential for gripping, passing and catching/marketing of balls. The better the grip, the faster the game, and the more exciting it is for the spectators. SportzEdge measured the non-linear velocity- and force-dependent friction of rugby balls against the skin and optimised the pimple pattern; of water polo balls under wet conditions; and a variety of gloves against AFL balls. The latter study led to the regulation of gloves by the AFL in January 2013, which banned all gloves of a coefficient of friction larger than one in dry conditions.

Vibrations and sports equipment

Vibration of equipment leads to energy loss and uncomfortable feeling. The SportzEdge team investigates the vibrations of a range of tennis racquets and snowboards. For example, the team developed a standardised test for assessment of the edge grip in snowboards.

Foams, energy protection and injury prevention

The SportzEdge team investigates the non-linear visco-elasticity of different foams under compression and impact in terms of energy absorption potential (shoulder ratio), optimal compression strain and head injury criterion. The team developed a data base specifically for head gear designed for rapid selection of foams and other energy absorbers for various applications and impact energy levels. Non-linear modelling of various energy absorbing systems assists in optimising injury prevention.

Development of a sports shoe with directional energy transfer and return

The Development of a sports shoe with directional energy transfer and return project is based on a new concept and principle of directional energy transfer. The project involves the discovery of design solutions for directional energy transfer for sports shoes, optimisation thereof and development of prototypes. The design overcomes the disadvantage of conventional sports shoe soles; that the energy put into the sole in one specific direction is not transferred into the direction in which the energy should be returned. The new sports shoe sole improves the performance of athletes by optimised recycling of the athletes' energy and by avoiding energy waste. The directional energy transfer and return is destined to be customised for different athletes and their running styles.

Kansei Engineering of a new concept running shoe

The Kansei Engineering of a new concept running shoe project is based on a Japanese product design method that seeks to develop products which 'feel right' to their intended user. This is done by mapping the emotional needs and expectations of the specific user group to the functional and technical attributes of the product, which are then adjusted accordingly to optimise the feel and performance. In this project, Kansei methods and user-centred design processes are being applied to develop a new concept running shoe that best

meets the requirements of a specific ability-based user group.

Exertion Games Joggobot

We believe that in the future, exertion activities will become a new experience, involving interactions with autonomous embodied systems. Our vision is to develop Joggobot, an autonomous flying quadcopter that exemplifies our thinking about the combination of robotics and physical exercise. We use Joggobot to ask the question how (and if) robots should support us when exercising. As such, Joggobot helps us to understand the interactions between a person and a robot. We believe robots have been so far mainly investigated from a perspective where they do tasks for us we do not want to do: vacuuming floors, going into war zones, and cleaning up nuclear power plants. With Joggobot, we want to propose the idea of robots as companions for physical activity. This is important, as we know from sports research that social factors are the key when it comes to exercising.

Copy Paste Skate

Copy, Paste, Skate explores how interactive technology can support the experience of doing Skateboarding tricks. It pushes the envelope of interactive technology used in sports, venturing out of the well familiar grounds of systems for performance focused sports (think of the many systems for joggers for example) and into the realm of trick-focused sports.

The Copy Paste Skate system offers skaters novel ways of re-living their tricks right after they have attempted them. Our system addresses the full scale of senses vital to skating: hearing, vision and touch.

Over 20 local skaters have put Copy Paste Skate to the test, and many of them talked about how the system 'brings the tricks to life' and 'adds a new level to the skateboarding experience'.

Aerodynamics of Winter Sports Snowboard Cross (SBX) and Ski Cross (SX)

The Aerodynamics of Winter Sports Snowboard Cross (SBX) and Ski Cross (SX) are relatively young winter sport disciplines, represented at the Olympic Games since 2006 and 2010 respectively. Although freestyle disciplines, there is no judged component and the first athlete who crosses the finish line wins. Speed is the only performance parameter; however, in contrast with alpine skiing, SX garments must be loose and floppy by rule.

The project started in October 2010 with wind tunnel testing of the national SBX and SX team. The researchers tested conventional and new skiing positions in relation to 3D aerodynamic forces as well as different garments. The significance of differences in drag and lift force was assessed by a glide model which quantifies the advantage as a gain in distance.



Testing of loose fabrics on cylinders revealed that flutter is not necessarily a disadvantage. Several fabrics actually reduced the drag force, which is a new aerodynamic discovery. The project is ongoing and aims at fundamental research as well as at developing new winter sport garments for the Sochi 2014 Olympic Games.

Design and development advanced ski jump suits research

Design and development advanced ski jump suits research project develops a ski jump suit which improves aerodynamic performance by utilising aerodynamic advantages of seams and fabric surface structures. The aerodynamically improved suit must not be different from existing suits and comply with current FIS regulations. These restrictions compel finding a solution using existing ski jump suit materials (fabrics). No new materials which are different from current fabrics' physical properties can be used. The engineered suit is to have possessed current comfort and ergonomic attributes.

Sleep and recovery: a new frontier in human and sport performance

Sleep as a measure of health and well-being is being increasingly looked upon as one of the most crucial human necessities. The influence of sleep on post-exercise recovery and human performance is a topic of great and growing interest, as the recent body of scientific research confirms a link between sleep quality, cognitive processes, tissue recovery and metabolic function.

Sleep restriction and poor sleep quality are the key sleep attributes that affect the overall recuperative quality of the sleep state and influence personal well-being and human productivity.

A Research Project conducted by the Body-Centric Research Group led by Associate Professor Olga Troynikov from the School of Fashion and Textiles is addressing different thermal bedding environments, their interaction with the metabolic heat and sweat production in next to skin

microclimates, and resultant next-to-skin microclimate comfort levels.

The project is focused on objective evaluation of thermo physiological sleep comfort and the thermal and moisture balance of the human body in relation to the sleeping environment, and the heat and moisture management within the sleeping "pocket".

Similar to the wear comfort for clothing, the project investigates the ability of the bedding to maintain a comfortable body temperature during different dynamic phases of sleep and ultimately to develop bedding suitable to individual's needs and physiological attributes. The hope of this research is to optimize sleep bedding systems to assist in providing sleep quality that will maximize post exercise recovery and improve cognitive processes. The project is in collaboration with Australian Wool Innovation.

Alcohol and drugs in sport - alcohol-related player behavioural transgressions

This project examines fan social media responses to media-reported player behavioural transgressions which occurred in Australia's two largest professional sporting leagues, the National Rugby League (NRL) and the Australian Football League (AFL), over a 33 month period. Using netnography and content analysis, we aim to better understand the ways in which sport fans employed social media to voice their perceptions about alcohol-related player transgressions.

Exploring the use of sport-linked alcohol marketing via social media

This project seeks to identify, evaluate and catalogue how alcohol companies use social media marketing activities to create promotional leverage from their associations with professional sport. This study adopts a 'netnographic' approach, which modifies traditional ethnographic research methods in order to examine online messages and social media communities. It identifies the most prevalent forms

of social media for sport-linked alcohol promotion and undertakes a software-aided content analysis to expose themes from online text and images regarding types of promotion and messages. The research scopes the prevalence and nature of sport-linked alcohol promotion via social media platforms and develops the first ever inventory of this activity, providing data to shape discussions around harm reduction, implications for public policy, and recommendations for larger-scale research.

Drugs in sport

This project focuses on drug use in sport, but unlike other works addressing this problematic issue, we aim to de-mythologise the assumptions that prop-up the current drug controls in sport, and argue for a legitimate space for their use. In taking this position we not only explain the flaws and contradictions in the current anti-doping policies, but also reveal their adverse consequences for the long term well-being of athletes, including how they damage athletes' reputations and civil rights. In short, we provide workable policy options that 1) safeguard sport participation, 2) ensure the on-going value of sport-brands, and (3) protect the physical health and social liberty of athletes and players.

Sustainable Electrical Energy

Research project leader: Professor Grahame Holmes

Research team: Professor Ralph Horne, Professor Heinrich Schmidt, Professor Xinghuo Yu, Associate Professor John Andrews, Dr Manoj Datta, Dr Nuwantha Fernando, Dr Brendan McGrath, Professor Alan Pears, Dr Yolande Strengers, Dr Richardt Wilkinson

Research context

Electrical energy underpins almost every aspect of our modern technological society. But most electrical power is currently created by large fossil fuel power stations, and then dispatched to our homes through large long distance transmission systems that are expensive, inefficient, and detrimental to our environment. The aim of the Sustainable Electrical Energy initiative at RMIT is to help facilitate a transformational change in the supply, delivery and usage of electrical energy that will provide an environmentally friendly and economically sustainable long term future.

Electrical energy is essential for a modern society to survive and grow. However, the present global supply and demand paradigm is unsustainable – electrical energy demand keeps rising, greenhouse gas emissions associated with fossil fuel add to global warming, and much of the present electricity supply and delivery infrastructure is near the end of its useful life and requires replacement. One of the major global challenges of the 21st century is to find a way to meet our future energy needs without continuing to pollute our planet.

Consequently, the search is on around the world for environmentally friendly and sustainable sources of electrical energy, and the associated methodologies and technologies that can best use this energy.

The process of transforming our electrical energy systems to a sustainable future requires cross-disciplinary collaboration between universities, industry, government and consumers. Advances in basic technologies such as energy storage and conversion, must be combined with applied knowledge and innovations, to achieve practical and effective outcomes that will make a significant contribution and impact. Policies and regulations then need to be re-formulated to take advantage of these advances. Finally, there is an urgent need for consumer education and increased awareness, so that the available electrical energy is used to its best possible advantage.

RMIT University's unique combination of fundamental researchers, applied technologists and social scientists creates a golden opportunity to make a major contribution to this transformational process. The Sustainable Electrical Energy initiative provides the framework for these diverse discipline areas to come together and work to achieve a sustainable electrical energy future for our society.

Research themes

There are three research themes within the focus of the initiative:

1. **Fundamental Technologies**

The Fundamental Technologies theme links together current RMIT research activities relating to the supply and delivery of electrical energy using power electronic conversion systems, with energy storage using hydrogen and other advanced battery technologies.

The broad objectives of this program are to achieve significant fundamental advances in these technologies, and to facilitate their integration and usage into real world electrical energy distribution systems.

2. **Smart Grid Complex Systems**

The 'Smart Grid' Complex

Systems theme encompasses and expands current RMIT research activities into complex systems, with a particular focus on the smart energy and smart grid concepts that are currently attracting increasing attention around the world, and the complex systems theory that is required to make them viable. The theme enfolds electrical power systems with large scale system control theory and wide area communication technologies, working to facilitate the integration of widespread distributed generation from renewable sources such as PV arrays and solar concentrators into our electricity distribution networks.

The broad objective of the program is to work in a larger scale context with energy utilities, industrial partners, other research agencies and government departments towards a transformational change in the way in which electrical energy is created and supplied to a modern society.

3. **Sustainable Energy Design, Policy and Assessment**

The Sustainable Energy Design, Policy and Assessment theme builds on current RMIT expertise in the social science perspective of Demand Side Energy Management and the analysis of Electrical Energy usage. This program focuses on the other side of the balance equation between electricity supply and demand, looking to achieve more effective end-user utilisation of electrical energy by increased uptake of energy management technologies, and increased public awareness about the linkage between consumer behaviour and total energy use.

The broad objectives of this program are to promote better understanding of policy and

other non-technical issues associated with the sustainable usage of energy, to facilitate and support industry and community assessment of energy needs and usage, and to assist governments to create more informed policies that better support the advancement of sustainable energy usage in the community.

Achievements

The Sustainable Electrical Energy initiative is now in the second year and it is anticipated to continue over the next few years as a program of research focus. The priority so far has been towards the first two research themes, building up research capability and linkages, establishing infrastructure and progressing a variety of specific research projects relating to fundamental technologies and smart grid system analysis and control.

Research is currently being conducted under several major grant awards. These include an ARC Discovery project to investigate the fundamental technology of Modular Multilevel Converters (MMC) for electrical grid applications, two ARC Linkage projects to explore electronic tap changing technology for distribution transformers, and to develop a knowledge based strategy for the design of power converter magnetic components, and two projects with the Advanced Manufacturing CRC to develop advanced technologies for Smart Grid distributed generation systems.

In conjunction with several other smaller grants, these projects are supporting 9 PhD students (3 completed in 2013) and a series of postgraduate and undergraduate design projects. A total of 18 major international conference papers and 4 international journal transactions papers have been published over the period 2013/2014.

A major target for 2014 is to establish a more permanent laboratory infrastructure to support the initiative. At the end of 2014, the School of Electrical and Computer Engineering will be relocating its entire electrical engineering program laboratories to Building 57. The new laboratory area has been purpose designed as an integrated research and teaching environment which can incorporate the Sustainable Electrical Energy initiative, combining 5 teaching laboratories and 3 research areas into one coherent, coordinated laboratory space, and incorporating a new Sustainable Building Service Technologies laboratory funded from the RMIT Sustainable Urban Precinct Program (SUPP).

The new laboratory environment also has a separate laboratory space to house the medium scale electrical microgrid test facility being developed under this initiative, with the intention to include a hydrogen energy storage subsystem into this system in 2015, funded under the SUPP scheme.

Professor Holmes and Professor Yu continue to liaise and coordinate their research activities with local and international external organisations in the electrical energy area. Current projects are in collaboration with local organisations CitiPower, SPAusnet and several others.

Professor Holmes has established international collaboration links with the Institute of Power Electronic Systems (ELSYS) in Nuremberg. Professor Yu has also fostered relationships with a number of universities in China over the last year.

During 2014, arrangements are being finalised to host visiting researchers from Brazil and China for extended periods over the next 12 months.



Unmanned Aircraft Systems (UAS)

Research Project Leader: Dr Reece Clothier

Research Team: Professor Alireza Bab-Hadiashar, Professor Simon Watkins, Associate Professor Cees Bil, Associate Professor Roberto Sabatini, Dr Graham Dorrington, Dr Alex Fisher, Dr Reza Hoseinnezhad, Dr Manas Khurana, Dr Kyriakos Kourousis, Dr Matthew Marino, Dr Sridhar Ravi, Dr Milan Simic, Dr Graham Wild

Research context

Unmanned Aircraft Systems (UAS), also commonly referred to as drones, are the fastest growing sector of the aviation industry with sales expected to top \$15 billion by 2014. Australia is well positioned to capitalise on this emerging technology, which has many highly beneficial applications in defence, emergency services, mining, agriculture, media, and infrastructure and environmental management.

The RMIT UAS Research Team was established to address the broad

range of safety, regulatory, social and technical challenges facing this emerging industry. The long term aim of the RMIT UAS Research Team is to enable the safe and routine operation of UAS in a variety of civil, commercial and defence applications.

The Team designs, manufactures and operates a number of small unmanned rotorcraft and fixed wing aircraft for flight testing.

Research themes

Safety and airspace integration

This research theme aims to address the safety and regulatory challenges associated with operating UAS in non-segregated airspace and over populous areas. Research themes include quantitative risk modelling, airspace and Air Traffic Management System integration and human factors. The outcomes from this research stream have been used to support the reform of aviation safety guidance material in Australia.

System autonomy

The system autonomy theme focuses on the development of advanced guidance, navigation, sensing, communication, and safety

systems for unmanned aircraft. Increasing autonomy reduces the need for high bandwidth communications links, decreases pilot workload, and can lead to improvements in safety and mission performance. Research focus areas include machine vision, multi-target detection, tracking and identification, autonomous path planning, automated voice communication systems, and obstacle detection and avoidance.

Societal acceptance

This research theme explores the broader social, political, legal, and economic factors associated with the integration of UAS into society. Research undertaken in this theme includes stakeholder perception studies to support the development of business and industry communication strategies, and the analysis and development of regulatory and legislative frameworks for UAS (including privacy and insurance).

Bio-inspired UAS

Led by Professor Simon Watkins and Dr Sridhar Ravi (RMIT Vice Chancellor's Fellow), this research area focuses on the design and



analysis of bio-inspired systems for UAS. Research includes the study of natural flyers (e.g. birds and insects) and their natural environment (flows and turbulence) for innovations in the design of micro air vehicles.

Achievements

Safety and airspace integration

2013 achievements under this research theme include:

Secured a grant with 2014 Northrop Grumman on Australian Airworthiness Assessment of the Northrop Grumman Triton UAS (\$55,753.30 USD EX GST). Principle Investigator in conjunction with Dr Kyriakos Kourousis. To commence 2014.

New grant with Thales Australia on UAS Integration Scoping Project. Total project value of \$110,000, \$20,000 cash to RMIT. Principle investigator is Dr Reece Clothier.

New grant with CSIRO to study Airspace Risk, Total \$35,000. Principle investigator is Dr Reece Clothier. Work has led to the submission of one journal publication.

Continued work on Project ResQu (led by the Australian Research Centre for Aerospace Automation (ARCAA) in partnership with Insitu Pacific Ltd, Boeing Research and Technology - Australia, and the Queensland State Government) - \$20,000 to RMIT in 2013. Work has led to the acceptance of one journal paper (in press), submission of a further two journal papers (under review), one book chapter (in press), and three peer reviewed conference papers.

Procurement and commissioning of a new \$250,000 Air Traffic Management, Human Factors and Autonomous Systems Laboratory at Bundoora, to support new research into human system interaction.

In recognition of the growing expertise in this field, lead researcher Dr Reece Clothier was nominated as the industry co-chair of the Civil Aviation Safety Authority,

Standards Consultative Committee, UAS Sub-Committee. This Sub-Committee is responsible for the development of new regulations for civil UAS in Australia.

System autonomy

2013 achievements under this research theme include:

Successful grant under the 2014 Victoria Government Technology Innovation Voucher, Flight Data Systems, Automated Emergency Recovery System for Small UAS, total project value \$75,817 (Ex GST), \$31,250 cash to RMIT. Principle Investigator in conjunction with Professor Simon Watkins.

Continued informal project work in collaboration with Boeing Research & Technology – Australia, as well as researchers from Queensland University of Technology, to explore novel approaches for the analysis and certification of highly autonomous systems. This has resulted in two peer reviewed conference publications and the preparation of two journal papers.

Continued undergraduate project work with Thales Australia to develop and identify the issues and challenges associated with Air Traffic Control (ATC) to UAS voice communications, the exploration of viable technologies and the minimum requirements on the ATC to UAS link necessary to maintain safety and efficiency.

Continued undergraduate project work with the Melbourne Metropolitan Fire Brigade, supporting the development and enhancement of small UAS. This has led to the submission of one journal paper (under review).

Societal acceptance

2013 achievements under this research theme include:

- Preparation and submission of two journal papers.
- Three engagement activities, including invited keynote address and the Williams

Foundation.

- Held an industry workshop on insurance for unmanned systems.

Bio-inspired UAS

2013 achievements under this research theme include:

Grant with Defence Science Institute and the DSTO to develop and test a prototype autonomous UAS capable soaring on currents around buildings like birds; total project value \$73,500, \$35,000 cash to RMIT. Principle Investigator in conjunction with Professor Simon Watkins.

Provisional patent filed for new bio-inspired technology that has the potential to significantly reduce the impact of turbulence for both unmanned and manned aircraft operations. There have been four journal papers associated with this work (one published, two in press, one under review).

Further information is available on the website <http://ruasrt.com/>

Nano Materials and Devices (NMD) Program



Program Leader
Professor Mike Austin

Program summary

The aim of the Nano Materials and Devices research program is to investigate the design and modelling, synthesis, fabrication and characterisation of advanced nanostructured materials with customised properties for targeted applications. Application areas include flexible electronic devices, photonics, chemical/biological analysis, catalysis, and energy conversion and storage technologies. The program focuses on both discovery-type fundamental research and applied research which includes the development of new nanostructured materials, the discovery of new physical phenomena and the creation of novel device structures.

Researchers associated with the program are members of a number of RMIT research centres. Their research provides breakthroughs in modern technologies and contributes to improving and revolutionising sectors such as electronics, information technology, energy, environmental science, biotechnology and food safety.

Key research activities

- Modelling of nanoparticles and nano-structured materials
- Piezoelectric thin films for energy scavenging
- Memristor devices for memory technologies
- Nanotechnology enabled fuel cells
- Dynamic plasmonic devices
- Industrial, environmental and biological sensors
- Micro/nano biomedical devices for drug delivery

Associated RMIT Research Centres and Groups

- Centre for Advanced Materials and Industrial Chemistry (CAMIC)
- Centre for Advanced Electronics and Sensors (CADES)
- Centre for Molecular and Nanoscale Physics (NANOPHYS)
- Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS)
- Functional Materials and Microsystems Research Group

Centre for Advanced Materials and Industrial Chemistry (CAMIC)

Director:

Professor Suresh Bhargava

Researchers and students:

Applied Electrochemistry:

Dr Lathe Jones (Deputy Director), Dr Blake Plowman, Daniel Oppedisano, Manika Mahajan, Dr Ilija Nadjovski

Catalysis and Biocatalysis

Dr Selvakannan Periasamy, Dr Deepa Dumbre, Dr Sarvesh Soni, Mohammed Amin, Tibra Mozammel, Katie Tur, Nick Nola

Nanobiotechnology

Associate Professor Vipul Bansal, Dr Ravi Shukla, Dr Rajesh Ramanathan, Dr Hemant Daima, Dr Jos Campbell, Nafisa Zohora, Nicholas Bruzzese, Zahra Homan, Vishal Mistry, Dedrick Song, Mahsa Mohammad Taheri, Ahmad Esmaelzadeh Kandjani, Amanda Nicole Abraham, Catherine Carnovale, Vivian Li, Ben Mapleback, Dipesh Kumar

Organometallic and

Supramolecular: *Dr Neda Mirzadeh, Dr Steve Priver, Dr Shesh Bhosale*

Sensors:

Dr Sam Ippolito, Dr Ylias Sabri, Matthew Griffin, Sarath Chandran, Beбето Lay, Mohibul Kabir

Resources Utilisation:

Dr James Tardio, Scott McMaster, Dr Rahul Ram (Rio Tinto), Dr Hailey Reynolds, Praneeth Koppineni, Manu Agarwal, Jackie Dong

Associate Members

- *Professor Salvy Russo and Theoretical Chemistry Group (School of Applied Sciences)*
- *Professor Kourosh Kalantar-Zadeh and Sensors And Nanotechnology Group (School of Electrical & Computer Engineering)*
- *Professor Milan Brandt and The Advanced Manufacturing Precinct Group and Facilities (School of Aerospace, Mechanical and Manufacturing*

- Engineering)
 - Associate Professor Rajarathinam Parthasarathy and The Process Engineering Group (School of Civil and Environmental Engineering)

Research context

The Centre for Advanced Materials and Industrial Chemistry (CAMIC) was established in 2012 as a multidisciplinary centre that strives to undertake high quality fundamental and applied research.

The Centre is situated in the School of Applied Sciences in the College of Science, Engineering and Health. To develop real-world solutions to problems of national and international significance, CAMIC focuses on research in the field of environmental damage mitigation technology and advanced materials, with specialisation in the areas of industrial chemistry, metal nanoparticles, and bio nanoscience and technology, with a view to facilitating their use in medical formulations, contaminant removal in industrial waste and improving chemical processes for industry.

Research themes

In order to create a truly multidisciplinary research platform, the Centre's mission is to bring together the fields of:

Bio-nanotechnology

- Catalysis
- Electrochemistry
- Industrial chemistry
- Materials chemistry
- Software engineering
- Electrical engineering
- Organometallic chemistry
- Computational Physics

Achievements

Australian Research Council Linkage Scheme

Professor Suresh Bhargava, Dr Lathe Jones, Dr James Tardio, et al., were awarded \$615,000 (ARC) plus \$550,000 (Cash) for a project on *Advanced studies on the hydrometallurgy and electrochemistry of primary copper sulphide ores* (LP130100991). This was the largest amount awarded in Recourse and Metallurgy.

Associate Professor Vipul Bansal, Dr Ravi Shukla, Professor Suresh Bhargava et al., were awarded \$510,000 (ARC) plus \$450,000 (Cash) for a study on *Radio-magnetic nanoparticles as bimodal positron emission tomography/magnetic resonance imaging contrast agents for dendritic cell tracking* (LP130100437).

Some statistics of CAMIC's share of grants:

- Nation Wide: 1.10 % of total grants, (14th largest individual grant from 306)
- Victoria: 3.61% of total grants (6th largest individual grant from total 90)
- ATN: 8.67% of total grants (Largest individual grant from total 45)
- RMIT: 23.69% of total grants (Largest individual grant from total 15)
- College of Science, Engineering and Health: 36.46% (Largest individual from 10)
- School of Applied Sciences: 79.95% (Largest individual from 3)

Workshops and lectures

CAMIC, RMIT University, Melbourne University, and JNCASR India were awarded \$34,540 for the Renewable Energy Australia-India Workshop on Smart Functional Nanomaterials.

Additionally, Dr K.C. Gupta (Director, IITR, Lucknow, India), Dr Yogeshwar Shukla (Director grade scientist), and Dr Govindasamy Mugesh (Indian Institute of Science, Bangalore, India), gave public lectures hosted by CAMIC.

International Visitors to CAMIC

Professor Suresh Bhargava hosted a public lecture presented by the President of the Global Research Alliance and Chancellor of the Academy of Scientific and Innovative Research (AcSIR), Dr RA Mashelkar, which focused on accelerating growth through inclusive innovation in technology, business, workflow, system delivery and organisational process.

Two RMIT Foundation Fellowships to CAMIC were awarded to fund international visits from Dr B.M. Reddy (IICT, Hyderabad) and Dr Kattesh V. Katti (USA).

Academy of Scientific & Innovative Research (AcSIR)

A Memorandum of Understanding with AcSIR was established for a double badged PhD program for studies into Air Pollution Control, Energy and Green Technology.

PhD students

Ms Leila Salhi, from Physics and Materials Engineering at Institut National des Sciences Appliquées I.N.S.A. in Toulouse, France, completed a 20 week internship with CAMIC working on a joint project between CAMIC and Alcoa's Technology Delivery Group (TDG) in Western Australia to develop a method for detecting alkali emissions in alumina refinery processes.

Mr Robert Gericke, a visiting PhD student from Institut für Anorganische Chemie TU Bergakademie Freiberg, Germany, came to CAMIC for 6 months to



conduct research in the synthesis of mixed metal compounds containing carbanions.

Journal cover page highlights

CAMIC members produced over 40 publications in quality peer reviewed journals during 2013, including the following cover pages.

Ramanathan, R., Field, M.R., Smooker, P.M., O'Mullane, A.P., Bhargava, S.K., and Bansal, V., (2013), *Aqueous phase synthesis of copper nanoparticles: A link between bacterial heavy metal resistance and nanoparticle synthesis*, *Nanoscale*, 5, pp. 2300-2306.

Goethals, E.C., Elbaz, A., Lopata, A.L., Bhargava, S.K., and Bansal, V., (2013), *Decoupling the effects of the size, wall thickness, and porosity of curcumin-loaded chitosan nanocapsules on their anticancer efficacy: size is the winner*, *Langmuir*, 29(2), p. 658-66.

Mirzadeh, N., Drumm, D.W., Wagler, J., Russo, S.P., Bhargava, S.K., (2013), *Different solvates of the dinuclear cyclometallated gold(I) complex [Au₂(μ-2-C₆H₄AsMe₂)₂]: a computational study insight into solvent-effected optical properties*, *Dalton Transactions*, 42, pp. 12883-12890.

CAMIC: Beyond 2013

CAMIC's first Research Day was held on 6 June, 2013, Melbourne Hosted by CAMIC Director Professor Suresh Bhargava, the annual research day functions as a strategic review for CAMIC Research involving invited guests from high profile organisations.

CAMIC discipline leaders delivered strategic presentations, and CAMIC's research students were provided with an opportunity to promote their work.

The morning session was chaired by CAMIC Deputy Director Dr Lathe Jones and consisted of student and early career researcher presentations. The afternoon session provide a platform for the strategic review which was kickstarted by Professor Bhargava's lecture on *From the mind to the market place: balancing creativity and productivity through innovation*.

The session also included presentations from Professor Andrew Holmes (FRS), Dr Andrew Hind (General Manager, Agilent Technologies Australia), Professor Denise Cuthbert (Acting Deputy Vice Chancellor & President, Research & Innovation), Dr Marcus Zipper, (Deputy Chief Science and Commercial Intelligent Processing Transformational Capability Platform Leader – CSIRO)

and Professor Andrew Smith (Dean, School of Applied Sciences). A dinner for the invited guests and senior CAMIC personnel was held at the Marriott Hotel.

Other highlights

- An Endeavour Fellowship to Oxford University was awarded to Blake Plowman, and he was also successful in securing a Marie Curie fellowship to continue his stay there.
- A Victoria Fellowship to Stanford University was awarded to Jos Campbell.
- Professor Suresh Bhargava won the National RACI Applied Research Award for 2013 and was elected as a foreign fellow of the Indian National Academy of Engineers (INAE) for his contribution to industrial chemistry.
- Professor Bhargava received the 2013 RACI Applied Science award.
- Professor Bhargava received Best Indian Executive of the Year award from Honorable John Howard, Ex-Prime Minister of Australia.

Further information is available on the website:

www.rmit.edu.au/research/camic



Centre for Advanced Electronics and Sensors (CADES)

Director: Professor Kourosh Kalantar-zadeh

Researchers: Professor Andrew Ball, Professor Arnan Mitchell, Associate Professor Vipul Bansal, Associate Professor Anthony Holland, Associate Professor Kay Latham, Dr Eric Adetutu, Dr Madhu Bhaskaran, Dr Khashayar Khoshmanesh, Dr Jianzhen Ou, Dr Sharath Sriram

Research context

The research in the Centre focuses on micro- and nano-electronics and sensor technologies. This research is underpinned by expertise in the synthesis of novel nanostructured functional materials, sensors, micro/nano electronic and micro/nano fluidic devices and systems.

The Functional Materials and Microsystems Research Group is closely aligned with this Centre and is investigating nano-devices for fundamental and applied research in energy, sensing, and memory technologies.

Research themes

The Centre of Advanced Electronics and Sensors (CADES) conducts research in the following areas:

- **Electronics:** investigation of two dimensional electronic devices, micro- and nano- devices for resistive switching and nanostructured solar cells.
- **Sensors:** development of gas sensors and membranes for greenhouse emission, sensors for human health and food safety, microbial analysis in low dimensional microfluidics systems, as well as nanoscale plasmonic chemical and biological sensors.
- **Functional materials:** study and development of materials which are incorporated in sensors, actuators, energy harvesting systems, solar cells and microfluidics.

Achievements

Electronics: Synthesis of two dimensional semiconducting nanostructures and devices

An area of ongoing research by this research centre is the synthesis of two dimensional (2D) semiconducting structures for various applications, including electronic elements and sensors. The focus is on metal oxides and metal dichalcogenides. The research in this area has been featured in prestigious journals such as Nature Nanotechnology, Advanced Materials, Advanced Functional Materials, and Nanoscale.

Solar cells

The centre has a high reputation in the development of solar cells based on nanostructured metal oxides. This includes the development of dye sensitized solar cells based on WO₃ for the first time and the creation of exceptionally high efficiency dye cells based on Nb₂O₅. We have also been involved in the development of high efficiency dyes and heterostructures. The research has appeared in prestigious journals such as ACS Nano, Langmuir and Journal of Materials Chemistry.

Sensors: Microfluidic and dielectrophoretic manipulation of nanoparticles

This research effort focuses on controlling and manipulating nanoparticles in microfluidic flow using an electric field. We study the ability to create suspended optical elements, thermally conductive coolers and biosensors. The research in this area has been published in prestigious journals such as Analytical Chemistry, Electrophoresis, Lab-on-a-chip and Applied Physics Letters.

Development of gas selective membranes with embedded nanoparticles

This is an exciting project which focuses on the creation of membranes selective to important greenhouse gases such as CO₂ and CH₄. This project, which is conducted in collaboration with researchers from CSIRO, focuses on the measurement of such gases generated by ruminant.

Functional materials: Electronic and sensing characteristics of nanostructured contacts

There has been significant interest

in using electronically contacted nanostructures (especially metal oxides and conductive polymers), whereby the nanostructure morphology modifies the impedance, stoichiometry, and surface properties of the resulting electrical interface. Typically, such nanostructured materials demonstrate extraordinary properties that resulted from the effects of nano-dimensions.

The research in this area has been published in prestigious journals such as ACS Nano, Nano Letters, Advanced Functional Materials, Sensors & Actuators B, Nanotechnology and Journal of Physical Chemistry.

Grants in 2013

- ARC Discovery grant: Professor Kourosh Kalantar-zadeh and Dr Madhu Bhaskaran - \$270,000 for three years.
- NHMRC Development grant: Professor Kourosh Kalantar-zadeh - \$515,000 for two years.
- ARC Linkage grant: Associate Professor Vipul Bansal - \$510,000 ARC continuation and \$450,000 industry contribution (Cell Therapies Pty Ltd).
- The Centre received a significant Category 2 grant – Victoria Postdoctoral Fellowship to support Dr Jos Campbell for three years - \$300,000, \$150,000 in 2013. Jos will travelled to Stanford University to conduct his collaborative research for two years and will return to RMIT in 2015 to continue his position.
- The Centre has also signed up three new top-up scholarships with CSIRO for 2014 (\$21,000 each – \$63,000 total)

Awards in 2013

- Dr Rajesh Ramanathan was awarded the RMIT University Doctoral Research Excellence Prize as well as the prestigious Endeavour Award by to spend a 6-month sabbatical at University Massachusetts Amherst, USA.
- Dr Sivacarendran Balendhran was awarded the Vice-Chancellor's Higher Degree by Research Publication Excellence Prize.

Further information is available on the website:

www.rmit.edu.au/research/cades

Centre for Molecular and Nanoscale Physics

Director: Professor Gary Bryant

Researchers: Professor Gary Bryant, Professor Salvy Russo, Professor Peter Daivis, Professor Dougal McCulloch, Associate Professor Toby Allen, Associate Professor Andrew Greentree, Dr Jared Cole, Dr Kay Latham

Research context

The Centre for Molecular and Nanoscale Physics (NANOPHYS) conducts high quality fundamental research in nanoscale physics, by combining world leading expertise in theoretical, computational and experimental aspects of physics at the nanoscale. The Centre brings together expertise in nanoscale materials from the very small (atoms at the quantum level), through molecules (e.g. proteins) through to membranes, supramolecular complexes and nanoparticles.

Research themes

The Centre focuses on high quality fundamental and applied research within the following broad themes:

- Computational modelling of matter, including: atomic structure, properties of nanomaterials, surfaces and interfaces, polymers, colloids, proteins and ion channels.
- Controllable quantum devices, spintronics and open quantum systems.
- Structure and dynamics of soft matter, including biological membranes and nanoparticles.
- Design and fabrication of functional coatings, and understanding the structure and properties of matter including carbonaceous materials, e.g. diamond-like and glassy carbon materials, nano-structured carbon.
- Mechanical and thermal properties of nanomaterials; theoretical and computational nanofluidics; from applications of statistical and thermal

physics to nanosystems.

- Other areas of research the Centre focuses on are biological membranes and the transport of molecules, ions, peptides and functionalised bio nano devices; crystal engineering of functionalised nanomaterials; and advanced characterisation of matter at the nanoscale.

Achievements

The Centre had a very successful year, having been successful in a number of major grants, hosting conferences and workshops, and having a number of outreach activities. Highlights include:

Awards

Professor Dougal McCulloch was awarded the Vice-Chancellor's Research Excellence Award, the most prestigious research award in the University.

Dr Kay Latham has been elected President of the Royal Australian Institute of Chemistry (Victoria).

Success in the ARC Centre of Excellence Program

Nanophysics members Associate Professor Andrew Greentree and Dr Brant Gibson have led the RMIT node of a successful ARC Centre of Excellence bid. The Centre of Excellence for Nanoscale BioPhotonics (CNBP) will receive \$23 million over seven years commencing in 2014. Only 12 Centres of excellence were awarded from 103 proposals, so this is an outstanding success.

Success in the ARC Discovery Program

- Dr Jared H. Cole, Professor Salvy Russo, Professor Alexey Ustinov, Total : \$359,000.
- Associate Professor Andrew Greentree, Total: \$300,000.

Success in ARC LIEF (Linkage Infrastructure, Equipment and Facilities) program

Collaborative facility for high resolution fabrication, imaging, and characterisation of nanostructured materials, \$500,000.

The development of the next generation of electronic, optical, and biomedical devices requires methods that can quickly manipulate and characterise matter at the nanoscale. This project will establish new tools that will allow researchers to build novel device structures and analyse them at nanoscale spatial resolutions. The new facilities are required to meet the demands of a growing number of innovative projects being undertaken within a large multidisciplinary consortium of research groups. The facilities will be housed in state-of-the art laboratories and managed as open access resources for researchers which will enable advances in the areas of energy harvesting, environmental monitoring, and electronics.

Other grants

Professor Gary Bryant and Dr Chris Garvey, Hamilton and Kent, *Comparative SANS study of solute exclusion in multilamellar bilayer systems: sucrose and trehalose*, Bragg 3303, Bragg Institute (ANSTO), 2014, \$36,000.

Professor Gary Bryant, *Structure and dynamics of colloidal hard-spheres with low polydispersity*, ISAP, 2013, \$8,000.

Professor Gary Bryant and Dr Chris Garvey, *Neutron scattering study of crystallization colloidal suspensions*, Bragg 3289, Bragg Institute (ANSTO), 2013, \$36,000.

Associate Professor Toby Allen Major Supercomputer funding: VLSCI (Victorian Life Science Computational Initiative), NCI (National Computational Infrastructure) and IVEC (WA); VLSCI: Sampling activation pathways in ion channel function. VLSCI: Charged protein-lipid interactions and the regulation of membrane ion channel function. VLSCI: Mechanisms of charge-membrane interactions and transport. Total: 63 million CPU hours for 2014 (At 4c/CPUhour (NCI website) ~ \$2,520,000).

Profiling and other activities
The 37th annual meeting of the Australian Society for Biophysics (ASB2013) was held at RMIT from 24-27 November 2013, with presenters from the United States, Canada and the United Kingdom as well as Australia. With over 160 registrations, it was the most successful meeting for the Australian Society for Biophysics to date. The meeting was chaired by Professor Gary Bryant, and sponsored by NANOPHYS, as well as the School of Applied Sciences and the RMIT Health Innovations Research Institute and the School of Applied Sciences. Associate Professor Toby Allen was also a member of the organising committee.

4th workshop on Computational Modelling of Protein and Membranes was hosted by NanoPhys at RMIT from 8-10 July 2013. It was a very successful meeting organised by Associate Professor Toby Allen, and attended by about 100 people from across Australia and New Zealand.

Meeting on Statistical Mechanics of Soft Matter (SM)2 was held on 21-22 November 2013, and was designed to fill a gap in the Australian conference scene by bringing together the soft matter and statistical physics community from across Australia (and internationally) to exchange research ideas and present new results. 36 talks were presented, to around 50 attendees. The meeting was chaired by Professor Peter Daivis, and sponsored by NANOPHYS. It is planned to make this an annual event, with the theme varying a little each year. In 2014 we will host the Ian Snook Conference on Chemical Physics, to be held 4-5 December 2014.

Further information is available on the website:
www.rmit.edu.au/research/nanophys

Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS)

Node Director: Professor Arnan Mitchell

Researchers: Dr Thach Nguyen, Dr Vijay Sivan, Dr Iryna Khodasevych

Current research students: Geethaka Devendra, Ren Guanghui, Tim Lunn, Kiplimo Yego, Eike Zeller, Andreas Boes, Anthony Hope

Completed Research Students (completed 2013-2014): Tristan Crasto, Naser Dalvand, Charan Shah, Iryna Khodasevych

Research context

CUDOS is funded by the Australian Research Council under the Centres of Excellence Program, with further support from our seven constituent universities and fifteen partner investigators. Our Centre of Excellence brings together a powerful team of researchers in optical science and photonics technology both in Australia and internationally whose efforts will lead to significant advancement in capabilities and knowledge in this crucial field, which underpins advances in areas of national and international importance.

Optical science stands at the edge of a revolution in miniaturisation and integration, directly analogous to the silicon electronics revolution that has reshaped the world over the past 50 years. CUDOS will develop the science and engineering to transform photonic integrated circuits into a practical, powerful technology employing optical signal processing to enable critical applications spanning communications, sensing and security.

The RMIT node of CUDOS is focussed on photonic chip technology using the industry standard platforms of lithium niobate and CMOS compatible silicon photonics, exploring unusual structures, novel post-process and advanced concepts in 'hybrid integration' interfacing multiple different materials to create a new platforms that harnesses the unique benefits of each material system.

Achievements

In the 2013-2014 reporting period the researchers at RMIT made some significant advancements. We have shown that it is possible to manipulate the ferroelectric domains of lithium niobate using UV laser irradiation and have shown that this approach can be used to achieve powerful nonlinear optic platforms. We have also shown, in collaboration with RMIT Vice Chancellor Research Fellow Professor James Friend, that these domain engineered platforms can also exhibit unique acoustic properties presenting some exciting cross-disciplinary opportunities between RMIT's leading research in photonics and surface acoustic waves with significant potential outcomes in both fundamental physics and applications such as sensing and ultrafast photonic signal processing. In late 2013, a UV laser direct write system was established in our laboratories at RMIT and which is dedicated to this research.

We have also made some significant advancement in silicon photonics in collaborative research with our International Partner Investigators at The University of Ghent, Belgium. We have worked with our collaborators to realise unique polarisation manipulation structures in silicon photonics that can be realised using the IMEC CMOS foundry in Belgium. This work has been spearheaded by CUDOS PhD candidate, Mr Anthony Hope, who has been working at The University of Ghent since August 2013 and will return to Australia in September 2014. We have also partnered closely with researchers at The University of Ghent to establish a unified design framework for photonic chips which can be used by all of the researchers within CUDOS and indeed by all photonics researchers in Australia and across the globe. RMIT's contributions to this framework are being incorporated into the core platform which is being recognised as one of the international standard frameworks for photonic chip design.

Further information is available on the website: www.cudos.org.au

Functional Materials and Microsystems Research Group

Leaders: Dr Madhu Bhaskaran and Dr Sharath Sriram

Researchers: Professor Michael Austin, Professor Kourosh Kalantar-zadeh, Professor Arnan Mitchell

Research context

The Functional Materials and Microsystems Research Group comprises of a team of researchers adept at thin film synthesis, microfabrication, and materials characterisation developing platforms incorporating electronic materials for research in fundamental physics, applied sciences, and microsystems. The materials and devices being investigated are targeted at energy, sensing, and memory technologies.

The activities of the Group are undertaken within the Microelectronics and Materials Technology Centre, and will soon be aligned to RMIT University's new, state-of-the-art Micro Nano Research Facility. The Group is also closely aligned with the Centre for Advanced Electronics and Sensors.

Research themes

Our current research activities focus on five themes:

1. Energy harvesting micro- and nano-devices
2. Synthesis and characterisation of piezoelectric thin films
3. Dynamic plasmonic devices
4. Memristor micro- and nano-devices
5. Flexible electronic and electromagnetic devices

Energy harvesting micro- and nano-devices

This research project focuses on energy harvesting using piezoelectrics from low frequency vibrations for powering micro- and nanodevices. Energy harvesting

using piezoelectric thin films in a novel approach, reliant on high performance materials that can be integrated into device fabrication processes. The use of piezoelectrics in the form of thin films enables the realisation of innovative designs.

This research project is funded by the ARC Discovery Project DP1092717, 2010-2014 and RMIT University (Emerging Researcher Grant, 2010).

Synthesis and characterisation of piezoelectric thin films

Piezoelectric thin film capability is an excellent and diverse platform for micro- and nano-scale research. Our group carries out extensive research into the synthesis and micro- and nano-scale characterisation of piezoelectric thin films. It utilises a combination of optimised RF sputtering processes; a full suite of microscopy, spectroscopy, and diffraction capabilities; and novel electromechanical characterisation techniques. The materials studied encompass complex oxide perovskite zirconates, titanates, and niobates.

This research project has received funding from the Australian Institute of Nuclear Science and Engineering (2006-2008), the CASS Foundation (2008), the ARC Linkage, Infrastructure, and Equipment LE0882246, 2008 and LE120100004, 2012, and ARC Discovery Project DP1092717, 2010-2014.

Dynamic plasmonic devices

The use of functional oxides, with specific focus on three properties – electro-optic effect, piezoelectricity, and ferroelectricity – will allow fundamental scientific investigations into plasmonic effects. Moreover, the multidisciplinary combination of fundamental physical concepts and electronic materials/devices will enable innovative experimental approaches. Unexplored research areas envisioned are the use of controlled ferroelectric domain thin films for second harmonic generation and the use of active tuning of metallic nanoparticles for plasmonic devices.

This research project is funded

by the ARC Discovery Project DP110100262, 2011-2014 and has received equipment funding also from the Australian Research Council (Linkage, Infrastructure, and Equipment LE100100215, 2010).

Memristor micro- and nano-devices

Memristors are considered the fourth, and until recently the missing, electronic circuit element. They have unique properties by which they remember their previous electronic experiences, making them suitable for multi-state and artificial memories. This project will deliver new knowledge pertaining to the functioning of materials in memristor micro- and nano-devices, with scientific data to enable the design of interfaces and materials for high-speed switching. This will enable memristors to be the basic building blocks for artificial grey matter.

This research project is funded by the ARC Discovery Project DP130100062, 2013-2015 and received seed funding support from the School of Electrical and Computer Engineering, RMIT University (2011) with equipment funding from the ARC Linkage, Infrastructure, and Equipment LE120100004, 2012).

Flexible electronic and electromagnetic devices

Our group harnesses its expertise in materials science and microfabrication to realise flexible electronic devices. The devices we make are predominantly on silicone (PDMS) substrates, with potential to incorporate pneumatics and microfluidics. We have developed novel pneumatic radio frequency switches, flexible thin film resistors, and terahertz fishnet metamaterials.

This research project has received seed funding from the School of Electrical and Computer Engineering, RMIT University (2010) and a Victoria Fellowship (2012).

Achievements

Research Funding

The most significant outcome for funding applications in 2013 was a successful ARC Discovery Project on two-dimensional materials (DP140100170) for \$270,000. This ensures that most key research activities are supported by ARC Discovery Project funding in 2014. A collaborative ARC LIEF grant (\$500,000) was also successful.

High impact publications

The core research areas of the Group produced 18 journal articles in 2013, with an average impact factor >7. Three of the published articles were among the most downloaded for the journal issue. One article from 2012, continued to be highly downloaded and was featured as an 'Editor's Pick' by Applied Physics Letters. Ground-breaking research on dielectric nanophotonic structures appeared in Optics Express and was featured as a 'Research Highlight' in Nature Photonics. An article on novel flexible oxide devices also appeared

in Nature Publishing Group's Asia Materials. An article on an innovative plasmonic approach for terahertz micro-devices appeared in Advanced Optical Materials, and was selected as one of the 'Best of 2013' by the journal.

Cover art

The high quality journal articles have achieved further visibility by four of them featuring on the journal cover for issues in Applied Physics Letters, Advanced Functional Materials, Advanced Materials, and Advanced Optical Materials.

Media coverage

The Research Group's publication in Advanced Materials on layered molybdenum oxide received international media attention and has been featured in >70 media outlets including The Australian and Phys.org. Research on advanced terahertz micro-devices in Advanced Optical Materials also featured in the media. The ability to realise fully transparent and flexible electronics was particularly favoured in the

media, with a number of reports on the potential for unbreakable phones.

The Group has had a very strong online presence throughout 2013, with consistently high number of visitors to the Group webpage. The Group page has been averaging >1,000 visits per month throughout 2013.

The Group also has a strong social media presence on Facebook marketing key research publications, outcomes and achievements, and creating a strong HDR student research culture.

Awards and Fellowships

Dr Madhu Bhaskaran was awarded the 2013 Malcolm Moore Industry Research Award.

Further information is available on the website:

www.rmit.edu.au/research/groups/functional-materials



Functional Materials and Microsystems Research Group



Institute Organisational Structure

The Schools are, with the overall University, the key stakeholders in the Institute. The management structure of the Institute includes:

Executive/Research Leaders Group Committee comprising the Institute Director, Program/Group Leaders from each of the three research programs, Research Institute Manager, Administrative Officer, and R&I administrative and finance support staff, responsible for daily operational and resource matters.

Institute Steering Group involving Heads of relevant Schools, key R&D Representatives from Colleges to advise on and review operational plans and ensure engagement with Schools' activities and plans.

Administrative Team

- Professor Xinghuo Yu, Director
- Dr Ian Griffiths, Manager, Commercialisation and Industry Linkage
- Dr Marilena Kavoura, Manager, Commercialisation and Industry Linkage
- Petra Van Nieuwenhoven, Research Institute Manager
- Sarah Barter, Administrative Officer

PTRI Executive/Research Leaders Group Committee

- Professor Mike Austin, School of Electrical and Computer Engineering
- Professor Suresh Bhargava, School of Applied Sciences
- Professor Athman Bouguettaya, School of Computer Science and Information Technology

- Professor Milan Brandt, School of Aerospace, Mechanical and Manufacturing Engineering
- Professor Gary Bryant, School of Applied Sciences
- Professor Caroline Chan, School of Business IT & Logistics
- Dr Reece Clothier, School of Aerospace, Mechanical and Manufacturing Engineering
- Professor Andrew Eberhard, School of Mathematical and Geospatial Sciences
- Professor Franz Konstantin Fuss, School of Aerospace, Mechanical and Manufacturing Engineering
- Dr Ian Griffiths, Platform Technologies Research Institute
- Professor Grahame Holmes, School of Electrical and Computer Engineering
- Professor Kourosh Kalantar-zadeh, School of Electrical and Computer Engineering
- Dr Marilena Kavoura, Platform Technologies Research Institute
- Professor Arnan Mitchell, School of Electrical and Computer Engineering
- Professor Mark Sanderson, School of Computer Science and Information Technology
- Professor Heinrich Schmidt, School of Computer Science and Information Technology
- Professor Timos Sellis, School of Computer Science and Information Technology
- Professor Lewi Stone, School of Mathematical and Geospatial Sciences
- Dr Sharath Sriram, School of Electrical and Computer Engineering

- Professor Mike Xie, School of Aerospace, Mechanical and Manufacturing Engineering
- Professor Kefei Zhang, School of Mathematical and Geospatial Sciences

PTRI Steering Committee

- Professor Mike Austin, School of Electrical and Computer Engineering
- Professor Athman Bouguettaya, School of Computer Science and Information Technology
- Professor Ian Burnett, School of Electrical and Computer Engineering
- Professor Caroline Chan, School of Business IT and Logistics
- Professor Matthew Cuthbertson, College of Science, Engineering and Health
- Professor Franz Konstantin Fuss, School of Aerospace, Mechanical and Manufacturing Engineering
- Dr Ian Griffiths, Platform Technologies Research Institute
- Professor John Hearne, School of Mathematical and Geospatial Sciences
- Dr Marilena Kavoura, Platform Technologies Research Institute
- Professor Chun Qing Li, School of Civil, Environmental and Chemical Engineering
- Professor Ralph Horne, College of Design and Social Context
- Professor Geoffrey Stokes, College of Business
- Professor Heinrich Schmidt, School of Computer Science and Information Technology
- Professor Aleksandar Subic, School of Aerospace, Mechanical and Manufacturing Engineering

- Professor Andrew T. Smith, School of Applied Sciences

PTRI External Advisory Board

- Mr Clive Davenport, Director Emeritus, Micro Nano and Emerging Technologies Commercialization and Education Foundation (MANCEF), (Chair)
- Professor Ah Chung Tsoi, Dean, Faculty of Information Technology, The Macau University of Science and Technology
- Professor Allan Hahn, Honorary Emeritus Professor, Australian Institute of Sport
- Mr Bruce Grey, Managing Director Advanced Manufacturing CRC
- Professor David Hill, Chair of Electrical Engineering, The University of Hong Kong

Vice Chancellor's Research Fellows

- Dr Sasan Adibi, School of Business Information Technology and Logistics
- Dr Lam Bui, School of Electrical and Computer Engineering
- Dr Hai Dong, School of Computer Science and Information Technology
- Dr Mahdi Jalili, School of Electrical and Computer Engineering
- Dr Everson Kandare, School of Aerospace, Mechanical and Manufacturing Engineering
- Dr Kai (Alex) Qin, School of Computer Science and Information Technology
- Dr Sridhar Ravi, School of Aerospace, Mechanical and Manufacturing Engineering
- Dr Ravi Shukla, School of Applied Sciences
- Dr Francisco Tovar Lopez, School of Electrical and Computer Engineering

Vice Chancellor's Senior Research Fellows

- Associate Professor Andrew Greentree, School of Applied Sciences
- Associate Professor Gary Rosengarten, School of Aerospace, Mechanical and Manufacturing Engineering
- Associate Professor Donald Wlodkowic, School of Applied Sciences

Core Members

- Professor Sylvester Abanteriba, International Relations
- Associate Professor Firoz Alam, School of Aerospace, Mechanical and Manufacturing Engineering
- Associate Professor John Andrews, School of Aerospace, Mechanical and Manufacturing Engineering
- Professor Michael Austin, School of Electrical and Computer Engineering
- Associate Professor Vipul Bansal, School of Applied Sciences
- Associate Professor Paul Beckett, School of Electrical and Computer Engineering
- Associate Professor Peter Bertok, School of Computer Science and Information Technology
- Professor Suresh Bhargava, School of Applied Sciences
- Dr Madhu Bhaskaran, School of Electrical and Computer Engineering
- Professor Satinath Bhattacharya, School of Civil, Environmental and Chemical Engineering
- Dr Sheshanath Bhosale, School of Applied Sciences
- Professor Cornelis Bil, School of Aerospace, Mechanical and Manufacturing Engineering
- Professor Athman Bouguettaya, School of Computer Science and Information Technology
- Associate Professor Serdar Boztas, School of Mathematical and Geospatial Sciences
- Professor Milan Brandt, School of Aerospace, Mechanical and Manufacturing Engineering
- Professor Ian Burnett, School of Electrical and Computer Engineering
- Dr Brett Carter, School of Mathematical and Geospatial Sciences
- Professor Caroline Chan, School of Business IT and Logistics
- Dr Peggy Chan, School of Applied Sciences
- Professor Prem Chhetri, School of Business IT and Logistics
- Professor Graham Clark, School of Aerospace, Mechanical and Manufacturing Engineering
- Professor Brian Corbitt, College of Business
- Professor Peter Davis, School of

Applied Sciences

- Dr Stephen Davis, School of Mathematical and Geospatial Sciences
- Professor Hepu Deng, School of Business IT and Logistics
- Professor Edward Doyle, School of Applied Sciences
- Professor Andrew Eberhard, School of Mathematical and Geospatial Sciences
- Professor Franz Fuss, School of Aerospace, Mechanical and Manufacturing Engineering
- Professor Kamran Ghorbani, School of Electrical and Computer Engineering
- Dr Brant Gibson, School of Applied Sciences
- Associate Professor Andrew Greentree, School of Applied Sciences
- Dr Rahul Gupta, School of Vocational Engineering
- Dr Fengling Han, School of Computer Science and Information Technology
- Professor John Hearne, School of Mathematical and Geospatial Sciences
- Associate Professor Anthony Holland, School of Electrical and Computer Engineering
- Professor Grahame Holmes, School of Electrical and Computer Engineering
- Professor Kathryn Horadam, School of Mathematical and Geospatial Sciences
- Dr Mahdi Jalili, School of Electrical and Computer Engineering
- Professor Sabu John, School of Aerospace, Mechanical and Manufacturing Engineering
- Associate Professor Margaret Jollands, School of Civil, Environmental and Chemical Engineering
- Professor Kourosh Kalantar Zadeh, School of Electrical and Computer Engineering
- Professor Dinesh Kumar, School of Electrical and Computer Engineering
- Dr Margaret Lech, School of Electrical and Computer Engineering
- Professor Chun Qing Li, School of Civil, Environmental and Chemical Engineering
- Associate Professor Xiaodong Li,

- School of Computer Science and Information Technology
 - Professor Dougal McCulloch, School of Applied Sciences
 - Dr Brendan McGrath, School of Electrical and Computer Engineering
 - Professor Adela McMurray, School of Management
 - Professor Arnan Mitchell, School of Electrical and Computer Engineering
 - Professor John Mo, School of Aerospace, Mechanical and Manufacturing Engineering
 - Professor Adrian Mouritz, School of Aerospace, Mechanical and Manufacturing Engineering
 - Dr Melih Ozlen, School of Mathematical and Geospatial Sciences
 - Dr Rajarathinam Parthasarathy, School of Civil, Environmental and Chemical Engineering
 - Associate Professor Gary Rosengarten, School of Aerospace, Mechanical and Manufacturing Engineering
 - Associate Professor Wayne Rowe, School of Electrical and Computer Engineering
 - Professor Salvy Russo, School of Applied Sciences
 - Professor Mark Sanderson, School of Computer Science and Information Technology
 - Dr Sebastian Sardina, School of Computer Science and Information Technology
 - Professor Heinrich Schmidt, School of Computer Science and Information Technology
 - Dr Falk Scholer, School of Computer Science and Information Technology
 - Professor Timos Sellis, School of Computer Science and Information Technology
 - Professor Robert Shanks, School of Applied Sciences
 - Professor Mohini Singh, School of Business IT and Logistics
 - Professor Andrew Smith, School of Applied Sciences
 - Dr Sharath Sriram, School of Electrical and Computer Engineering
 - Professor Lewi Stone, School of Mathematical and Geospatial Sciences
 - Professor Aleksandar Subic, School of Aerospace, Mechanical and Manufacturing Engineering
 - Professor Yasuhiro Tachibana, School of Aerospace, Mechanical and Manufacturing Engineering
 - Dr James Tardio, School of Applied Sciences
 - Professor Zahir Tari, School of Computer Science and Information Technology
 - Associate Professor James Thom, School of Computer Science and Information Technology
 - Professor Pavel Trivailo, School of Aerospace, Mechanical and Manufacturing Engineering
 - Associate Professor Olga Troynikov, School of Fashion and Textiles
 - Professor Jiyuan Tu, School of Aerospace, Mechanical and Manufacturing Engineering
 - Professor Chun Wang, School of Aerospace, Mechanical and Manufacturing Engineering
 - Professor Liuping Wang, School of Electrical and Computer Engineering
 - Professor Simon Watkins, School of Aerospace, Mechanical and Manufacturing Engineering
 - Dr Jonathan Watmuff, School of Aerospace, Mechanical and Manufacturing Engineering
 - Associate Professor Donald Wlodkowic, School of Applied Sciences
 - Associate Professor Khoi Loon Wong, School of Electrical and Computer Engineering
 - Professor Hong Ren Wu, School of Electrical and Computer Engineering
 - Professor Yimin Xie, School of Civil, Environmental and Chemical Engineering
 - Professor Kefei Zhang, School of Mathematical and Geospatial Sciences
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- Dr Ahmad Abareshi, School of Business IT and Logistics
 - Dr Sasan Adibi, School of Business IT and Logistics
 - Dr Akbar Afaghi Khatibi, School of Aerospace, Mechanical and Manufacturing Engineering
 - Dr Arathi Arakala, School of Mathematical and Geospatial Sciences
 - Professor Colin Arrowsmith, School of Mathematical and Geospatial Sciences
 - Dr Sivacarendran Balendhran, School of Electrical and Computer Engineering
 - Dr Anthony Bedford, School of Mathematical and Geospatial Sciences
 - Dr James Cameron Bennett, School of Mathematical and Geospatial Sciences
 - Professor Stephen Bird, School of Medical Sciences
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 - Dr Vincenzo Bruno, School of Business IT and Logistics
 - Professor Gary Bryant, School of Applied Sciences
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 - Dr Jared Cole, School of Applied Sciences

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- Dr Yan Ding, School of Mathematical and Geospatial Sciences
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- Dr Kiao Inthavong, School of Aerospace, Mechanical and Manufacturing Engineering
- Dr Samuel Ippolito, School of Applied Sciences
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- Dr Lathe Jones, School of Applied Sciences
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- Associate Professor Booi Kam, School of Business IT and Logistics
- Dr Everson Kandare, School of Aerospace, Mechanical and Manufacturing Engineering
- Dr Ibrahim Khalil, School of Computer Science and Information Technology
- Dr Khashayar Khoshmanesh, School of Electrical and Computer Engineering
- Associate Professor Roger La-Brooy, School of Aerospace, Mechanical and Manufacturing Engineering
- Associate Professor Kay Latham, School of Applied Sciences
- Dr Charles Lau, School of Business IT and Logistics
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- Dr Huai Liu, School of Computer Science and Information Technology
- Dr Yi Mei, School of Computer Science and Information Technology
- Dr Nedaossadat Mirzadeh, School of Applied Sciences
- Associate Professor Aidyn Mouradov, School of Applied Sciences
- Dr Giang Thach Nguyen, School of Electrical and Computer Engineering
- Dr Robert Norman, School of Mathematical and Geospatial Sciences
- Dr George Opletal, School of Applied Sciences
- Dr Ian Peake, School of Computer Science and Information Technology
- Dr Selvakannan Periasamy, School of Applied Sciences
- Dr Siddhi Pittayachawan, School of Business IT and Logistics
- Dr Kai Qin, School of Computer Science and Information Technology
- Dr Peter Radcliffe, School of Electrical and Computer Engineering
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- Associate Professor Colin Rix, School of Applied Sciences
- Dr Caspar Ryan, School of Computer Science and Information Technology
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- Associate Professor James Scott, School of Electrical and Computer Engineering
- Associate Professor Lina Shahwan-Akl, School of Health Sciences
- Associate Professor John Shepherd, School of Mathematical and Geospatial Sciences
- Dr Ravi Shukla, School of Applied Sciences
- Dr David Silcock, School of Mathematical and Geospatial Sciences
- Dr Kandeepan Sithamparanathan, School of Electrical and Computer Engineering
- Professor Aaron Smith, College of Business
- Dr Andy Song, School of Computer Science and Information Technology
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- Dr Michelle Spencer, School of Applied Sciences
- Dr Maria Spichkova, School of Computer Science and Information Technology
- Dr Yolande Strengers, School of Global, Urban and Social Studies
- Dr Monir Takla, School of Aerospace, Mechanical and Manufacturing Engineering

- Associate Professor Lachlan Thompson, School of Aerospace, Mechanical and Manufacturing Engineering
- Dr Francisco Tovar Lopez, School of Electrical and Computer Engineering
- Dr Sumeet Walia, School of Electrical and Computer Engineering
- Dr Jidong Wang, School of Electrical and Computer Engineering
- Dr Kelvin Wong, School of Aerospace, Mechanical and Manufacturing Engineering
- Dr Suqin Wu, School of Mathematical and Geospatial Sciences
- Professor Irene Yarovsky, School of Aerospace, Mechanical and Manufacturing Engineering

- Professor Leslie Yeo, School of Civil, Environmental and Chemical Engineering
- Dr Wenwu Yu, School of Electrical and Computer Engineering
- Dr Jeremy Yuille, School of Media and Communication
- Dr Iman Yusuf, Research & Innovation
- Dr Fabio Zambetta, School of Computer Science and Information Technology
- Professor Panlop Zeephongsekul, School of Mathematical and Geospatial Sciences
- Dr Xiuzhen Zhang, School of Computer Science and Information Technology
- Dr Ron van Schyndel, School of Computer Science and Information Technology

Affiliates

- Professor Peter Coloe, College of Science, Engineering and Health
- Dr Erjiang Fu, School of Mathematical and Geospatial Sciences
- Dr Yuriy Kuleshov, School of Mathematical and Geospatial Sciences
- Dr John Le Marshall, School of Mathematical and Geospatial Sciences
- Dr Dong-Yang Wu, School of Aerospace, Mechanical and Manufacturing Engineering



Higher Degree by Research (HDR) Students

HDR students contributed to the Institute's research outcomes by collaborating on members' research projects. The institute acknowledges the contributions of the following HDR students:

Babak Shoeiby	Marjan Hadian Jazi	Amanda Perdomo
Rosmalini Ab Kadir	Partha Halder	Seyedhossein Pourali
Sadjad Abdoli	Joseph Harland	Uthpala Subodhani Premarathne
Ummul Fahri Abdul Rauf	Muhamud Hasan	Leon Purton
Arthur Adamopoulos	Lai Hooi	Zhinoos Razavi Hesabi
Francisca Adamopoulos	Demetris Hoplaros	Guanghui Ren
Kassahun Endris Adem	Ming Hu	Amgad Rezk
Manu Agarwal	Bo Hu	Geoffrey Rigby
Saeid Ahmadi Nasab	Taavi Hunt	Andre Rousseau
Nasrin Akter	Yusnira Husaini	Yan Rui
Layla Mehdi Alhasan	Husna Sarirah Husin	Chao Rujikietkumjorn
Nurra Ali Khelil	Sharin Hazlin Huspi	Nooshin Sadeghi Taheri
Michael Allen	Inam Ullah Inam Ullah	Siti Maliza Salleh
Mohammed Alrashidi	Lukman Hakim Iwan	Khresna Bayu Sangka
Manal M Y A Alsaif	Yu Kang	Sven Schellenberg
Sinan Al-Wandi	Mohd Nazri Kasuan	Julian Schirra
Wilfred Kiapin Kilepak Amai	Borhan Kazimipour	Reuven Segal
Aslina Anjang Ab Rahman	Mahsa Keshtkaran	Shahrooz Shahparvari
Darius Antoni	Norhazlin Khairudin	Hassan Shakil Bhatti
Senthuran Arunthavanathan	K.I. Khan	Yidan Shang
Muhammad Asif	Rudaba Khan	Negin Shariati Moghadam
Robiatun Adayiah Awang	Amirali Khodadadian Gostar	Ariba Moti Siddiqi
Sultana Baby	Myung Kim	Amanpreet Singh
Yuntian Bai	Praneeth Koppineni	Sujatha Sivabalan
Jenna Baldock	Johannes Kotzerke	Robert Smith
P.M.Thilaksiri Bandara	Rapee Krerngkamjornkit	Mona Soodi
Stuart Bannister	Heshan Dhanushka Kumarage	Reuben Stanton
Fahri Benli	Siu Sai Lai	Yunkai Sun
Aekarin Borrirak	Kwong Kei Lai	Peter Sykes
Jacobien Carstens	M.Hadi Latifi	Audrey Lee Yen Tan
Hui Fai Chan	Mildred Ching Ling Lee	Srinivasareddy Telukutla
Andrew Charles	Chia Lee	Anuradha Karunasena Thanthri
Kai Wei Cheng	Catherine Lin	Waththage
Peter Chomley	Stefan Litzenberger	Sara Vahaji
Man Hon Chow	Shuai Liu	Julie Vine
Siu Choy	Weerayut Lorchirachoonkul	Michelle Viney
Lillian Chuang	Paul Lund	Kevin Walker
Robin Clarke	Cameron MacRae	Shuang Wang
Christine Close	Pritheega Magalingam	Michael Wang
Lishan Cui	Emad Abdulhadi A Malaekah	Mani Williams
Michael Czajka	Uzma Malik	Xiang Wu
Jane Daly	Richard Mallows	Zhenghua Xu
Paul Davies	Franziska Mally	Hao Yan
Jampaiah Deshetti	Stuart McFarlane	Heo Yong
Xuran Du	Peter McKenzie	Khalid Yousif
Ronald Eaborn	Mohsen Modirshanechi	Chongguang Yu
Markus Eckelt	Syazilawati Mohamed	Jiaxing Zhan
Ismail Elferjani	Mahsa Mohammadtaheri	Nuozi Zhang
Masih Fadaki	Ahmad Mojiri	Rui Zhuang
Ehsan Farno	Eleswara Mylangam	Nafisa Zohora
Christopher Feigl	Mir Newaj	
Abdur Rahim Mohammad Forkan	Leonie Newnham	
Anagi Lilangika Gamachchi	Hussein Nili Ahmadabadi	
Maria Gange	Amandeep Singh Oberoi	
Nima Golforoushan	CHIN EANG ONG	
Britni Green	Ruchada Paradonsaree	
Peter Haddad	Hemlata Patil	

Institute Achievements: Research Grants

The Institute is noted for its excellent achievements through participation in Commonwealth Government Cooperative Research Centres, State Government Centres of Excellence, Australian Research Council Grant Schemes.

External and internal grants To support the continued development of critical mass in the three research programs, PTRI researchers actively pursued funding support from the Australian competitive and government grant schemes and industry in-kind funding opportunities. In addition, industry grants served as recognition of RMIT's capabilities and expertise in the relevant areas – all of these and the aforementioned ARC successes are listed below:

External Grants

ARC Discovery Grants

Professor Andrew Eberhard, Professor Natasha L. Boland, Professor Jeff Linderoth, *Decomposition and duality: new approaches to integer and stochastic integer programming*, \$468,608, 2014-2016.

Dr Jared H. Cole, **Professor Salvy Russo**, Professor Alexey Ustinov, *Understanding and eliminating dissipation in superconducting devices: the origin of two-level defects*, \$359,000, 2014-2016.

Professor Xinghuo Yu, Dr Wenwu Yu, *Exploring emerging collective behaviours in large-scale data-driven networked systems*, \$331,000, 2014-2016.

Professor Timos Sellis, Dr Jason S. Culpepper, Professor Nikos Mamoulis, Professor Christian S. Jensen, *Efficient and effective ad-*

hoc search using structured and unstructured geospatial information, \$422,000, 2014-2016.

Professor Mark A. Sanderson, Dr Falk N. Scholer, Professor Kalvo P. Jarvelin, Professor Bruce Croft, *Effective summaries for search results*, \$372,110, 2014-2016.

Professor Mike Xie, *Design of composites for exceptional functional properties by maximising the poisson effect*, \$323,175, 2014-2016.

Professor Chun-Qing Li, Associate Professor Sujeeva Setunge, Dr Annan Zhou, *Accurate prediction of remaining safe life of buried pipelines*, \$280,000, 2014-2016.

Dr Brendan McGrath, Professor Grahame Holmes, *Regulation of the cell bus voltages of large scale modular multilevel converters: advanced energy converters for future electricity grids*, \$362,000, 2014-2016.



Professor Kourosh Kalantar-zadeh, Dr Madhu Bhaskaran, Professor Michael Strano, *Synthesis, characterisation, and applications of atomically thin layers of transition metal oxides and dichalcogenides*, \$270,000, 2014-2016.

Professor Irene Yarovsky, Professor Molly M. Stevens, *Understanding biomolecular interactions of nanoparticles for engineering efficient biomedical materials and devices*, \$345,000, 2014-2016.

Professor Leslie Yeo, Dr Xuehua Zhang, Dr Ofer Manor, *Acoustowetting: microscale and nanoscale liquid manipulation for microfluidic applications*, \$410,000, 2014-2016.

Professor Chun H Wang, Professor Anthony J. Kinloch, **Professor Adrian P. Mouritz, Professor Kamran Ghorbani**, *Electromagnetically self-assembled nano-reinforcement: synergistically improving damage tolerance and diagnosis of composite materials*, \$382,000, 2014-2016.

Associate Professor Benjamin A. Burton, **Dr Melih Ozlen**, *Unlocking the potential for linear and discrete optimisation in knot theory and computational topology*, Administering University: The University of Queensland, \$350,000, 2013-2015.

Associate Professor Andrew Greentree, *Interacting quantum systems: from solid-state theory to practical photonic platforms*, \$300,000, 2013-2015.

Professor Jinhua Lu, Professor Xinghua Yu, Professor Guanrong Chen, *Structure inference and adaptive intervention of evolving complex networks*, \$320,000, 2013-2015.

Professor Dougal McCulloch, Dr Andre Anders, *Design and synthesis of boron nitride thin film coatings with exceptional properties*, \$365,000, 2013-2015.

Professor Mark Sanderson, Professor Falk Scholer, Associate Professor Andrew Turpin, Professor Bruce Croft, Professor Jamie Callan, *Sub-collection retrieval: understanding and improving search engines*, \$315,000, 2013-2015.

Dr Sharath Sriram, *Multilayer thin film memristors: designing interfaces and defect states in perovskites for nanoscale multi-state memories*, \$315,000, 2013-2015.

Professor Jiyuan Tu, Professor Jacopo Buongiorno, Dr Chi Pok Cheung, *Fundamental investigation of heat and mass transfer in nanofluids: a mechanistic approach*, \$315,000, 2013-2015.

Professor David Suter, Dr Tat-Jun Chin, **Professor Alireza Bab-Hadiashar**, Professor Pei Chen, *Improved image analysis: maximised statistical use of geometry/ shape constraints*, Administering University: The University of Adelaide, \$330,000, 2013-2015.

Professor Ba-Ngu Vo, **Dr Reza Hoseinnezhad**, *A stochastic geometric framework for Bayesian sensor array processing*, Administering University: The University of Western Australia, \$295,000, 2013-2015.

Professor Mark Burry, Professor Robin Drogemuller, Associate Professor Jane Burry, Associate **Professor Asha Rao, Professor Simon Watkins**, *Integrating*

architectural, mathematical and computing, 2013-2015.

Associate Professor Xiaodong Li, Professor Xin Yao, *Novel decomposition methods for large scale optimization*, \$317,000, 2012-2014.

Professor Peter J. Davis, Professor Billy D Todd, Professor Ian K. Snook, Dr Kaloian Koynov, *Accurate transport theory for nanofluidic separation science*, \$315,000, 2012-2014.

Dr Sebastian Sardina, Associate Professor Maurice Pagnucco, Professor Guiseppe De Giacomo, *Optimisation of embedded virtual complex systems by re-using a library of available components*, \$300,000, 2012-2014.

Professor Jiyuan Y Tu, Dr Kiao Inthavong, Professor Chunying Chen, Professor Goodarz Ahmadi, *An integrated model for assessing health effects of nanoparticle inhalation*, \$290,000, 2012-2014.

Professor Chun Hui Wang, Associate Professor Martin Veidt, Dr Francis Rose, *Towards autonomous structural safety prognostics: integrating in-situ imaging and predictive modeling*, \$285,000, 2012-2014.

Professor Kathryn J. Horadam, Dr Stephen A Davis, *Novel dissimilarity techniques for characterising noisy spatial networks*, \$285,000, 2012-2014.

Professor Dougal McCulloch, *New generation pulsed magnetron sputtering for the synthesis of advanced materials*, \$238,029, 2011-2013.

Professor Salvy Russo, *Understanding and optimising the microstructures of Ge-As-Se glasses for superior device performance*, Administering University: Australian National University, \$105,000, 2011-2014.

Dr Paul L Beckett, Professor Ian S Burnett, Professor Dr Hong R Wu, Mr Scott E Johnston and Mr Justin

M Spangaro, *Experiential media signal processing on null convention logic*, \$240,000, 2011-2013.

Professor Sabu J John, Professor Chun Hui Wang and Dr Lijing Wang, *Fibre-sized energy generators and storage in multi-functional fabrics*, \$163,332, 2011-2013.

Professor Lin Padgham, **Dr John R Thangarajah** and Dr Wei Liu, *Tools, methodologies and reasoning support for developing companion-toy modules*, \$225,000, 2011-2013.

Professor Zahir Tari, Dr Abdun N Mahmood, Associate Professor Jiankun Hu, *Detecting Supervisory Control and Data Access (SCADA) malicious programs to protect Australian critical infrastructure*, \$270,000, 2011-2013.

Professor Jiyuan Y Tu, Associate Professor Xiangdong Li and Professor Qingyan Chen, *Developing an integrated predictive model for optimal design of ventilation systems in buildings*, \$245,538, 2011-2013.

Professor Chun Hui Wang, Dr Adrian C Orifici, Professor Dong Yang Wu, Mr Steve Georgiadis, *Optimised flush repairs for dissimilar composite material systems*, \$106,000, 2011-2013.

Professor Suresh K Bhargava, Associate Professor Kourosh Kalantar-zadeh, Dr Anthony P O'Mullane, Dr Vipul Bansal, Dr Samuel J Ippolito, Dr Steven Rosenberg and Dr Ian R Harrison, *A highly sensitive and selective nano engineered sensor for the online monitoring of mercury vapour emissions from harsh industrial processes*, \$290,000, 2010-2012.

Associate Professor Jiankun Hu, Professor Zahir Tari, Professor Xinghua Yu, and Dr Fengling Han, *Developing smart embedded host based intrusion detection systems*, \$365,000, 2010-2013.

Professor Sabu John and Professor Simon Watkins, *Energy capture from polymer bases synthetic foliage*, \$160,014, 2010-2013.

Professor Adrian Mouritz, Professor Chun Hui Wang and Professor Dong Yang Wu, *Optimisation of self-healing repair systems in aerospace composite structures*, \$86,207, 2010-2013.

Professor Xinghuo Yu, Professor Jeffery Hughes and Dr Wei Peng, *Practice-based Systematized Nomenclature of Medicine (SNOMED) concept learning for drug-disease precaution early detection and refinement*, \$160,014, 2010-2013.

ARC Discovery Early Career Researcher Award (DECRA)

Dr Mahdi Jalili, *Inference, control and protection of interdependent spatial networked structures*, \$395,220, 2014-2016.

Dr Francisco Tovar, *Lab-on-a-chip platforms for hemodynamics research: new approaches for the study of blood diseases*, \$375,000, 2012-2014.

Dr Khashayar Khoshmanesh, *Analysing cell-cell communication mechanisms using microfluidic platforms*, \$375,000, 2012-2014.

Dr Donald Wlodkowic, *Ecotoxicology-on-a-chip: towards smart devices in environmental biomonitoring*, \$125,000, 2013-2015.

ARC Future Fellowship

Professor Leslie Yeo, *Microscale MicroRNA detection and delivery for effective point-of-care cancer screening and therapeutics*, \$989,144, 2013-2017.

Dr Anthony P O'Mullane, *Surface modification of semiconducting organic charge transfer complexes with metal nanoparticles to create a new class of multifunctional materials*, \$583,528, 2011-2015.

Linkage Infrastructure, Equipment and Facilities (LIEF)

Professor Dougal G McCulloch, Professor James Friend, Dr Madhu Bhaskaran, Professor Joanne Etheridge, Professor Yi-Bing Cheng, Professor Paul Mulvaney, Professor Steven Praver, Professor Marcel M. Bilek, Professor Saulius Juodkazis, Professor Derek Abbott, **Associate Professor Yasuhiro Tachibana, Professor Suresh K. Bhargava**, Associate Professor Rachel A. Caruso, Professor Sally L. McArthur, Associate

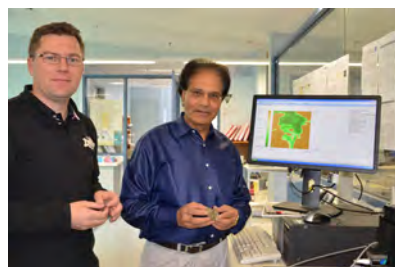
Professor Roberto F. Weinberg, Dr Alison M. Funston, Dr Boris T. Kuhlmeier, Dr Mikhail Lapine, Professor Christophe Fumeaux, *Collaborative facility for high resolution fabrication, imaging, and characterisation of nanostructured materials*, \$500,000, 2014.

ARC Linkage Grants

Professor Alireza Bab-Hadiashar, Professor David Suter, **Dr Reza Hoseinnezhad, Professor John Mo**, Professor Ba-Ngu Vo, Mr Kelvin J., *Intelligent collision avoidance system for mobile industrial platforms*, Partner organisation: Flexible Drive Agencies Pty Ltd, \$252,000, 2013-2016.

Dr Vipul Bansal, Dr Ravi Shukla, Professor Suresh K. Bhargava, Professor Rodney J. Hicks, A/Professor Simon J. Harrison, Dr Dominic M. Wall, Mr Raymond Wood, *Radio-magnetic nanoparticles as bimodal positron emission tomography/magnetic resonance imaging contrast agents for dendritic cell tracking*, Partner organisation: Cell Therapies Pty Ltd, \$510,000, 2013-2016.

Professor Suresh K Bhargava, Dr James A. Tardio, Professor Alan M. Bond, Professor Glenn T. Hefter, Dr Erich Koenigsberger, Dr Aleksandar N. Nikoloski, Dr Stephen C. Grocott, Dr Paul L. Brown, *Advanced studies on the hydrometallurgy and electrochemistry of primary copper sulphide ores*, Partner organisation: Rio Tinto, \$615,000, 2013-2016.



Dr Lawrence Cavedon, Professor Mark A Sanderson, Professor Lin Padgham, Professor Bruce Croft, Mr Nicholas Howden, *Spoken conversational search: contextual interactive techniques to support effective information search over a speech-only communication channel*, Partner organisation: Realthing Entertainment Pty Ltd, \$215,000, 2013-2016.

Professor Grahame Holmes, Mr Mohinder Pannu, *Solid state regulation of a distribution transformer to rapidly*

control voltages of low voltage distribution feeders, Partner organisation: Wilson Transformer Company Pty Ltd, \$176,000, 2013-2016.

Dr Xiaodong Li, Dr Fabio Zambetta, Dr Florian Mueller, Mr Clark J. Kirby, *Enhancing the Australian theme park experience by harnessing virtual-physical play*, Partner organisation: Village Roadshow, \$300,000, 2013-2016.

Professor Jiyuan Tu, Dr Chi Pok Cheung, Dr Xiaodong Li, Dr Akbar Afaghi-Khatibi, Dr Samuel J. Meure, Mr Andrew Glynn, *Developing an integrated optimisation platform for innovative design of composite fabrication process*, Partner organisation: Boeing Australia Ltd, \$205,000, 2013-2016.

Professor Kefei Zhang, Dr James C. Bennett, Dr Brett A. Carter, Dr Jizhang Sang, Professor Craig H Smith, Professor William F. Appelbe, *Innovative solutions to enhance space situational awareness*, Partner organisations: EOS Space Systems Pty Ltd, Victorian Partnership for Advanced Computing, \$320,000, 2013-2016.

Professor Athman Bouguettaya; Dr Margaret Hamilton, Dr Flora Salim, Dr Xiaodong Li, Professor Xinghuo Yu, Professor William Appelbe, *An integrated and real-time passenger travel and public transport service information system*, \$510,000, 2013-2016.

Professor Mark Sanderson, Professor Kefei Zhang, Dr Wayne Rowe, Dr Martin Tomko, *TRIIBE – Tracking Indoor Information Behaviour*, \$225,000, 2013-2016.

Professor Paul Slatter, Professor Sati Bhattacharya, Dr Rajarathinam Parthasarathy, Dr Nicky Eshtiaghi, *Novel and cost effective mixing technique for anaerobic digesters in municipal wastewater treatment plants*, \$250,000, 2013-2016.

Professor Chun Wang, Professor Adrian Mouritz, Dr Akbar Afaghi Khatibi, Dr Tim Hilditch, Dr Alireza Asgari, Dr Matthew Dingle, Professor Wingda Yang, Dr Brian Cox, *Improving affordability of composite materials to meet sustainability challenges*, \$360,000, 2013-2016.

Professor Xinghuo Yu, Dr Xiuzhen Zhang, Dr Pauline Chou, *Data mining complex transactional and criminal networks*, \$240,000, 2013-2015.

Associate Professor Serdar Boztas, Associate Professor Asha Rao, Professor Kathryn Horadam, Dr Steve Versteeg, Dr Carrie Gates, A fast and effective automated insider threat detection and prediction system, \$395,000, 2011-2014.

Professor Sabu John, Professor Chun Wang, Associate Professor Lijing Wang, Fibre-sized energy generators and storage in multi-functional fabrics, \$163,332, 2011-2013.

Professor Zahir Tari, Dr Abdun Mahmood, Professor Jiankun Hu, Detecting SCADA malicious programs to protect Australian critical infrastructure, \$270,000, 2011-2013.

Professor Jiyuan Tu, Mr Xiang Li, Qinghyan Chen, Developing an integrated predictive model for optimal design of ventilation systems in buildings, \$208,692, 2011-2013.

Professor Ian K Snook and Dr Amanda S Barnard, A theoretical hierarchy to investigate the electronic behaviour of graphene nanostructures under realistic conditions, \$240,000, 2011-2013.

Dr Rongping Wang and Professor Salvy Russo, Understanding and optimising the microstructure of Germanium-Arsenic-Selenium glasses for superior device performance, \$210,000, 2011-2013.

Professor Suresh K Bhargava, Dr Anthony P O'Mullane, Associate Professor Vipul Bansal and Dr Manneppalli L Kantam, Nano-engineered multi-functional materials for catalysis and sensing by an integrated chemical and electrochemical approach, \$320,000, 2011-2013.

Professor Arnan Mitchell and Dr Lam A Bui, Ultra-fast serialised all optical image processing: addressing the electronic bottleneck in the world's fastest camera, \$265,000, 2011-2013.

Dr Sharath Sriram, Dr Paul R Stoddart and Dr Tatiana S Perova, Dynamic substrates for surface-enhanced Raman scattering: piezoelectric actuated nanotextures with phase-locked signal processing, \$300,000, 2011-2013.

Professor Irene Yarovsky, Dr David J Henry, Theoretical modelling study of thin film permeability, \$300,000, 2011-2013.

Industry/Government Grants

Advanced Manufacturing CRC Grants

Professor Grahame Holmes, Power Control for Solar PV renewable energy, \$628,000, 2011-2013.

Professor Grahame Holmes, Next generation electronic technologies for smart grid distribution networks, \$120,000, 2013-2014.

Professor Milan Brandt, Additive manufacture of tools with conformal cooling for plastic injection moulding process using SLM, \$115,000, 2013-2014.

Professor Milan Brandt, Additive manufacturing productivity gains for industry, \$250,000, 2013-2014.

Dr Leslie Yeo, Microfluidic process intensification for advanced manufacturing, Administered by University of South Australia, \$940,000, 2013-2016.

Agilent Technologies Inc

Professor Suresh Bhargava, Dr Ylias Sabri, Dr Samuel Ippolito, The development of nano-engineered material sorbents for sending volatile organic compound (VOC) by FTIR, \$37,796 2013-2014.

Alcoa

Professor Suresh Bhargava, Dr Ylias Sabri, Dr Samuel Ippolito, Detection of Alkali Emissions on-site Alcoa Alumina Refineries, \$30,000 2013.

Australian Antarctic Division Research

Professor Kefei Zhang, Dr Robert Norman, Dr Brett Carter and Dr Suqin, GPS Radio Occultation for studying the Antarctic atmosphere and climate analysis, \$50,000, 2013-2015.

Australia-China Strategic Research Fund

Professor Liuping Wang, Professor Chun Qing Li and Dr Gang Ren, Developing advanced control system for mineral processing, \$45,000, 2013.

Australian Coal Association Research Program

Professor Prem Chhetri, The cumulative impact of growth on regional transport infrastructure: Central Queensland case study, \$91,443, 2013.

Australia-India Strategic Research Fund (AISRF)

Professor Suresh Bhargava, India Mini DME: A custom designed solution to bring stranded gas to energy markets, Partner organisations: CSIRO and CSIR-IIP, \$2,944,300 which with the equivalent money awarded to Indian partners totaled almost \$6m., 2013-2018.

Australian Urban Research Infrastructure Network (AURIN)

Professor Prem Chhetri and Professor Brian Corbitt, An analytical platform for the integration of VicHealth indicators survey and spatial objective contextual data, \$41,590, 2013-2014.

Australian Solar Institute (ARENA)

Professor Gary Rosengarten and Dr Mathew Bryson, Micro Urban Solar Integrated Concentrators (MUSIC), \$1,470,688, 2013-2016.

AutoCRC

Professor Aleksandar Subic, Gaseous fuels vehicle technologies, \$80,000

Development of a method to predict occupied seat vibration and comfort, \$80,000, 2013-2016.

BAE Systems Australia Pty Ltd

Professor Milan Brandt, SLM Manufacture and analysis of Al alloy structures, \$60,000, 2013.

Brandaroma Asia Pacific Pty Ltd

Professor James Friend received \$31,250 to fund a research project on SAW technology for use in fragrance atomization, 2013.

CSIRO

Professor Suresh Bhargava and Dr Selvakannan Periasamy, Catalytic conversion of natural gas into liquid fuels/chemicals using thermally stable nanoporous catalysts, \$50,000, 2013-2014.

Professor Suresh Bhargava, Dr Selvakannan Periasamy and Dr Sarvesh Kumar Soni, Size dependent catalytic reactivity of metal oxide catalysts, \$50,000, 2013-2014.

Professor Salvy Russo, Band structures of doped VO₂, \$50,000, 2013.

Professor Chun Qin Li, Development of a decision making tool for whole life care of stormwater pipeline network, \$10,000. Also received \$10,000 from each

council: City of Monash, City of Greater Dandenong, City of Port Phillip, City of Whittlesea, Darebin City Council, Brimbank City Council and Melbourne Water, 2013-2016.

Defence Materials Technology Centre (DMTC Ltd)

Professor Chun Hui Wang and Dr Ali Daliri, *Lightweighting Technologies*, Project No. 3.8.1., \$127,075, 2013-2014.

Associate Professor John Andrews, Professor Chun Hui Wang, Dr Bahman Shabani, Dr Chi Pok Cheung, *Reversible hydrogen fuel cell feasibility study*, Project No. 8.13, \$67,000, 2013-2014.

Professor Milan Brandt and Professor John Mo, *Investigation of tool wear during machining of titanium allow with cryogenic compressed air cooling*, \$34,000, 2013.

Defence Materials Organisation (DMO)

Professor John Mo and Professor Cees Bil, *Smart sustainment research for the development and delivery of customized training modules in system support engineering*, \$60,000 2013.

Professor Cees Bil, *US technologies research for the development and delivery of customized training on UAS design, operation support and regulations* \$7,000 and for a project on *Development of strategic research proposal for Unmanned Aircraft Systems (UAS)*, \$45,000, 2013.

Defence Science and Technology Organisation (DSTO)

Dr John Thangarajah, *Establish a conceptual framework for encoding tactical behaviours in an undersea warfare domain using an "Agent Oriented Software Engineering" approach*, \$135,000, 2013-2014.

Dr Michelle Spencer received \$20,000 for a research project on the *Development of chemically modified carbon nanotubes for application in multifunctional composite materials* and \$10,000 for a project on *Development of stable carbon nanotube models*, 2013-2014.

Professor Milan Brandt, *Additive manufacture of anti-biofouling systems for marine applications*, \$5,000, 2013.

Professor Jiyuan Tu, *Numerical study*

of turbulent bubbly flow around a moving underwater vehicle, \$20,000, 2013-2016.

Professor Chun Hui Wang, *Slotted Waveguide Antenna Stiffened Structure (SWASS) Structurally Integrated Radio frequency transparent windows in carbon fibre reinforced plastic structures*, \$30,000, 2013-2014.

Professor Kamran Ghorbani, *Slotted waveguide antenna stiffened structure (SWASS) technology demonstrator*, \$63,700, 2013-2014.

Department of Defence

Professor Kevin Massey and Professor Chun Wang, *Development of a multilateral mutual recognition framework for military airworthiness authorities*, \$31,818

Development of Defence Airworthiness training coursework package (Type certification of aircraft, airworthiness management frameworks), \$100,000, 2013-2014.

Department of Business and Innovation and Lexer Pty Ltd

Dr Xiuzhen Zhang, *Lexer social demographics*, \$12,500, 2013.

Department of Business and Innovation and Scientific Technology Pty Ltd

Dr Ron Van Schyndel, *Develop digital watermarks for telephone call recordings*, \$62,500, 2013.

Department of Innovation, Industry, Innovation, Climate Change, Science and Research and Tertiary Education/Enterprise Connect – Researchers in Business

Associate Professor Olga Troynikov, *Sports ergonomic garment project*, \$99,840, 2013-2014.



Department of Innovation, Industry, Science and Research (DIISR) and Australia-India Strategic Research Fund (AISRF)

Professor Suresh Bhargava, *Mercury emissions monitoring and mitigation: online sensing and catalytic oxidation of mercury for cleaner industrial processes*, \$8,500, 2013.

Driving Business Innovation (DBI) Victorian Postdoctoral Research Fellowships

Dr Brett Carter, *The equatorial ionosphere and its effects on radio applications*, \$300,000, 2013-2016.

Associate Professor Vipul Bansal and Mr Jos Laurie Campbell, *Nanocapsules endowed with imaging contrast alongside targeted and controllable drug release*, \$300,000, 2013-2016.

Enterprise Connect and EOS Pty Ltd

Professor Kefei Zhang, Dr James Bennett and C. Smith, *Innovative methods to determine the minimum optical and laser tracking data requirements for reliable orbit determination of space debris in the low-Earth orbit environment*, \$48,955, 2013-2014.

Enterprise Connect Researchers in Business Grant

Dr James Bennett, *Innovative methods to determine the minimum optical and laser tracking data requirements for reliable orbit determination of space debris in the low-Earth orbit environment*, \$53,849.40.

Florey Neuroscience Institutes

Dr Babak Abbasi, *Operations research modelling for decision support in stroke care services*, \$40,000, 2013-2016.

Geelong Manufacturing Council

Dr Victor Gekara, *Cleantech Innovations Geelong, Skills and Capabilities Audit*, \$14,988, 2013.

GS1 Australia Ltd

Professor Caroline Chan and Dr Kam Booi, *Healthcare data crunch*, \$20,000, 2013.

Ian Potter Foundation

Dr Oliver Jones, *Establishment of multi-user, advanced two-dimensional liquid chromatography facilities for separation science research*, \$70,000, 2013-2015.

Invention Development Management Company

Dr Kandapeen Sithamparanathan, *Spectrum sensing, energy efficient communications and interference mitigation in wireless communications*, \$11,036, 2013-2014.

IRG/Engility

Professor Heinz Schmidt, *Decision support toolkit: towards climate smart seaports in the Pacific Islands*, \$107,354, 2013-2014.

Melbourne Water Corporation

Dr Nicky Eshtiaghi, *Use of biosolids in enhanced fired clay bricks*, \$30,000, 2013-2016.

Mornington Peninsula Shire

Professor Athman Bouguettaya, Professor Timos Sellis, Dr Andy Song and Dr Flora Salim, *Innovative road safety technologies*, \$50,000, 2013.

National eResearch Collaboration Tools and Resources

Professor Mark Sanderson and Professor Falk Scholer, *Above and beyond speech, language and music: a virtual lab for human communication science*, \$139,888, 2013-2016.

National Ground Water Research and Educational Foundation

Dr Oliver Jones, *Aquifer storage and recovery of recycled water: identifying emerging contaminants in source water and examining their fate and transport*, \$7,400, 2013.

Pride Mobility Products Australia Pty Ltd

Professor Dinesh Kumar, *Making wheelchairs and mobility scooters safer*, \$12,500, 2013-2014.

Radio Frequency Systems

Dr Kamran Ghorbani, *Robotic filter tuning*, \$16,364, 2013-2014.

Rizmik Pty Ltd

Professor Franz K. Fuss, *Development of biofeedback system for training of foot muscles and gait pattern*, \$50,000, 2013.

Smartwood Pty Ltd

Dr Rajarathinam Parthasarathy, *Smartwood smartfuel*, \$6,000, 2013-2014.

Sports Analytics Pty Ltd

Associate Professor Anthony Bedford and Dr Adrian Schembri, *Development and testing of the online platform and GUI for the Ace model*, \$99,939, 2013.

The Trustee for Shiny Trust

Dr Andy Song, *Intelligence warehouse management with smart phones - Stage 2*, \$20,000, 2013-2015.

Transport & Logistics Industry Skills Council Ltd

Dr Victor Gekara and Dr Darryn Lynn Snell, *Workforce sustainability: assessing the situation and implications of ageing workforces in the Australian Transport and Logistics*, \$183,176, 2013-2014.

Victoria Police

Professor Stephen Davis and Professor Kathy Horadam, *Algorithms for quality assessment of forensic ridge patterns*, \$5,000, 2013-2014.

International Grants

Asian Office of Aerospace Research and Development

Dr Anthony O'Mullane, *Investigating the electrocatalytic properties of individual metallic nanoparticles*, \$40,000, 2013.

Google Research Awards

Professor Timos Sellis, Associate Professor James Thom, *Searching, combining and interpreting tabular data in scientific papers*, US\$57,799, 2013-2014.

United States Office of Naval Research Project

Professor Adrian Mouritz, *Critical appraisal published research into the response of naval composite materials and structures to explosive blast loading*, \$32,388, 2013-2014.

Professor Adrian Mouritz and Dr Akbar Afaghi Khatibi, *Fire modeling and testing of aluminum alloys and structures*, \$209,613, 2013-2016.

Yahoo! Inc Research Funding

Professor Mark Sanderson, *Re-finding information in the Web*, \$20,000, 2013.

Institute Achievements: Awards

PTRI's leading researchers are recognised for their cutting-edge research that generates economic, health, environmental or technological benefits at a national and international level.

PTRI researchers and research students have been recognised at national and international level for their contributions in their field of expertise. A number of those include:

ACM Distinguished Scientist Award

Professor Athman Bouguettaya, Head of the School of Computer Science and Information Technology, was named Distinguished Scientist by the Association of Computing Machinery (ACM). The award recognises significant accomplishment or having made a significant impact in the field of computing, computer science, and/or information technology.

University of Malaya Academic Icon Program

Professor Suresh Bhargava, Deputy Pro Vice-Chancellor (International) within the College of Science, Engineering and Health, was appointed Visiting Professor at the University of Malaya. He joins the Nanotechnology and Catalysis Research Centre (NANOCAT) under the UoM's Academic Icon Program.

2013 Chemical Research Society of India (CRSI) Medal

Professor Suresh Bhargava was awarded the 2013 Chemical Research Society of India (CRSI) Medal at the 15th National Symposium in Chemistry (NSC-15) and 7th CRSI-RSC joint symposium held in January at Banaras Hindu

University (BHU), Varanasi where he presented his CRSU Medal Lecture entitled In search of Innovation: Creating smart nanomaterials by designing at molecular level.

Indian National Academy of Engineering

Professor Suresh Bhargava was elected a Foreign Fellow of the Indian National Academy of Engineering (INAE) at a meeting of the Governing Council of the Academy. The Academy bestows the rank of Fellowship on Indian and foreign nationals who have demonstrated their eminence and achieved outstanding accomplishments in engineering and technology.

Royal Australian Chemical Institute (RACI)

Professor Suresh Bhargava was awarded the 2013 Applied Research Medal for his significant contributions towards the development of, or innovation through, applied research, or in industrial fields. The work covers a period of 10 years preceding the award, with the major proportion of the work having been done in Australia or its Territories.

Institution of Engineering and Technology (IET)

Professor Xinghuo Yu was elected Fellow of the Institution of Engineering and Technology (UK) in recognition of sustained achievements in his profession.

IEEE Dr.-Ing Eugene Mittelmann Achievement Award

Professor Xinghuo Yu was awarded the 2013 Dr.-Ing. Eugene Mittelmann Achievement Award by IEEE Industrial Electronics Society (IES) for his outstanding contributions to the field of Industrial Electronics. The award was presented at the Society's 39th annual conference IECON 2013 held in Vienna in November.

Fellow of the Association for Computing Machinery (ACM)

Professor Timos Sellis is the only academic in Australia named Fellow of the Association for Computing Machinery (ACM), the world's largest educational and scientific computing society. Being named a Fellow is ACM's highest honour and one of the most prestigious titles for computer scientists.



MOWE-IT

Professor Prem Chhetri was appointed to the International Expert Panel on an EU project called MOWE-IT - (Management of Weather Events in the Transport Systems). This is a €2.3 million project based in Germany and is funded through the European Union Seventh Framework Program. More details at <http://www.mowe-it.eu/>.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Dr Michelle Spencer was appointed Visiting Scientist at CSIRO, where she joined the Virtual Nanoscience Laboratory (VNLab) within the Materials Science and Engineering Division. Dr Spencer is collaborating with the leader of VNLab, Dr Amanda Barnard, and co-supervises a postdoctoral fellow there who is working on modelling the nanomorphology, environmental stability, and surface properties of zinc oxide nanoparticles.

Global Engineering Deans Council (GEDC) Executive Committee

Professor Aleksandar Subic was elected to the Global Engineering Deans Council (GEDC) Executive Committee for a three year term. The mission of the GEDC is to serve as a global network of engineering deans and to leverage their collective strengths for the advancement of engineering education, research and service to the global community.

The Australia Awards Endeavour Research Fellowship

Dr Ferry Jie from the School of Business IT & Logistics, Dr Nedaossadat Mirzadeh and Dr Rajesh Ramanathan from the School of Applied Sciences were awarded a 2014 Endeavour Research Fellowship which will provide support to undertake study, research and professional development overseas.

PTRI Research Performance Awards

To acknowledge the performance of PTRI's top researchers the following members received the PTRI research performance awards at the 2013 Planning Day:

Professor Chun Wang - for the highest number of publications in 2012

Professor Andrew Eberhard - for the highest number of publications in Mathematical Sciences in 2012

Professor Andrew Greentree - for the highest number of publications in Physical Sciences in 2012

Professor Suresh Bhargava - for the highest number of publications in Chemical Sciences in 2012



Dr Andy Song - for the highest number of publications in Information and Computing Sciences in 2012

Professor JiyuanTu - for the highest number of publications in Engineering in 2012

Associate Professor Kamran Ghorbani - for the highest number of publications in 2012

Professor Heinz Schmidt - for the highest research income in 2012

Professor James Friend - for the highest research income in Australian Competitive grants in 2012

Professor Kefei Zhang - for the highest research income in public sector grants in 2012

Professor Suresh Bhargava - for the highest research income in industry grants in 2012

Professor Grahame Holmes - for the highest research income in CRC grants in 2012

Professor Kourosh Kalantar-zadeh - for the highest number of citations in Scopus (2008-2012 publications)

Professor Hepu Deng - for the highest number of HDR completions in 2012



Institute Achievements: Outreach activities

PTRI's Outreach program is aimed at promoting public awareness and understanding of science and making informal contributions to science research.

PTRI is committed to promoting RMIT research and its outcomes internally and externally by hosting Distinguished Lectures, research seminars and national and international conferences. A number of these are listed below:

Distinguished Lecture Series

13 June 2013

Distinguished Lecture presented by **Professor Michael Tse**, Chair, Professor of Electronic Engineering at Hong Kong Polytechnic University and IEEE on *A network perspective of stock markets: get panicked or synchronized!*

18 June 2013

Distinguished Lecture presented by **Professor Gang Tao**, Professor in the Department of Electrical and Computer Engineering at the University of Virginia, USA on *Adaptive control: theory, techniques and problems*.

12 July 2013

Distinguished Lecture presented by **Professor Kok-Meng Lee**, Professor in the Woodruff School of Mechanical Engineering at the Georgia Institute of Technology (Atlanta, USA), Distinguished Professor with the Huazhong University of Science and Technology (Wuhan, China), and IEEE/ASME Fellow on *Paradigm shift, challenges and opportunities in mechatronics, intelligent manufacturing and innovative applications*.

8 November 2013

Distinguished Lecture presented by **Professor Jinhu Lu**, Professor of the Academy of Mathematics and Systems Science at the Chinese Academy of Sciences and Adjunct Professor of the School of Electrical and Computer Engineering at RMIT, on *Complex networks: Nexus of all realities in circuits and systems*.

17 December 2013

Distinguished Lecture presented by **Professor Chengqi Zhang**, Director, Centre for Quantum Computation & Intelligent Systems (QCIS), University of Technology, Sydney, Australia entitled *Big data research and development in computer science*.

Research Seminars

11 January 2013

Lecture presented by **Dr Adam Kellerman**, Research Fellow at UCLA entitled *Towards better space-weather predictions: understanding killer electrons in the Van Allen radiation belts*.

8 February 2013

Lecture presented by **Professor Leo Lorenz**, President of the European Centre of Power Electronics, IEEE Fellow, and member of the German Academy of Science on *Power semiconductor devices - technology trends and challenges in the application*.

1 March 2013

Research Seminar presented by Professor Pascal Van Hentenryck from the NICTA Victorian Research Lab, University of Melbourne on *Computational methods for disaster management*.

27 March 2013

Research Seminar presented by **Professor Chandra Lalwani**, Logistics Institute, University of Hull Business School, UK and Editor in Chief of International Journal of Logistics Management on Strategies for value enhancement in supply chain management and overcoming barriers to their implementation.

10 April 2012

IEEE/RMIT Distinguished Lecture hosted by SECE and presented by **Professor Metin Akay**, Founding Chair of the new Biomedical Engineering Department and the John S. Dun Professor of Biomedical Engineering at The University of Houston on *Advances (innovations) in neural engineering*.

5-7 June 2013

PTRI's Network Modelling, Optimisation and Dynamics (Netmod) Research group participated in an Optimisation in Industry workshop held in RMIT's Swanston Academic Building. The workshop brought together more than 120 researchers, graduate students and industry practitioners with an interest in solving challenging industrial problems using analytics, mathematical modelling, and

advanced optimisation and constraint programming methods. The workshop featured keynote speakers such as Dr Brenda Dietrich, IBM Fellow and Vice President.

16 July 2013

Professor Timos Sellis delivered his Inaugural Professorial Lecture on *Unleashing the power of Big Data*. Big Data is one of the biggest innovations in computing in the last decade and Professor Sellis talked about the importance of being able to process, store and understand these vast amounts of information. He also emphasised how the management of Big Data can drive decisions and discoveries in research.

29 July 2013

Research Seminar presented by **Dr Supab Choopun**, Associate Professor in the Department of Physics and Materials Science at Chiang Mai University, Thailand on *ZnO nanostructures for ethanol sensors and dye-sensitized solar cells*.

22 August 2013

Research Seminar presented by **Professor Mikhal Basin**, from Autonomous University of Nuevo Leon and Associate Editor of The International Journal of Innovative Computing Information and Control Autonomous University of Nuevo Leon on *Super-twisting algorithm for systems more than one*.

7 October 2013

Joint lecture with The Australian Mathematical Sciences Institute presented by **Professor Hiroaki Kitano**, President and CEO of Sony Computer Science Laboratories and developer of Sony's AIBO (Artificial Intelligence roBOt) and founder of the robotic world cup tournament known as Robocup on Act Beyond Borders Melbourne.

17 October 2013

Joint Research Seminar with School of Computer Science and Information Technology presented by **Professor Fabio Ciravegna**, Professor of Language and Knowledge Technologies at the

Department of Computer Science at The University of Sheffield, United Kingdom on *Through our eyes - involving citizens for situation awareness during large scale events*.

5 December 2013

Joint Public Lecture with the School of Business Information Technology & Logistics presented by **Dr Sheng Liang**, Chief Technology Officer, Cloud Platforms Group at Citrix and the founder of Cloud.com on *Delivering IT as a service*.



Bi-Monthly Networking Events

The PTRI Bi-Monthly Networking events are designed to establish a research environment which promotes a culture of sharing ideas and collaboration between young researchers and their peers.

10 September 2013

Presentation by Dr Sasan Adibi from the School of Business IT and Logistics on *Mobile Health (mHealth) – a sleep technology perspective*.

20 November 2013

Presentation by Dr Nedaossadat Mirzadeh from the School of Applied Sciences on *Organometallic species of gold: synthesis, characterisation and their potential applications*.

Conferences, workshops and symposiums

Participation in conferences is an important aspect of research at RMIT. PTRI would like to acknowledge the contributions of the following members:

South Africa February 2013

Professor Xinghuo Yu attended the Officers meeting in Cape Town

as Vice President (Publications) of IEEE Industrial Electronics Society and presented a research paper at the 2013 IEEE International Conference on Industrial Technology. He also presented an IEEE Distinguished Lecture on Smart Grids at Stellenbosch University, the University of Cape Town and the University of Pretoria on 26, 27 February and 1 March, respectively.

Brazil February 2013

PTRI Commercialisation and Industry Linkage Manager Dr Ian Griffiths visited Brazil where he attended the 2013 ISSNIP Biosignals and Biorobotics Conference: Biosignals and Robotics for Better and Safer Living at the University Federal Rio Janeiro. Ian presented a paper on Commercialization of medical technology for affordable healthcare. This session was attended by approximately 25 academics and students and showcased RMIT University's technology and potential as a partner with commercialization capabilities.

At the Universidade Federal do Espirito Santo Ian met with the Office of International Affairs to finalize the Memorandum of Understanding (MoU) between the Universities. Potential collaboration through the 'Research without Borders' grant scheme was also discussed as were potential collaborations at the Universidade Federal da Bahia.

RMIT Women's Research Network

The RMIT Women's Research Network was officially launched by Professor Daine Alcorn in February. This network was initiated by three early career researchers in the College of Science, Engineering and Health - Dr Madhu Bhaskaran, Dr Nicky Eshtiaghi, and Dr Suelynn Choy. The Network was established to encourage female academic staff and research fellows at all career stages to connect with one another in order to form positive professional relationships and collaborative research links. It also provides a supportive environment to share research ideas, interest and experiences, as well as for informal

support and mentoring. Further information is available at: <http://www.rmit.edu.au/seh/research/womens-research-network>

Australian Association for Unmanned Systems (AAUS) Workshop

Researchers in the UAS project team hosted a workshop on 26 March with the Australian Association for Unmanned Systems (AAUS), the peak not-for-profit industry association for UAS in Australia. The Workshop focused on UAS insurance and featured a specialist briefing provided by the UAS researchers on the safety risk management and regulation of civilian UAS. The Workshop brought together aviation insurance providers from Australia and New Zealand and was held in RMIT's Design Hub building.

Asian Office of Aerospace Research and Development (AOARD)

Program Managers from the Asian Office of Aerospace Research and Development (AOARD) of the US Air Force Office of Scientific Research (AFOSR) visited RMIT on 6 December 2013. The program managers presented an overview of the AOARD and their research in the areas of materials, chemistry, and nanoscience - all with a focus on fundamental science. The presentations were followed by a set of presentations by RMIT researchers in relevant areas.

2013 IEEE ECCE Asia Downunder Power Electronics Conference

Hosted by RMIT University, the 2013 Institute of Electrical and Electronics Engineers (IEEE) and Energy Conversion Congress and Exhibition (ECCE) Asia DownUnder conference was held in June at the Crown Conference Centre in Melbourne. The high quality conference program included six keynote presentations from acclaimed international power electronics researchers and accepted 222 technical papers across a broad range of topics. Australasian Conference on Information Systems (ACIS)

More than 285 participants attended the 24th annual Australasian Conference on Information Systems (ACIS) held at RMIT University, 4 – 6 December, 2013. The theme of the conference - which covered technical, organisation, business, and social issues in the application of Information Technology - was "IS: Transforming the Future". Professor Caroline Chan, Head, School of Business IT and Logistics and Conference Chair, welcomed two keynote speakers, Dr Sheng Liang, Citrix, and Professor Richard Watson, University of Georgia, who shared their knowledge and experience with participants. Researchers and scholars presented more than 170 research papers across 80 sessions.

Australian Early-Mid Career Researcher Forum national meeting

PTRI was co- sponsor of the Australian Early-Mid Career Researcher Forum's national meeting, Science Pathways: Engaging with Industry & Innovation held at the AMREP Education Centre in Melbourne, 17-18 October 2013. Through the EMCR Forum, the Australian Academy of Science exchanged ideas with early-mid career researchers about how they can more effectively engage with industry and apply a more innovative approach to their research. The 154 delegates in attendance consisted mostly of early-mid career researchers as well as Fellows of the Academy, and industry and government representatives. RMIT was represented by Dr Oliver Jones, School of Applied Sciences and Dr Sharath Sriram, School of Electrical and Computer Engineering.

Automation Software Engineering (AICAUSE) - Automated Systems Software Engineering and Testing Workshop

This workshop was organised by the Australia-India Research Centre for Automation Software Engineering and was held on 4 – 5 December 2013. The focus of the workshop was on ongoing research and trends on automated systems software, engineering and testing and it

brought together speakers from AICAUSE at RMIT, ABB Bangalore (India), NTNU Trondheim (Norway), the University of Melbourne, Swinburne University of Technology and the CSIRO. It also provided opportunities to further explore joint international projects and local collaboration in Victoria.

Celebrating Australia's Sports Technology and Engineering know-how

RMIT hosted a special event on 19 December 2013 celebrating Australia's Sports Technology & Engineering Know-How presented by the Australian Sports Technologies Network and RMIT University. This event saw the launch of the first Handbook on Sports Technology and Engineering, edited by Professor Franz K. Fuss and Professor Aleksandar Subic, School of Aerospace, Mechanical & Manufacturing Engineering.

Centre for Advanced Materials and Industrial Chemistry (CAMIC)- RMIT in India – Beyond 2013

From 2-5 December, 2013 RMIT University hosted highly regarded scientists and joint supervisors of RMIT PhD students from IICT (CSIR) Hyderabad. This visit was organised by Professor Suresh Bhargava and supported by the College of SEH, School of Applied Sciences, PTRI, School of Graduate Research and CSIRO Process Science and Engineering. The delegates participated in a number of activities such as a research training symposium, the RMIT-IICT (CSIR) Joint Workshop, Technology Enabled Active Learning interactive workshop and a visit to the CSIRO laboratories.





Institute Achievements: External partnerships

Establishing partnerships with peers, industry and government organisations, is also an important aspect of the University's strategy to deliver high level research outcomes.

Establishing partnerships with peers, industry and government organisations, is also an important aspect of the University's strategy to deliver high level research outcomes. PTRI researchers have been actively involved in interdisciplinary collaborations at a national and international level. A number of highlights include:

Academy of Scientific and Innovative Research (AcSIR)

The President of the Global Research Alliance and Chancellor of the Academy of Scientific and Innovative Research (AcSIR), Dr Mashelkar visited RMIT on 15 April, focusing on accelerating inclusive growth through inclusive innovation in technology, business, workflow, system delivery and organisational processes in his public lecture. The lecture, *Inclusive Innovation: The Global Game Changer* was hosted by Professor Suresh Bhargava, Deputy Pro Vice-Chancellor (International) of the College of Science, Engineering and Health. Following the lecture, RMIT's Vice-Chancellor and President, Professor Margaret Gardner AO, and Dr Mashelkar signed an historic Memorandum of Understanding for a joint PhD program between RMIT and AcSIR. The MOU provides researchers and doctoral students with exciting and challenging experiences as part of joint PhD and staff and research student exchange programs in areas such as aerospace, bio-nanotechnology, electrical engineering, sensor technology and sustainable energy.

AFL Football Operations Department

Dr Patrick Clifton, from the Sports Engineering Technologies (SportzEdge) research team, led an investigation to test a variety of glove brands and models after a request from the AFL's Football Operations Department. The one AFL-specific glove, the Franklin Football Glove, and popular models from other sports were tested in a laboratory, using AFL football leather fixed to a force plate, replicating dry and wet conditions. The gloves did not improve player grip in wet conditions and the result of the investigation was that six of the 10 gloves on average provided grip above that of a bare human hand in dry conditions. The recommendation was that they should not be used during AFL games. The AFL has accepted that and regulated against their use in the upcoming season. SportzEdge is now the official glove tester for the AFL, with manufacturers asking for feedback on how they can get their products passed for AFL player use.

Australian Antarctic Science Program

In one of six ear-marked projects to gain funding from the Australian Antarctic Science Program out of over 150 proposals, the SPACE Research Centre has been working with the Bureau of Meteorology (BoM), Australian Antarctic Division and University of Graz, Austria, to use GPS signal data to determine

how the atmosphere above Antarctica has behaved over the last 10 years. The emerging technique known as GPS radio occultation (RO), is regarded as the most accurate thermometer from space. Generating high quality and high resolution data, GPS RO can be used to fill the gaps in the current weather observation network, taking measurement anywhere across the world and during any weather events, such as storms and tropical cyclones. This new study builds on the Centre's world-leading research into atmosphere analysis using satellite data, expanding the focus from a region to a whole continent.

Australian Sports Technologies Network (ASTN)

The Australian Sports Technologies Network (ASTN) won a bid to establish the Sports Technologies Precinct under the Australian Government's Innovation Industry Partnerships (Precincts) Program. A government commitment of \$6 million over the next four years could see the project create up to 1,500 jobs across Australia, with at least 100 of these based in the precinct's Geelong headquarters. Professor Franz Fuss was appointed as an ASTN Board member in 2012. The precinct commenced in October and nodes will be established in Melbourne, Sydney and Brisbane to link national leading and developing sport technology manufacturers with sports organisations such as the AFL and Tennis Australia. RMIT

is a founding member of the ASTN and a core member of the Sports Technologies Precinct bid.

AutoCRC (Cooperative Research Centre for Advanced Automotive Technology)

While some manufacturers have responded to environmental concerns by moving away from internal combustion altogether in favour of battery or fuel cell-powered electric cars, the approach at RMIT's Green Engines Research Facility is to work with the local and international automotive industry to push the existing technology far beyond its current boundaries.

The first of its kind in the Asia-Pacific, the \$10 million lab opened in 2013 after three years of intense development. Its focus is the investigation of every possible alternative fuel - from liquid to gas and multi-fuel platforms - and enabling technologies that could be used in new-generation internal combustion engines. The aim is to identify strategic improvements and innovations to combustion and fuel delivery systems for engines that are cleaner, more efficient and better adapted to our 21st century carbon-constrained economy. The first research projects funded through the AutoCRC focus on gaseous fuels vehicle technologies, including liquid natural gas (LNG) conversion for heavy vehicles.

Boeing Research & Technology-Australia

RMIT researchers are undertaking a number of futuristic research projects in advanced composites that may, in coming years, find applications on civil and military aircraft such as used in aircraft manufacture, servicing or repair. Projects include the use of ultra-thin pins to increase the damage resistance of composites when unexpectedly hit by a small object, such as a bird during take-off or landing. Researchers are also developing ways of repairing composites quickly and easily in the event of damage, including the use of so-called self-healing. By

mimicking the human body when it is hurt, such as a cut or abrasion, RMIT researchers led by Professor Adrian Mouritz have developed innovative ways of composites repairing themselves without human intervention. The composite materials allow a lighter structure, which increases airplane efficiency, reduces fuel consumption and reduces weight-based maintenance and fees. Composites do not fatigue or corrode, which reduces scheduled maintenance and increases productive time.

CRC for Spatial Information and Japanese Space Agency (JAXA)

An agreement between the CRC for Spatial Information and Japanese Space Agency (JAXA) was established for the loan of equipment to decode the LEX data and the appointment of a postdoctoral researcher at RMIT to be paid for by the CRC. This work is in response to the feedback from earth to satellite in order to better transmit data and control the fine nature of the orbit. An agreement to extend this work into 2014 was signed in 2013.



CSIRO, Shiny Pty Ltd, Federation Logistics, Shiny Embroidery and the Australasian Production and Inventory Control Society

A two year project led by Dr Andy Song combines smart phone technology with the latest Artificial Intelligence (AI) techniques. Backed by a \$500,000 grant from the Victorian Government's Department of Business and Innovation Digital Futures Fund, this project applies

AI and uses some advanced data mining and dynamic optimization techniques to reduce the cost of daily warehouse operations, to reduce human error and to streamline the operation process.

The RMIT team is collaborating with a range of partner organisations including CSIRO, Shiny Pty Ltd, Federation Logistics, Shiny Embroidery and the Australasian Production and Inventory Control Society. The team has developed an effective warehouse management solution that benefits many SMEs, both in Australia and overseas providing an advanced but cost-effective solution, which increases productivity and reduces running costs.

CSIRO and Japan Science and Technology Agency

The development of cheaper and less toxic solar cells using nanotechnology was the focus of a collaborative research project conducted by RMIT, CSIRO and the Japan Science and Technology Agency. The team investigated the synthesis of semi-conductor inorganic nanocrystals using low-cost and abundant elements for printable solar cell applications.

The research was published in the high-impact Journal of the American Chemical Society. The RMIT research team was led by Professor Yasuhiro Tachibana from the School of Aerospace, Mechanical and Manufacturing Engineering.

EU COST Action ES1206

The RMIT SPACE Centre is the only Australian representative in the EU COST Action ES1206 with a project on GNSS for severe weather events and climate. The EU COST was very competitive (80 were invited to submit a full proposal out of EOI of 800, only 30 out of 80 were successful in the end).

Marie Curie International Research Staff Exchange Scheme

A School of Computer Science and IT team led by Professor Timos Sellis has been working with

researchers from 12 institutions in 10 countries on the 'SemData' project which is supported through the Marie Curie International Research Staff Exchange Scheme.

The project deals with the growing area of Semantic Data Management which refers to a way of organising and using data based on its meaning. Professor Timos Sellis is joined on the SemData project by fellow researchers including Professor Mark Sanderson, whose expertise lies in information retrieval, and Dr Jenny Zhang, who specialises in using and interpreting social media data. The international relationships established and strengthened through this project will be invaluable for other initiatives as well as putting the School of Computer Science and IT on the map of European Union-funded projects, which the team hopes to further explore through the RMIT Europe initiative.

Metro Group (RMIT Vietnam)

Professor Xinghuo Yu visited RMIT Vietnam and a departmental store of the METRO Group to discuss potential research collaboration in energy saving buildings. A potential research project is being developed between Metro group and RMIT.

Centre for Advanced Materials and Industrial Chemistry (CAMIC)

Director Professor Suresh Bhargava organised a delegation consisting of the highest profile Science Leaders in Minerals and Materials Science to visit Indian Research Partners and Institutions to initiate and further develop strong research ties with India. The capability, research issues and concerns of Indian institutions have considerable complementarity with those of their Australian counterparts and an enormous opportunity exists to leverage such complementary expertise to conduct ground-breaking and environmentally and economically significant research across the two communities. Members of the delegation include: Dr Calum Drummond (Group Executive CSIRO), Professor Andrew

Holmes (FRS), Professor Alan Bond (FRS), and RMIT's own Professors Salvy Russo, Dougal McCulloch, Andrew T Smith, Arnan Mitchell and Gary Bryant along with Professor Bhargava.

Unmanned Aerial Systems research

The PTRI research team for Unmanned Aerial Systems led by Dr Reece Clothier took delivery of three Bask Aerospace MR4 Aerodrones in January 2013. The MR4 is being used to support research in multi-vehicle collaboration, the development of multi-sensor payloads, aerodynamic analysis, and the development of advanced guidance, navigation and control systems for small unmanned aircraft. The MR4 is also being used to provide undergraduate students with practical hands on experience in the design, operation and maintenance of small unmanned aircraft systems as part of their studies in the undergraduate Aerospace Engineering Program. RMIT is currently the only Australian University to offer a subject dedicated to UAS design.

The research team also took delivery of a Javelin fixed-wing UAS in February, which was donated to the team by Mr Ryan Vu, a graduate of the RMIT Aerospace Program and founder of local UAS business ECV Aeronautics. The arrival of the Javelin is a milestone in capability for the Unmanned Aerial Systems research team. The Javelin is being used to support a wide range of research in advanced control, airborne sensing, and UAS performance in different civil applications.

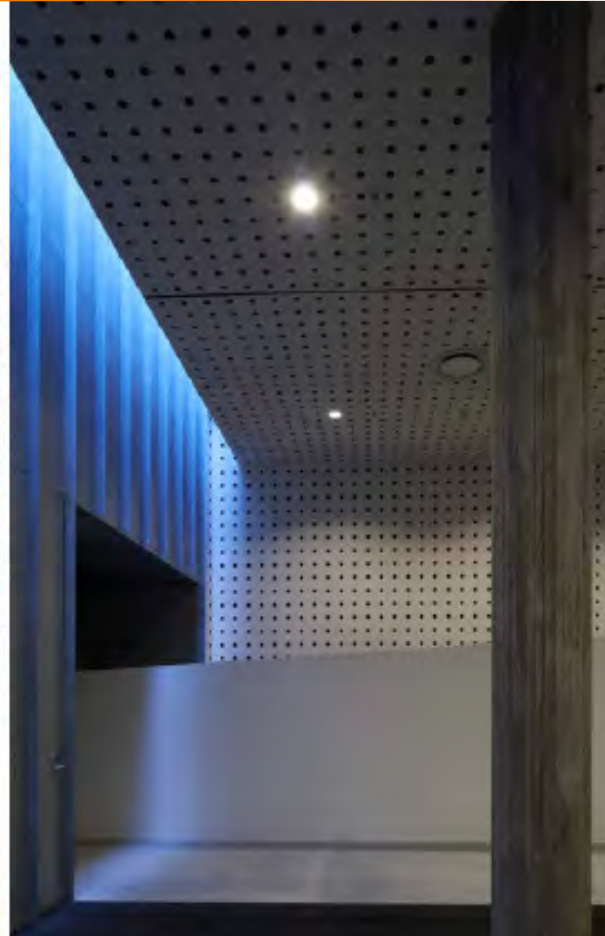
Project ResQu

Dr Reece Clothier is a key contributor to Project ResQu, led by the Australian Research Centre for Aerospace Automation (ARCAA) in partnership with Insitu Pacific Ltd, Boeing Research & Technology - Australia, and the Queensland State Government. One of the core objectives of Project ResQu is to support the development of safety

regulations for civil unmanned aircraft systems in a wide range of civil and commercial applications.

Dr Clothier is part of a team of researchers developing risk models and decision support tools to guide the development of airworthiness and operational regulations for UAS.

Dr Clothier is also exploring factors influencing the public's perception of the risks associated with UAS operations. The two-year \$7.2m project plays a significant role in shaping safety regulations, and in turn, address one of the greatest challenges facing the civil UAS industry.



Contacts

General enquiries:

Platform Technologies
Research Institute
GPO Box 2476
Melbourne VIC 3001
Tel. +61 3 9925 4324
Fax +61 3 9925 2387
ptri@rmit.edu.au

Professor Xinghuo Yu
Director
Tel. +61 3 9925 5317
Fax +61 3 9925 2387
x.yu@rmit.edu.au

Petra Van Nieuwenhoven
Research Institute Manager
Tel. +61 3 9925 4324
Fax +61 3 9925 2387
petra.vannieuwenhoven@
rmit.edu.au

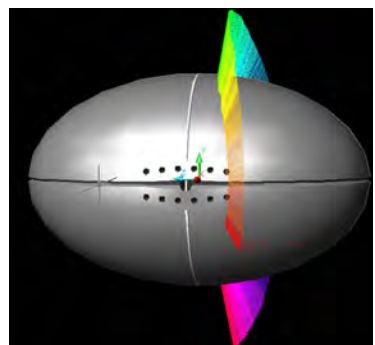
Sarah Barter
Administrative Officer
Tel. +61 3 9925 8362
Fax +61 3 9925 2387
sarah.barter@rmit.edu.au

Program leaders:

Professor Andrew Eberhard
Program leader
Informatics and Networks
(I&N)
Tel. +61 3 9925 2616
andy.eb@rmit.edu.au

Professor Franz K. Fuss
Program leader
Innovative Engineering
Systems (IES)
Tel. +61 3 9925 6123
franz.fuss@rmit.edu.au

Professor Mike Austin
Program leader
Nano Materials and Devices
(NMD)
Tel. +61 3 9925 2459
michael.austin@rmit.edu.au



Publications

During 2013 PTRI researchers produced publications which contributed significantly to scientific knowledge impacting on the relevant area of research.

In 2013, PTRI members achieved great success in publications, with 3 books, 36 book chapters, 576 journal articles and 218 conference proceedings. They are listed below:

Books

Belkin, M., Corbitt, B., and Wickramasinghe, N., (2013), Strategic ICT planning in pathology, Springer Science and Business Media, 9781461444770

Gregory, M., and Gance, D., (2013), Security and the networked society, Springer, 9783319023908

Strengers, Y., (2013), Smart energy technologies in everyday life: Smart utopia?, Palgrave Macmillan, 9781137267047

Book chapters

Adibi, S., Dara, R., Wickramasinghe, N., Chan, C., and Varadarajan, S., (2013), Privacy-enabled mobile-health (mHealth)-based diabetic solution in SmartData: Privacy meets Evolutionary Robotics, Springer, 9781461464082

Ahmed, K., Hussain, A., and Gregory, M., (2013), An efficient, robust, and secure SSO architecture for cloud computing implemented in A Service Oriented Architecture in Principles, Methodologies, and Service-oriented Approaches for Cloud Computing, IGI Global, 9781466628557

Brandt, M., and Sun, S., (2013), Laser-assisted machining: Current status and future scope in Laser-Assisted Fabrication of Materials, Springer, 9783642283581

Cheong, F., and Cheong, C., (2013), Queensland floods (2010-2011) and

“Tweeting” in Encyclopedia of Natural Hazards, Springer, 9789400702639

Cutler, C., Chanda, N., Shukla, R., Sisay, N., Cantorias, M., Zambre, A., McLaughlin, M., Kelsey, J., Upendran, A., Robertson, D., Deutscher, S., Kannan, R., and Katti, K., (2013), Nanoparticles and phage display selected peptides for imaging and therapy of cancer in Recent Results in Cancer Research: Theranostics, Gallium-68, and other Radionuclides - A Pathway to Personalized Diagnosis and Treatment, Springer, 9783642279942

Dunn, J., Ding, Y., and Rao, A., (2013), Computational fluid dynamics: Designing a feedback system for non-mathematical users to overcome the barriers to real-time CFD analysis in Designing the Dynamic: High Performance Sailing and Real Time Feedback in Design, Melbourne Books, 9781922129130

Felicetti, P., Xie, Y., and Tang, J., (2013), Integrated computational multidisciplinary design environment (ICMDE): A dynamic approach to structural design in Designing the Dynamic: High-performance Sailing and Real-time Feedback in Design, Melbourne Books, 9781922129130

Feng, Y., Yu, X., and Han, F., (2013), On digitization of variable structure control for permanent magnet synchronous motors in AC electric motors control: Advanced Design Techniques and Applications, John Wiley and Sons, 9781118331521

Gu, T., Wu, Z., Tao, X., Pung, H., and Lu, J., (2013), Mining emerging patterns for activity recognition in Contrast Data Mining: Concepts, Algorithms and Applications, CRC Press, 9781439854327

Hugel, H., and Jones, O., (2013), Natural product chemistry in action:

The synthesis of melatonin metabolites K1 and K2 in Metabolomics Tools for Natural Product Discovery: Methods and Protocols, Springer, 9781627035774

Jones, O., and Hugel, H., (2013), Bridging the gap: Basic metabolomics methods for natural product chemistry in Metabolomics Tools for Natural Product Discoveries: Methods and Protocols, Springer Science and Business Media, 9781627035774

Mei, Y., Tang, K., and Yao, X., (2013), Evolutionary computation for dynamic capacitated arc routing problem in Evolutionary Computation for Dynamic Optimization Problems, Springer-Verlag, 9783642384158

Paramita, M., Guthrie, D., Kanoulas, E., Gaizauskas, R., Clough, P., and Sanderson, M., (2013), Methods for collection and evaluation of comparable documents in Building and using Comparable Corpora, Springer, 9783642201271

Pavelyev, A., Pavelyev, A., Matyugov, S., Yakovlev, O., Liou, Y., Zhang, K., and Wickert, J., (2013), Radio wave propagation phenomena from GPS occultation data analysis in Wave Propagation Theories and Applications, InTech, 9789535109792

Pozzetti, A., Bil, C., and Clark, G., (2013), Fuzzy logic application in performance-based contracting process in Concurrent Engineering Approaches for Sustainable Product Development in a Multi-Disciplinary Environment, Springer-Verlag, Springer Science+Business Media, 9781447144250

Shanks, R., and Kong, I., (2013), General purpose elastomers: Structure, chemistry, physics and performance in Advances in Elastomers I: Blends and Interpenetrating Networks, Springer Verlag, 978-3-642-20924-6

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