University of South Australia

# Institute for Telecommunications Research Annual Report 2013

Connected. Reliable. Real Solutions.

The **Vision** for the Institute for Telecommunications Research is to advance human knowledge in the transmission, processing and use of information, to enable high impact technologies which can deliver economic, social, cultural, environmental and health benefits.

Our **Mission** is to conduct world class fundamental research, partnered with industry to develop and deliver technologies in a vibrant research and education environment.

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# RESEARCH HIGHLIGHTS 2013
# INSTITUTE FOR TELECOMMUNICATIONS RESEARCH

## SPEEDY RESEARCH

A satellite-based remote sensing system developed by an ITR-led consortium performed outstandingly in gruelling field trials conducted in Canada's arctic wilderness. Environmental data collected by ground terminals placed thousands of kilometres apart were transmitted to a satellite which successfully captured, stored and downlinked the data to a central ground station. The Global Sensor Network is now being developed for commercial applications.

*ITR engineer Ricky Luppino tests remote sensing technology in Canada.*

## BEST OF THE YEAR

Along with NASA, ITR was chosen as a finalist for Technology of the Year award, presented by the Wireless Innovation Forum. ITR was selected for its highly innovative use of Software Defined Radio in the Global Sensor Network, which enables remote data gathering and bidirectional communication from very large numbers of sensors at very low cost.

## INNOVATOR AWARD

ITR Director Professor Alex Grant won the Pearcey Entrepreneur Award for South Australia. This award recognises people who have successfully bridged the gap between academia and industry. Professor Grant was also honoured this year when he was appointed a member of the 2014 Australian Research Council (ARC) College of Experts.

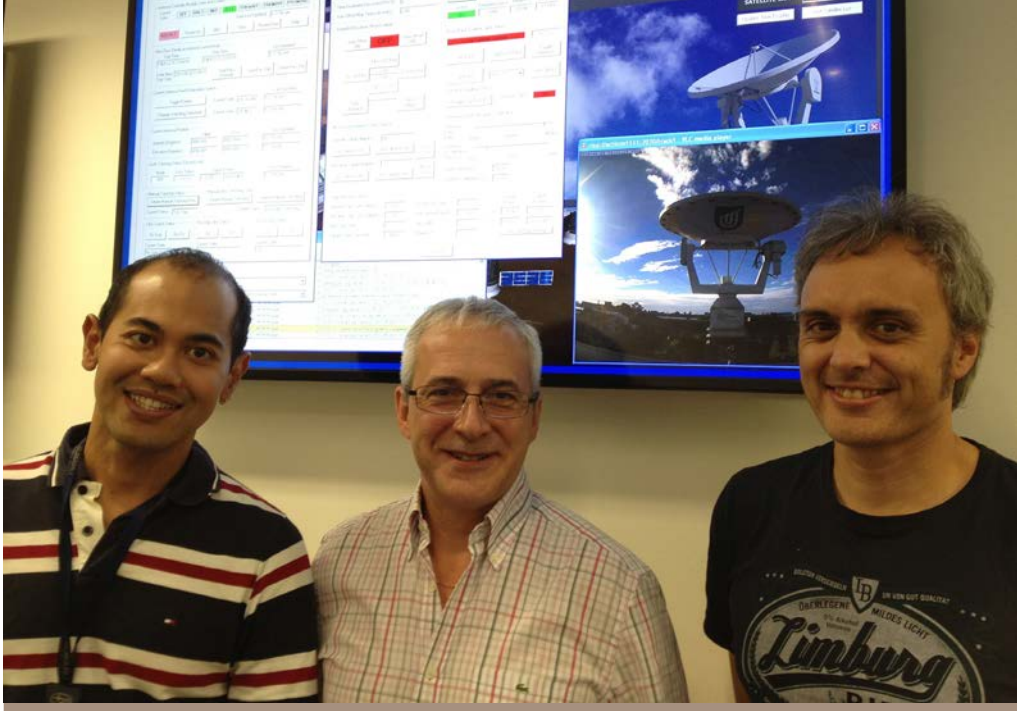
## LOUD AND CLEAR

ITR PhD student Demi Gao won the University of South Australia's Three Minute Thesis (3MT) competition, finishing up in the top eight students in the National Finals. To compete in the 3MT, students must describe their PhD or Masters research in just three minutes.

*ITR PhD student Demi Gao impressed judges with her passion for improving hearing implants.*

## POST-DOCTORAL HONOUR

ITR Research Fellow Dr Roy Timo was awarded a Humboldt Research Fellowship for Post-Doctoral Researchers. The program will support Dr Timo in a two-year research project on non-asymptotic information theory, working with Professor Gerhard Kramer at the Technical University in Munich. Professor Kramer is President of the IEEE Information Theory Society and Head of the Institute for Communications Engineering.



## ROCKET MEN

Engineers at ITR successfully tracked an Ariane V rocket packed with a 2500kg payload bound for the International Space Station. With four missions now under its belt, ITR is one of only six tracking stations globally which record the rocket's speed, location and status on its journey to the Space Station.

*Launch trackers: ITR engineers Hidayat Soetiyono and Marc Lavenant (L and R) with Pierre Letapissier (centre) from the French Government Space Agency, Centre National d'Etudes Spatiales (CNES).*

## TALKING CARS

Communications technology company Cohda Wireless, which was founded by ITR researchers in 2005, attracted substantial investment from networking equipment firm Cisco Systems and semiconductor maker NXP B.V. Cohda Wireless is developing so called 'talking car' technology which warns drivers ahead of time via audio and visual alerts of impending hazards that could lead to accidents.

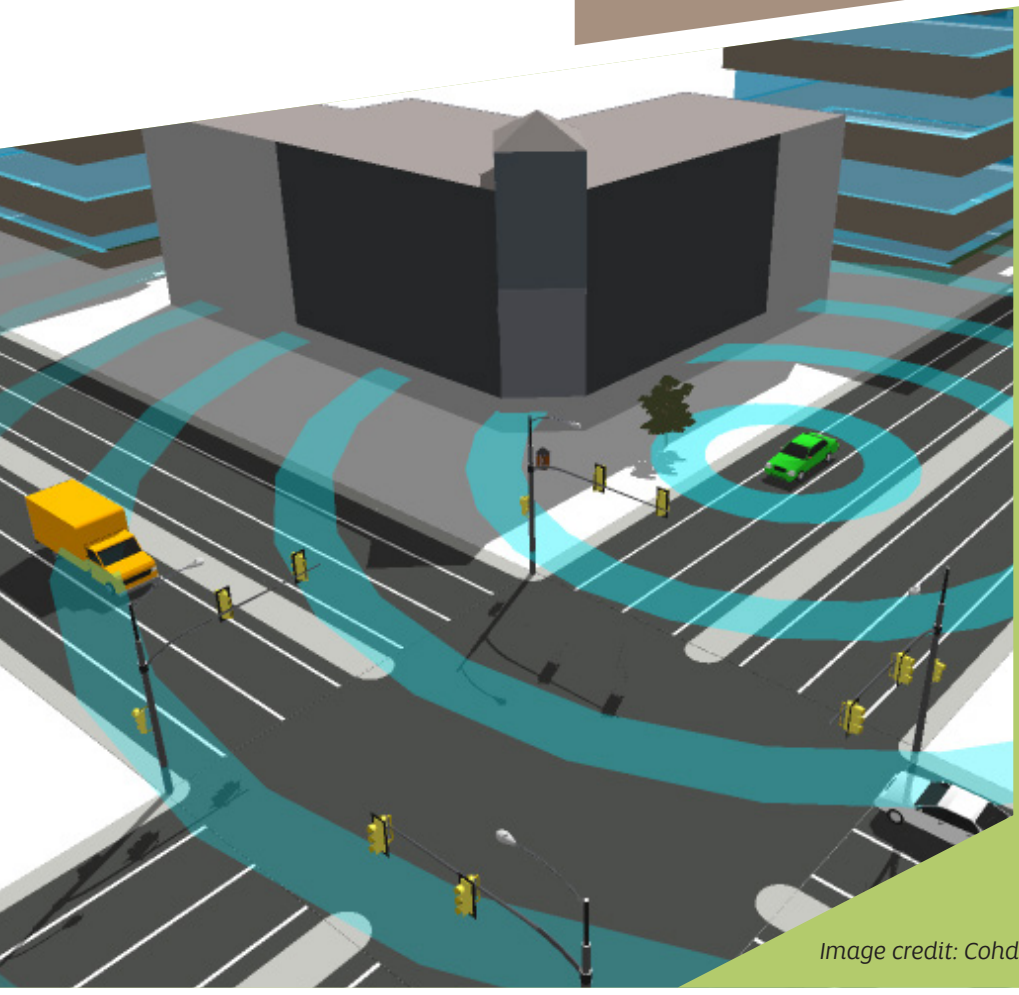


*Image credit: Cohda Wireless*

# ITR Advisory Board Membership

| | |
|---|---|
| Dr Neil Bryans (Chair) | Adjunct Professor, University of South Australia<br>Fellow, Defence Science & Technology Organisation<br>Edinburgh, SA |
| Prof Sakkie Pretorius (outgoing)<br>Prof Richard Head (incoming) | Deputy Vice Chancellor & Vice President, Research & Innovation<br>University of South Australia |
| A Prof Brenton Dansie (acting)<br>Prof Rob Short (incoming) | Pro Vice Chancellor, Division of ITEE<br>University of South Australia |
| Prof Alex Grant | Director, Institute for Telecommunications Research<br>University of South Australia |
| Mr Brett Biddington | Principal<br>Biddington Research Pty. Ltd. |
| Prof Reg Coutts | Managing Director<br>Coutts Communications, SA |
| Dr Peter Shoubridge | Research Leader, Military Communications Branch<br>Defence Science & Technology Organisation<br>Edinburgh, SA |
| Mr Jeff Kasparian | Business Manager<br>Institute for Telecommunications Research<br>University of South Australia |
| Dr Gregory Clark | Chairman, KaComm |
| Dr Craig Fowler (replaced Mr Ralph Leonard) | Deputy Chief Executive,<br>Department of Further Education, Employment, Science and Technology |

# ADVISORY BOARD REPORT

The ITR Advisory Board convened twice in 2013 – on 23 April and 28 November.

**The Director's report presented key highlights and achievements in 2013:**

> Professor Alex Grant was nominated to the ARC College of Experts and in addition, received the Pearcey Entrepreneur Award for South Australia.

> ITR was successful in winning one of the three Australian Research Council Discovery Project Grants awarded to UniSA.

> Three staff were promoted: Dr Terence Chan promoted to Associate Professor; Dr Gottfried Lechner and Dr Siu Wai Ho both promoted to Senior Research Fellow.

> The number of journal articles published by ITR academics reached an all-time high. ITR ranked highest across all UniSA institutes and schools in terms of quality publications per FTE. Similarly, ITR leads the University in Research Income per research staff member.

> 2013 saw 30 students undertaking a Higher Degree by Research at ITR – this is the largest number in the history of the Institute.

Professor Alex Grant also presented performance results on major projects and proposals:

> Completion of the Global Sensor Network project, culminating in highly successful field and satellite trials. Ten provisional patents were filed in 2013. Discussions with two potential partners are underway to investigate commercialisation pathways for the technology.

> Professor Alex Grant leads an ongoing bid for an Intelligent Transport Cooperative Research Centre, to be submitted in 2014. UniSA is the lead institution and several universities, industry partners and government agencies are expected to join in the bid.

> ITR was part of a bid led by Edith Cowan University in Western Australia to establish a CRC for Cybersecurity.

> ITR formed part of a Centre of Excellence bid for Wireless Technology and Spectrum Economics.

> Several ARC Discovery, Linkage, DECRA and Future Fellowship proposals worth $3.4m were submitted.

In the Advisory Board meeting of the 28th of November, the Board noted that ITR faced many changes driven by both internal and external factors. These included Professor Alex Grant stepping down as Director, as well as some senior staff transitioning into retirement. The ongoing loss and financial constraints within the university and within the Division of Information Technology, Engineering and the Environment were seen as challenges facing ITR.

The Board proposed a strategically focussed meeting to be convened in March 2014 to more fully consider options for the future.

The Board acknowledged and thanked Professor Alex Grant for his immense contribution to ITR during his term as Director, as he steps down from this position at the end of 2013.

Mr Jeff Kasparian was appointed as Acting Director of ITR, to commence January 1, 2014.

Board Chair

**Dr Neil Bryans**

Adjunct Professor, University of South Australia

DSTO Fellow, South Australia

# DIRECTOR'S REPORT

**Professor Alex Grant**

2013 has been a period of intense activity at ITR, with the completion of our Global Sensor Network project (pages 16-17) . This has been a landmark project for the Institute, blending fundamental research with field-proven implementation. The team has now completed both highly successful aircraft and satellite trials around Adelaide as well as in Canada. This was a fantastic step forward, which validates key elements of the system's operation within the most representative environment available.  This includes testing to demonstrate the highest level of bandwidth efficiency possible for realistic distributions of very high numbers of ground-based sensors. Looking forward, we are pursuing commercialisation of the outcomes, leveraging the substantial portfolio of patents that were filed as part of the project.

ITR researchers have again achieved great success this year. Senior Research Fellow Dr Roy Timo, for example, has been awarded a prestigious Alexander von Humbolt Fellowship. This will enable him to undertake research at the Technical University of Munich, working with long-standing ITR collaborator (and IEEE Information Theory Society President) Professor Gerhard Kramer.

I'm also pleased that a team of ITR researchers has been awarded funding from the IEEE Information Theory Society to hold a School of Information Theory in Adelaide in 2014. This will be the first time this annual international event will be held in Australia and we look forward to attendance by a number of distinguished international speakers.

Our Computational and Theoretical Neuroscience laboratory received a huge boost with the appointment of Dr Tony Vladusich, who joins ARC Senior Fellow Mark McDonnell to investigate how the brain processes and communicates information.

ITR has been awarded an ARC Linkage Grant to continue its work with Cohda Wireless on vehicle-to-vehicle communications for road safety. ITR Research Fellow Dr Robby McKilliam will join me in collaborating on this project.

Turning to student achievements, ITR PhD student Demi Gao excelled herself by winning the University of South Australia 3 Minute Thesis (3MT™) public speaking competition. Demi went on to compete against 43 other finalists at the national competition held in Sydney, placing in the top eight competitors in the country. We are extremely proud of her achievements which are particularly remarkable as she only moved to Australia from China 12 months previously.

Demi's research on improving the performance of cochlear implants is supervised by Dr Mark McDonnell, whom I would like to praise for assisting in her success. 3MT is a challenging experience, where research students must describe in just three minutes the significance of their research to a non-specialist audience.

Another ITR student also won accolades – this time for his ability to explain the commercial potential of his research. Final Year ITR student Jun Li won the ITEK Commercialisation Award for the most outstanding project at the ITEE Division Festival of Innovation. ITEK is the technology commercialisation arm of the University of South Australia. Jun Li is doing his research on visible light communications and location-based information transmission, and is supervised by Dr Siu Wai Ho.  He was awarded the prize for his ability to clearly demonstrate how his research could lead to product development and commercialisation.

As I step down from the role of Director in December, I look forward to the continued success of ITR in the capable hands of Mr Jeff Kasparian who will be acting director in 2014.

**Professor Alex Grant**

# FLEXIBLE RADIOS AND NETWORKS

**Sector Leader: Associate Professor Linda Davis, Associate Research Professor of Wireless Communications**

## What we do

Communication network solutions are moving away from big fixed infrastructure deployments with dedicated applications. Instead, we are moving towards distributed, scalable, cooperative, self-organising, reconfigurable networks with adaptable applications. Wireless radio technologies are key elements in achieving this flexibility.

At ITR, the Flexible Radios and Networks sector encompasses research and development in technologies including reconfigurable and software defined radio, cooperative communications, hybrid networks, distributed compression, network coding for routing and security, as well as vehicle-to-vehicle and short-range communications.

## Progress and research highlights

### Vehicular Communications

The year got off to a great start with the awarding to ITR and Cohda Wireless of an ARC Linkage Project, 'Safer Roads through Wireless Communications'. Dedicated short-range communications is an emerging industry standard for vehicle-to-vehicle and vehicle-to-infrastructure wireless communication. Using this technology, vehicles can share their position, speed and direction in order to avoid collisions. The aim of this project is to further increase the safety benefits of these systems, by adding radar capabilities that leverage the existing communications signals. This novel concept of joint communications/radar has the advantage of piggybacking on existing wireless signals, re-using spectrum and requiring no new hardware or antennas. This will deliver new road safety technologies that will ultimately make roads safer for all Australians.

In another line of work, ITR, Cohda Wireless and researchers from the University of Adelaide's Centre for Automotive Safety Research have been collaborating to understand the potential road safety benefits of collision avoidance technology. Vehicle trajectories were generated from in-depth reconstructions of nearly 100 crashes on South Australian roads. These trajectories were 'replayed' through Cohda Wireless on-board units, in order to estimate how much warning drivers may have been able to receive had the vehicles been fitted with this technology. Modelling of driver reaction and autonomous vehicle response revealed that crashes could have been avoided, or crash speed significantly reduced, in up to 80 percent of cases considered. These results were presented at the 2013 Intelligent Transport Systems Summit in Sydney.

### Radar Signal Processing and Tracking

Passive radars use broadcast communication signals, for example digital TV, to detect and track targets of interest including aircraft, cars and trucks. In collaboration with DSTO, passive radar signal processing research with a focus on detection was published in a seminal paper in IEEE Transactions in Signal Processing in April. With applications to both active and passive radars, Associate Professors Kutlu Doğançay and Linda Davis are also undertaking research in target tracking for multistatic radars which have multiple transmitter and multiple receiver antennas. With the IEEE Radar Conference held in Adelaide in 2013, Professor Harmann Rohling from Technical University Hamburg-Harburg extended his stay to include a research visit at ITR in radar and OFDM (Orthogonal frequency-division multiplexing) technologies. OFDM is a method of encoding digital data on multiple carrier frequencies.

### Software Defined Radio Laboratory

Using facilities refurbished in 2012, activities in the SDR lab ramped up to support radio prototype implementations for the Global Sensor Network (GSN) field trials in 2013. Stretching resources to the limit, field-programmable gate array (FPGA) development was also undertaken for external customers, including the Defence Science and Technology Organisation.

### Network Coding

2013 saw the completion of the 4-year ARC Discovery Project 'Robust Transmission, Identification and Key Agreement in Communications Networks'. This research, carried out by Professor Alex Grant and Associate Professor Terence Chan together with Dr Badri Vellambi and Dr Siu Wai Ho aimed to characterise the fundamental limits in transmission, identification, key agreement and to develop efficient network coding strategies for networks with unreliable links and compromised security. The results have been published in IEEE Transactions on Information Theory, IEEE Journal on Selected Areas in Communications, and the IEEE Symposium on Information Theory.

Physical layer network coding research was also a highlight, with an SDR-based demonstration by student intern Quoc Bao Nguyen together with Dr Ying Chen and Dr David Haley presented at the Australian Communication Theory Workshop, hosted by ITR in Adelaide in January.

### Global Sensor Network (GSN)

Several of the key advances and significant development work for GSN continued to be supported by expertise from the Flexible Radios and Networks sector. Involving many ITR researchers, highlights included software defined radio implementations, signal processing for acquisition, diversity sampling and processing, as well as multi-antenna and polarization channel modeling. (see GSN feature, page 16-17).

*Associate Professor Linda Davis and Dr Ying Chen*

### Translation to Teaching

In 2013, Dr Ingmar Land and Dr Ramanan Subramanian translated their research expertise into teaching as course coordinators and face-to-face lecturers and tutors for the core subject EEET 3028 Communication Systems at level 3 of the undergraduate Bachelor of Engineering (Electronics & Communications) program at the University of South Australia. They taught at UniSA's Mawson Lakes campus and in Singapore. Dr Robby McKilliam transformed EEET3041 Signals and Systems into a hands-on fundamentals course with tight turnaround from theory to practice.

### Visitors

ITR received visits from Professor Harmann Rohling and Dr Matthias Heitz late in the year. ITR staff members Dr André Pollok and Dr Ying Chen held discussions with Professor Rohling around reduction of peak-to-average-power ratio in OFDM systems. Dr Ingmar Land discussed with Dr Heitz the development of algorithms for self-organising OFDM networks. Theoretic results and directions for algorithm improvement were developed and will be followed up by Dr Heitz. Dr André Pollok visited TUHH (the Hamburg University of Technology) in September/October. He engaged with its researchers on developing subcarrier-wise and symbol-wise beamforming for multi-antenna OFDM systems and the reduction of the peak-to-average ratio.

Iqbal Hussain, a PhD student at KTH (Royal Institute of Technology, Sweden) who is supervised by Professor Lars Rasmussen visited ITR in November and December. Iqbal collaborated with Dr Ingmar Land on the design of complexity-constrained rateless codes. The work led to a paper to be presented at ISIT 2014.

Rajitha Senanyake, a PhD student at University of Melbourne, visited ITR in September. She worked with Associate Professor Linda Davis and Dr Ingmar Land on massive MIMO systems and resource allocation. The visit was part of her prize for best student paper at the 2013 Australian Communications Theory Workshop in Adelaide.

Associate Professor Linda Davis spent three weeks in New Zealand as an invited visiting researcher with the University of Canterbury's Wireless Research Centre (WRC). Working in close collaboration with WRC's researchers and industrial clients resulted in optimisation of multiple antenna line-of-sight fixed terrestrial wireless links for spectrally efficient and robust communications for infrastructure monitoring and control.

Associate Professor Terence Chan was an invited speaker at the 2013 Information Theory Workshop in Spain. He was also invited to speak at the 2013 First Workshop on Entropy and Information Inequalities in Hong Kong.

Dr Gottfried Lechner chaired the Australian Communication Theory Workshop in Adelaide in January, and also served on the Technical Program Committee of the IEEE International Symposium on Information Theory.

## Where next

The ARC Discovery Grant awarded to Professor Alex Grant on Foundations for Future Wireless Networks will be well underway in 2014. Future wireless networks must reliably deliver faster and faster data rates to increasingly mobile terminals. Demand is driven not only by more use of mobile broadband on portable computing platforms, but also by the proliferation of machine-to-machine applications. The fundamental impediment to delivering these desired features (in a way that efficiently uses scarce radio spectrum) to outdoor mobile users is the harsh nature of the mobile radio channel. This project will deliver mathematical foundations and key technologies for future wireless communications networks to provide reliable, low-cost, high speed, spectrum-efficient communications to highly mobile users.

2014 will be a big year for top-tier international conferences coming to Australia - many for the first time. ITR Flexible Radios and Networks researchers will contribute to technical program committees and organization of the IEEE International Conference on Communications in Sydney, the IEEE Statistical Signal Processing Workshop on the Gold Coast, the IEEE Information Theory Workshop (ITW) in Hobart and the IEEE International Symposium on Information Theory and Its Applications (ISITA) in Melbourne.

Continuing what might constitute an Australian festival of information theory (following directly on from ISITA and ITW) ITR will host the first Australian School of Information Theory in Adelaide in November. Sponsored by the IEEE Information Theory Society, this event features keynote lectures from internationally acclaimed researchers Professor Frank Kschischang, Professor Raymond Yeung, Professor Young-Han Kim and Professor Girish Nair, together with student poster sessions and collaborative open-problem workshops.

# HIGH SPEED DATA COMMUNICATIONS

Professor Bill Cowley, Professor of Communications Signal Processing

## What we do

Optical fibre currently carries most of our 'wired' communications. With the increasing demand for mobile communications, ITR is also investigating a range of optical transmission options for medium to high-speed communication to untethered terminals. These methods offer the potential for broadband mobile communications without using any radio frequency spectrum. In addition, ITR continues to work in the area of high speed (GBit+) RF communications.

## Progress and research highlights

**Free Space Optical.**

Free Space Optical (FSO) techniques offer excellent potential for Gbit communications for aerospace and terrestrial applications. Optical communication payloads for high-speed applications can be smaller and lighter than their RF counterparts but tend to suffer from fading caused by atmospheric scintillation. ITR has in the past undertaken theoretical work to investigate the fundamental limits on channel capacity for optical fading channels. This research has demonstrated that huge improvements in the reliability of optical transmission should be possible if suitable diversity, channel coding, interleaving and modulation methods are used.

Adaptive optical transmission offers very attractive performance gains in terrestrial applications. Given that FSO channels through the atmosphere suffer from fades over millisecond timescales, the adaptive concept is to adjust transmit power, modulation method and/or transmission rate as the channel quality varies. Both ITR staff and students have explored various approaches and published several papers in this area. In one case we showed that significant performance gains are possible by varying the symbol rate of coded FSO links in log-normal fading, while even larger gains are possible when both symbol rate and transmit power are adjusted.

Optical transmission at tens of Gbits to GEO satellites provides a quite different application domain for FSO communications. This topic was the subject of collaboration in mid-2013 at the German Aerospace Centre (DLR), funded by the DAAD (the German Academic Exchange Service). Again there's a strong incentive to use optical feeder links to GEO satellites, given the scarcity of RF bandwidth. In this case the challenge is to devise a communication strategy that is robust enough to uplink fading, but feasible to implement in low-complexity on-board processing. We devised some very promising new approaches to this task during the study period, with the results to be published in the 2014 IEEE International Conference on Communications.

**Visible Light Communications** ITR has explored related techniques for indoor optical communications. Visible Light Communication (VLC) is an optical wireless technology using visible light to transmit information, thus offering illumination and communication. Although VLC has superior energy efficiency and its maximum possible usable bandwidth is approximately 390 THz, multipath dispersion poses a serious challenge. To tackle this challenge, we presented a pulse amplitude modulated single carrier system with frequency domain equalization (PAM-SCFDE) for VLC. This was presented at the 2013 IEEE Wireless Communications and Networking Conference (WCNC). PAM-SCFDE shows advantages in terms of power-spectral efficiency, system complexity and bit-error rate comparing with the existing solutions.

VLC offers other advantages as well. Recently, ITR postgraduate students Mr Asanka Nuwanpriya Kekirigoda Mudiyanselage and Mr Muhammad Yasir have proposed an indoor positioning system based on VLC. Indoor positioning systems play a critical part in location-based services. High precision positioning systems will support different mobile applications in future wireless systems. After six months of experimental testing and refinement of our positioning system, results showed that the system achieves position errors of less than 0.15 metres. Based on our research results, final year project student Mr Jun Li has further developed a mobile application. His project, Location-based Information Transmission Systems, was awarded an ITEK Commercialisation Award for the most outstanding project at the UniSA Festival of Innovation in 2013.

*Professor Bill Cowley*

## Where next

In 2014, ITR will continue its research into both FSO and VLC topics. New HDR candidates have started and grant applications have been submitted in both these areas. Numerous exciting challenges remain to realize the full potential of methods such as adaptive transmission.

Our research aims to bring these techniques into significant practical use within the next several years. We will also continue to push the boundaries for highly bandwidth-efficient radio communications.

*Asanka Nuwanpriya and Muhammad Yasir testing a new system based on Visible Light Communications which sends information using LEDs.*

# SATELLITE COMMUNICATIONS

**Sector Leader: Associate Professor Adrian Barbulescu, Associate Research Professor of Satellite Communications**

## What we do

2013 was a key year in demonstrating the performance and efficiency of new concepts and algorithms for the low-complexity hardware required for machine-to-machine (M2M) communications.

During 2013, ITR's Satellite Communications research activities were focused on the development of the Global Sensor Network (GSN) (page 16-17). The challenge was to show that the newly designed GSN system was capable of receiving messages from tens of thousands of sensors during a single satellite pass in a 25 kHz bandwidth channel, at low cost and using low power hardware. In addition to these requirements, the system had to be able to survive in very rough and remote environmental conditions.

ITR was able to validate key elements of the GSN system in both local trials, using an aircraft with an on-board payload acting as a surrogate satellite, and in real world field conditions. After the success of the aircraft trials in the Adelaide region, ITR's research and engineering team travelled to Canada. Trials were conducted in Waterloo, Detour and Diavik, the latter being a remote settlement in Canada's Northwest Territories, 220km south of the Arctic Circle. The team was pleased with the success of the trials, despite the tough conditions in these sparsely populated provinces.

## Progress and research highlights

### THISS Technologies

An ARC linkage project with THISS Technologies commenced in mid-2013. This project aims to extend understanding and engineering practice for satellite modems. This will directly lead to the provision of cheaper, more robust satellite communications infrastructure supporting a wider range of services. More efficient use of expensive satellite bandwidth, together with small user terminals will make satellite communications a viable and economic option for users in remote locations, where cost has until now been prohibitive. Project outcomes will include fundamental contributions to the theory of information transmission, novel coding and decoding methods for satellite communications.

### People

In 2013, ITR senior engineer Mark Lavenant spent eight weeks at the Toulouse CNES division Direction Des Lanceurs, Sous-Direction Developpement, in France. This follows on from a previous professional placement in France in 2012, and continues ITR's ongoing collaborative relationship with French research and development.

Back at ITR, Marc supervised French student Julien Starozinski. Julien travelled to Australia from the Ecole Centrale de Nantes, France, to do an internship project from April to August 2013. The aim of the internship was to assist with the analysis of data retrieved during field trials performed for the Global Sensor Network (GSN) project.

Julien was tasked with producing animations for the various flight paths during these field trials, thereby illustrating connectivity between aircraft (the satellite surrogate), and ground (user terminals). This project used knowledge of transmitted and received data packets onboard the aircraft, as well as GPS information about the aircraft's position. Google Earth and Keyhole Markup Language (KML) files were used to enable a simple visualization of the flight, as well as quality of the air-ground communications link (e.g. signal strength for link). Matlab code was developed in order to produce further statistics for connectivity between user terminals and the surrogate 'satellite'.

In other space-based projects, ITR engineer Hidayat Soetiyono led a team to provide tracking services for the fourth Autonomous Transfer Vehicle (ATV). Each year, an ATV mounted on an Ariane rocket transports goods and supplies to the International Space Station (ISS) in orbit above the Earth. During the rocket's flight, ITR collects data regarding its position and status. These data are critical to minimise the time taken by the ATV from launch to docking with the ISS. The ATV 'Albert Einstein' was the heaviest spacecraft ever launched by Ariane, weighing in at 20,190 kilograms. The rocket lifted off on 5 June, docking 10 days later with the ISS. On 28 October 2013 its thrusters moved the ATV out of orbit (de-orbit) and placed it on a steep flight path to perform a controlled destructive re-entry (crash) into the Pacific Ocean.

## Where next

ITR will continue to bring new ideas, techniques and technologies to the area of satellite communications, in both high and low speed applications. There is an increasing demand in the area of high speed communications as our insatiable appetite for speed and bandwidth efficiency grows, and the marked growth and capability in small satellites has the potential to open up a number of application uses that were before not possible. We believe our research will provide solutions to the need for efficiency and data integrity in these different but challenging areas.

### Satellite payload research

In a collaboration which brought together two different research areas within the University of South Australia, ITR student Abdullah Parvez was co-supervised by ITR's Associate Professor Adrian Barbulescu and Professor Markus Stumptner, Director of UniSA's Advanced Computer Research Centre.

For his Master of Engineering in Telecommunications, Abdullah aimed to create a software database for quick prototyping of satellite payloads. His thesis introduces an ontology-based conceptual payload design approach for a multi-mission satellite, using reconfigurable hardware. The proposed approach of a machine-to-machine-(M2M) readable design minimises human interventions and improves end system reliability.

Abdullah investigated the structure of the software development platform and suggested key core ontologies - Requirements Ontology, Functional Ontology and Resource Ontology - that represent all the design knowledge required for constructing a satellite communication payload. The resulting ontology framework provides a systematic way to achieve integration and interoperability through the use of a shared vocabulary. Abdullah's research has enabled the construction of a knowledge base that provides capability to infer a specific knowledge embedded in it, or to construct new knowledge by exploring the concepts modelled in it.

Satellite Research Sector leader Associate Professor Adrian Barbulescu represented ITR at the Aerospace Futures conference in Adelaide in July. The conference was organised by the Australian Youth Aerospace Association. Dr Barbulescu presented a talk to satellite communications students on career options.

Preliminary testing was conducted at ITR on behalf of tracking company exactEarth to assess the feasibility of the company receiving signals at the Mawson Lakes dish. exactEarth develops global Automatic Identification Systems for vessel tracking, collecting data on ship locations, and delivering this data to a global customer base.

ITR began work with exactEarth in January 2011 when a series of test passes was conducted on an exactEarth satellite. The tests were to gauge ITR's S-band ground station capability to support exactEarth operations. Following these initial tests, exactEarth continued to use ITR's ground station tracking services for various experiments and tests.

### Spot 5 Satellite Reception

ITR has operated its 6.8m steerable antenna commercially since 2003, receiving data from the French SPOT satellites. ITR operators Wendy Clark, Trevene Leonard and Thomas Schneider tracked SPOT 5 satellites on a daily basis. Wendy Clark in particular has been with ITR since the inception of SPOT tracking in 2003 has worked tirelessly with the team to provide high quality service 365 days a year. This project finished in 2013.

### QB50 CubeSat

A cubesat is a very small satellite which has a mass of up to two kilograms. Despite the small size, recent progress in micro-electronics allows cubesats to carry out useful functions. They are usually launched in groups, into low earth orbit.

UniSA and the University of Adelaide are collaborating on a cubesat project called SUSat (South Australian University Collaboration Satellite), which will be part of the QB50 constellation. In this international program, about 50 cubesats will be injected into a LEO 'string of pearls' constellation in 2015. There are three Australia teams building QB50 cubesats. ITR is providing the communications payload for SUSat and associated UHF and VHF ground station facilities.

Cubesat projects often provide excellent training for university-based teams. In the SUSat case, six final year or intern students have provided a significant part of the ITR work for the SUSat communications system. During 2013 the first iteration of a custom PCB was designed for the communications payload. At the University of Adelaide, students from Mechanical Engineering and Computer Science are involved in other sub-systems, including the on-board computer and attitude control system (attitude is the control of the direction in which the satellite is pointing).

# COMPUTATIONAL AND THEORETICAL NEUROSCIENCE

**Sector Leader: Dr Mark McDonnell, Senior Research Fellow**

## What we do

ITR's Computational and Theoretical Neuroscience Laboratory (CTNL) brings together researchers, students and interdisciplinary collaborators to answer fundamental scientific questions about how electrical signals are used in the brain to represent and process information. A particular emphasis is on reverse engineering the biophysical mechanisms exploited by networks of neurons to reliably communicate with each other, despite high levels of stochastic noise. Increasing our understanding in this area will enable us to design new engineered electronic systems that mimic neurobiology.

## Progress and research highlights

### Computational modelling of neurobiology and sensory Perception

> Computational Vision

This year saw a new research area established in the group – that of computational vision. This work is led by Dr Tony Vladusich, who joined the group late in 2012. Dr Vladusich is developing an empirically grounded mathematical theory of human visual perception. This theory replaces an important and widespread assumption concerning the nature of visual representation in the human brain; namely, that the perceptual variables of lightness, gloss and transparency are independent. This new work shows that a common perceptual representation, known as blackness-whiteness space, ties these perceptual variables together and enables one to study them in a unified way to account for experimental data on surface perception in human vision. In 2013, Dr Vladusich published three journal papers in this area, and was an invited speaker at the UniSA-DSTO workshop on Computational Neuroscience held in Adelaide in February,

> The influence of stochastic variability on neurobiological computation

Following publication of a review paper on stochastic noise in the nervous system in Nature Reviews Neuroscience in 2011, Dr Mark McDonnell was invited to the University of Western Sydney to give a talk on this paper and discuss collaborations. Dr McDonnell was also invited to speak on this work at the IEEE Engineering in Medicine and Biology Congress in Osaka, Japan.

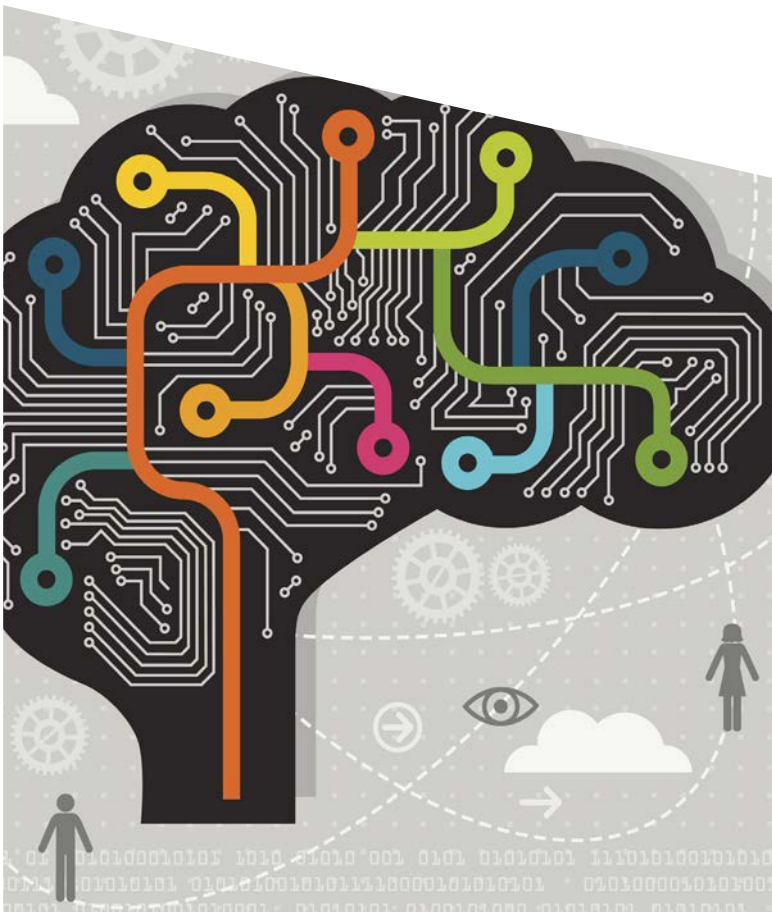
Several visitors were hosted by the CTNL group in 2013, for the purpose of progressing collaborations in this area. This included Associate Professor Bruce Graham, of Stirling University, UK, Dr Li Dong, of Hong Kong Baptist University, and Dr Tara Hamilton from University of Western Sydney. Journal papers in this area were published in Biological Cybernetics and Physical Review.

> Networks Neuroscience

This field of research aims to reveal the 'wiring diagram' of how different parts of the brain are connected by nerve cell contacts. For example, we have studied how different hypothetical network topologies impact on the overall electrical activity of the network during modelled sensory input. In 2013, Dr McDonnell was an invited speaker on this topic at the CSIRO Workshop on Information Processing in Cognition, in Sydney. ITR hosted a visit by Dr Mahdi Jalili, of RMIT, to discuss collaboration, while journal papers were published in Physica A and Physical Review E. In 2013, a PhD student formerly within the group, Brenton Prettejohn, was posthumously awarded the degree of PhD.

### Reverse-engineering the brain

Dr McDonnell and ITR's Dr Russell Brinkworth continue to work with PhD student, Daniel Padilla, on research that aims to mimic how the mammalian cortex learns to identify and predict sequences from data. Results from this project were presented at IEEE CyberneticsCom conference in Jogjakarta, Indonesia. A new research student, Migel Tissera, joined the group to work on a project in this area. Migel Tissera completed his Bachelor of Mechatronic Engineering at University of South Australia.



### Biomedical engineering

2013 was a successful year for PhD student, Gao (Demi) Xiao. Demi excelled in terms of public communication, winning the University of South Australia Three Minute Thesis Competition, and then progressing to the final stage (top 8) of the national finals of the competition held in Sydney. We congratulate Demi on this achievement. Demi's research involved improving the performance of cochlear implants and bionic eyes. She is working on applying information theoretic methods to make predictions for the optimal number of electrodes in such biomedical electronic prosthetics.

This project is in collaboration with Associate Professor David Grayden, of the University of Melbourne. Demi also presented her work at the IEEE Engineering in Medicine and Biology Congress, in Osaka, Japan. This paper was published in the refereed conference proceedings. PhD student, Bahar Moezzi, joined the group to work on a project in the area of biomedical engineering, to develop models of the auditory system relevant to cochlear implants. Bahar has a Masters degree from Columbia University in New York City.

### Conferences and visitors

Early in the year, four members of the group visited Melbourne to attend and present at the annual Neuroeng workshop, also known as the Australian Computational Neuroscience Workshop. Dr McDonnell gave a talk, while three PhD students presented posters.

In 2013, Dr Bingchang Zhou, from the Northwestern Polytechnical University, Xi'an, P.R. China, completed a 12 month research visit, resulting in a joint paper. Other notable events included Dr McDonnell becoming a member of the Editorial board of the international journal, PLoS One, and a guest-editor for Proceedings of the IEEE and Frontiers in Computational Neuroscience.

## Where next

Future research will pursue modelling the olfactory cortex, in collaboration with Associate Professor John Bekkers and ITR PhD student, Brett Schmerl. The aim of this project is to predict how network connectivity within the olfactory cortical region influences its electrical activity, and ultimately its function. This three-year project, titled 'Persistent firing in cortical interneurons: mechanisms and potential anticonvulsant role' is funded by the National Health and Medical Research Council (NHMRC) in a grant that is providing $500K total funding for 2013-2015. The modeling phase of this project will begin at ITR in 2014.

Overall, our research is leading to new mathematical and computational models of neurobiological systems; new hypotheses regarding computation and communication in biological neurons and brains; new methods and tools for neuroscience research; and new approaches in biomedical engineering and biologically inspired technology.

*Photo Above*

*Back Row - Daniel Padilla, Demi Gao, Brett Schmerl, Bahar Moezzi, Migel Tissera*

*Front Row - Dr Bing Chang Zhou (Northwestern Polytechnical University, China), Dr Mark McDonnell and Dr Tony Vladusich*

# GLOBAL SENSOR NETWORK PROGRESS IN 2013

**Dr David Haley, Technical Director and ITR Senior Research Fellow**

**Mr Ricky Luppino, Project Manager**

In 2013, the Global Sensor Network (GSN) low earth orbit satellite system being developed by the ITR proved its efficacy in both surrogate and real world satellite trials. The GSN has the potential to radically lower the cost of one and two-way satellite communication with very large numbers of remotely located sensors. The success of trials conducted in 2013 indicates that the GSN will enable an entirely new category of sensor application that previously was not cost effective.

## Adelaide trials

In May the GSN underwent its first field trials, using an aircraft provided by project partner DSTO as a surrogate satellite. Twelve terminals were positioned across the greater Adelaide area, including one terminal deployed on a buoy in the ocean (Gulf St Vincent) and another in a lake at Gawler, north of the city. Inside each shoe-box sized purpose-built terminal was a GPS unit transmitting its location, while the water-based terminals contained sensors for water temperature. The software in each terminal made this small collection of 12 units appear to a simulated satellite-receiving system on board a plane as if they were thousands of terminals, all transmitting their data at the same time. The signal processing system on board the aircraft was able to locate all the terminals (via the GPS) and also received temperature data from water based terminals. The results were outstanding, with the system proving it can successfully receive transmissions simultaneously from thousands of individual ground terminals.

The next step was to test the system in a real world scenario. In July and August nine sensor terminals were deployed across Adelaide. Sensors attached to the terminals collected information on position and temperature. This information was transmitted to a satellite travelling overhead, access to which was provided by project partner COM DEV (Canada). The success of the system was again demonstrated when it was shown that signals from all nine terminals were successfully received at a data hub located at ITR in Adelaide.

## Media attention

In June, a short video about the GSN was produced to inform potential investors and the general public about the benefits of the technology. The video featured project partners including the Australian Institute of Marine Science, SAGE Automation, as well as the then South Australian Industry Minister the Honourable Mr Tom Kenyon praising the concept of the GSN.

The success of these trials attracted considerable media interest. Stories about the GSN appeared in key mainstream and industry publications including the Australian newspaper, and Communications Day.

http://www.itr.unisa.edu.au/projects/global-sensor-network

## Canadian trials

November brought the biggest test yet for the GSN, with ITR engineers and researchers travelling to remote Northern Canada to test the system over vast distances. This trial was conducted for the University of Waterloo, Ontario by ITR together with space hardware company COM DEV and vessel tracking organisation exactEarth.

Ground terminals were placed in three remotely located sites across Canada thousands of kilometres apart. Sensors within the terminals retrieved data on soil moisture, air temperature, wind speed and precipitation and transmitted these to a satellite. Analysis showed the information was successfully captured, stored and downlinked to a central ground station. The Canadian trials build on the success of the Adelaide aircraft and local satellite trials, by showing that the GSN is not only capable of receiving signals from thousands of terminals simultaneously, but that those terminals can be thousands of kilometres apart.

## Technology of the Year nomination

The success of the GSN during 2013 culminated in late December with the system being nominated for an international award. The design and performance of the GSN from on-paper concept to field-proven system in just three years clinched its nomination for the award for Technology of the Year. Presented annually by the Wireless Innovation Forum (WinnForum) the award is given to an individual or organisation for a 'breakthrough product or technology in the field of Software Defined or Cognitive Radio'

When it is considered that the co-nominee for the award was NASA - for a communication system developed for the International Space Station - this is an impressive achievement indeed. ITR will find out in early 2014 whether it has won the award.

All up, the GSN program represents a significant outcome, with contributions from 28 academics and engineers within ITR.

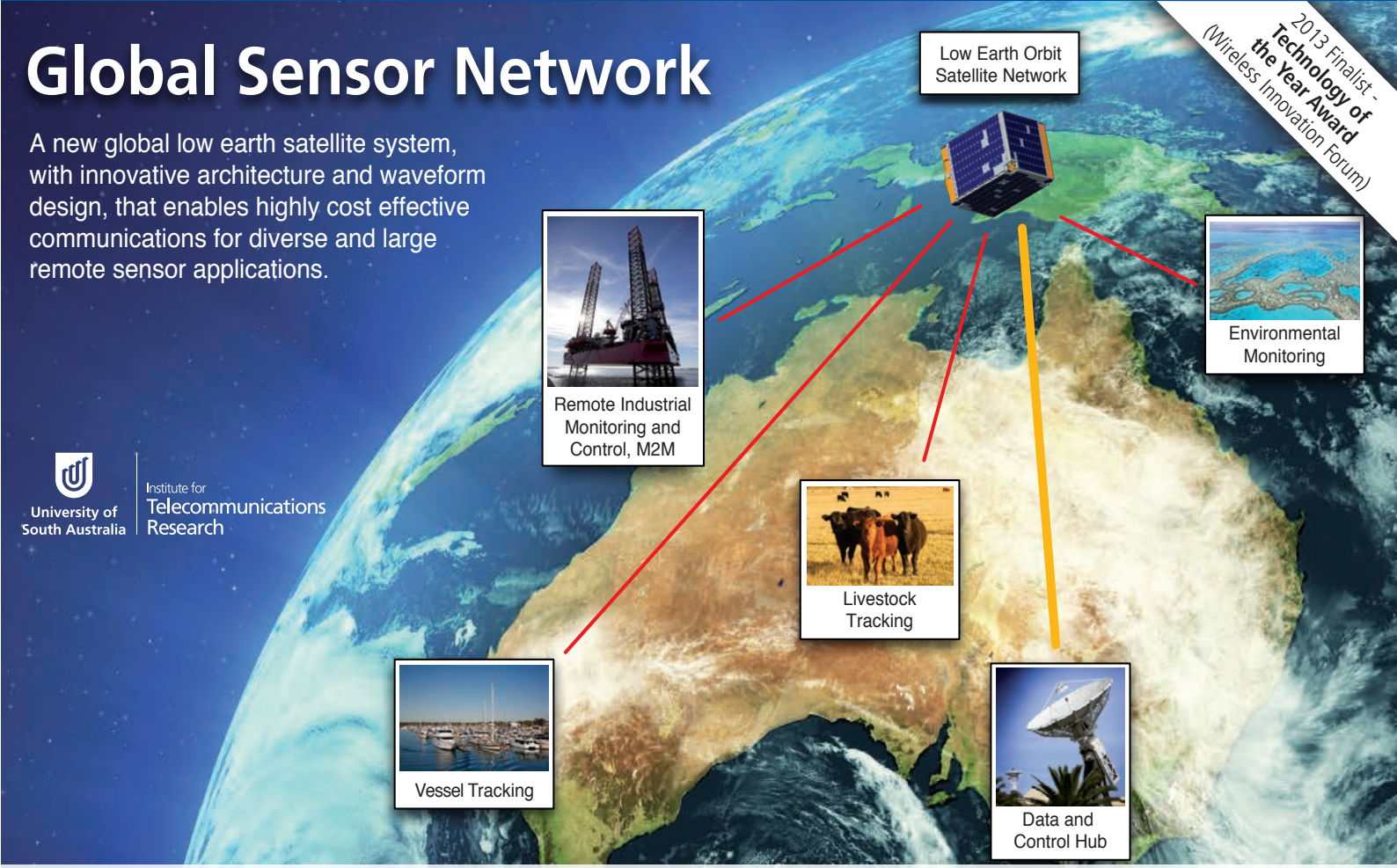
GSN partners include COM DEV (Canada) and SAGE Automation, CSIRO, DSTO and the Australian Institute of Marine Science. The development of the Global Sensor Network was assisted by funding from the Federal Government's Australian Space Research Program.

As a result of these efforts, 10 provisional patents have so far been filed for technology developed for the GSN. Discussions were held during 2013 to investigate commercialisation pathways for the technology.

# Global Sensor Network

A new global low earth satellite system, with innovative architecture and waveform design, that enables highly cost effective communications for diverse and large remote sensor applications.

2013 Finalist - **Technology of the Year Award** (Wireless Innovation Forum)




University of South Australia | Institute for Telecommunications Research

Australian Government, Department of Defence, Defence Science and Technology Organisation

Australian Institute of Marine Science

COM DEV

CSIRO

Printed March 2014

## What is the Global Sensor Network?

The design of the GSN enables highly cost effective communications for diverse and large array remote sensor applications. When fully operational, the network would consist of a number of low earth orbit satellites carrying receivers to record and process sensor data, such as temperature, from ground and sea-based terminals. This data would be decoded and sent to a collecting hub, where it would be processed into useable information. Because Australia has a huge land area and relatively low population, there is a real need for systems which can autonomously monitor conditions remotely and communicate this information to population centres.

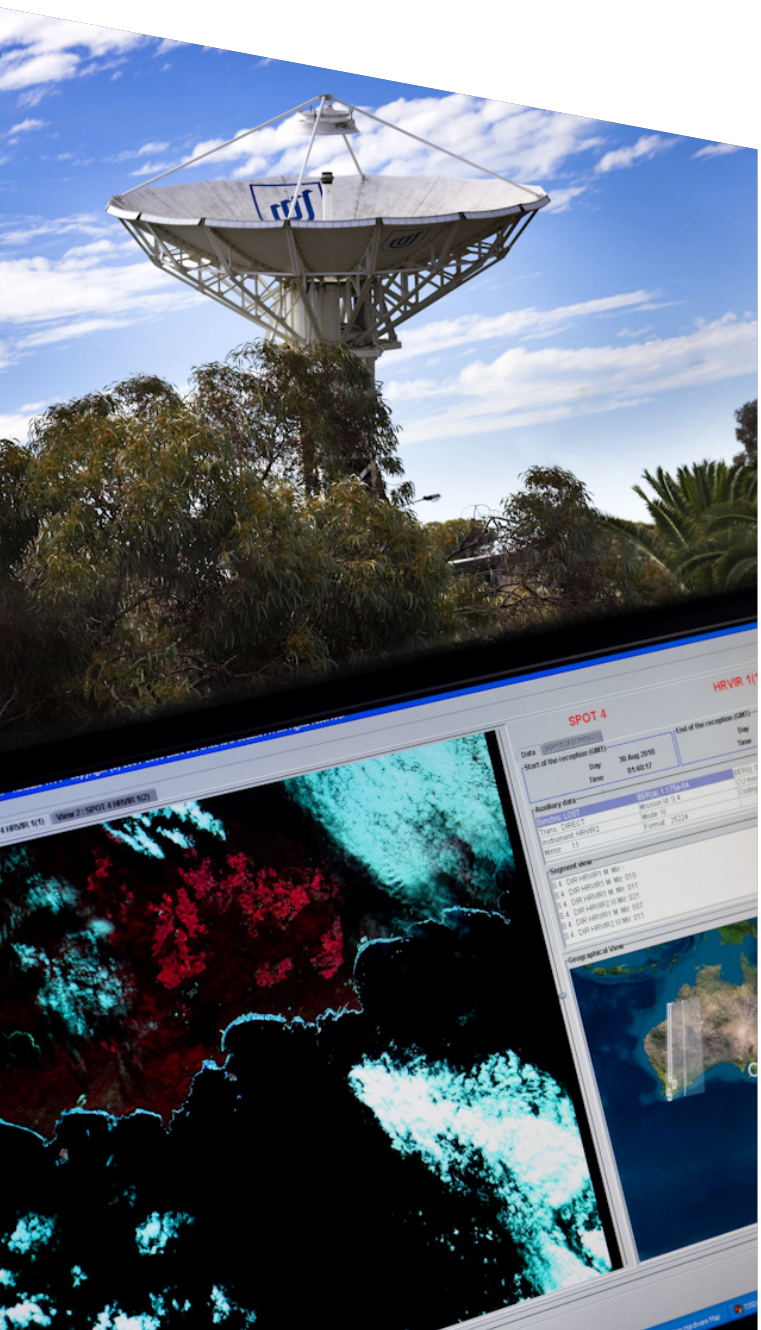
However, existing telecommunications systems only operate where people live, or are provided by expensive satellite systems affordable by relatively few users. What the GSN can do is provide a low cost, two-way satellite messaging system to remote areas, for use in applications such as environmental monitoring, livestock tracking, animal and fish migration research, remote control of mining and drilling sites, national security and defence, and vessel tracking. The system is two-way – receiving information from terminals, but in addition, also enabling users to remotely adjust sensors and even upgrade software without being on site.

The GSN cleverly exploits new software defined radio (SDR) -based architectures and waveform designs, which are used across the space segment, ground station and terminals. The result is a cost effective, scalable and flexible system that is able to support very large numbers of users while maximising the use of precious satellite frequency spectrum.

# INDUSTRY PROJECTS

In 2013 ITR dedicated significant resources to completing the Global Sensor Network Program, highlighted in this report (page 16-17). The GSN represents a great example of how ITR contributes to both industry and government needs. The project involved a combination of strong theoretical and mathematical research and analysis, simulation and optimisation. This approach was combined with a team focusing on the implementation and demonstration of the outcomes, and involved a tight integration between academics, engineers and the end users.

ITR's strengths in responding to industry and government needs are being able to take problems at concept level and ultimately provide an outcome that is useful and advantageous to stakeholders. The following industry projects undertaken in 2013 provide a flavour of ITR's breadth and depth of capability.




## ATV4 Satellite Tracking Services

ITR provided tracking services using its S-band steerable tracking facility at Mawson Lakes, South Australia, for the fourth successful Autonomous Transfer Vehicle, "Albert Einstein", launch to the International Space Station.

## SPOT Satellite Tracking

ITR continued to provide daily tracking services from its 6.8m steerable antenna tracking facility, receiving data from the French SPOT-4 and SPOT-5 satellites. This is now the 11th year of providing such a service.

## High Performance Algorithms for Next Generation Quantum Key Distribution

Quantum Key Distribution (QKD) is a new technology for long term security of exchanged keys. It is an invaluable component to secure future communication infrastructure but its applicability is hampered by its low key rates. QKD post-processing - transforming the correlated and partly secret results of quantum measurements into a secure key - is a computationally intensive task and well elaborated for kbit/s key rates. Handling higher rates in real-time faces completely new methodological and algorithmic challenges. HiPANQ addresses these challenges and aims to develop effective methods for rates in the 100 Mbit/s regimes.

## International Space University

ITR provided lectures and workshops in satellite communications and project management for the very successful Southern Hemisphere Summer Space Program (SH-SSP). UniSA and the International Space University ran this five-week multi-disciplinary live-in program in January this year.

## ATN/DAAD Energy-Efficient Multicarrier Transmission

This joint project between ITR and Hamburg University of Technology focuses on two aspects of orthogonal frequency-division multiplexing (OFDM). The first was differential modulation with incoherent detection; and the second included principles for reducing the high dynamic signal range. For both aspects the team will apply the concept of signal processing in finite fields.

## Free Space Optical Trials

Building on previous sponsored work that resulted in trials of a functional, real-time, free-space-optical transceiver, the current project extends the design to double the data rate and then undertake performance measurements under realistic fading channels. Evaluation includes the demonstration of reliable video transmission over optical channels with significant scintillation. The results show significant increases in performance and reliability of the coded systems developed when compared to un-coded FSO.

## FPGA and Communications Algorithm Development for Flexible Data Capture

The Flexible Data Capture project involved the development of an FPGA (Field Programmable Gate Arrays) based system to implement a high-speed data card using an 8-channel off-the-shelf hardware. This system was required to record analogue signals in real-time at 250 MSPS/channel and provide control to decimate the sample rates at run-time. A highly-programmable digital down conversion (DDC) design was developed to decimate the incoming data stream, before being streamed over a PCIe interface to a PC for display.

## QB50

2013 saw ITR begin a new project to design and develop a communications payload for the international low earth orbit satellite project QB50. This network of 50 cubesat satellites (each weighing approx. 1kg) is due to be launched in 2015, to orbit at an altitude of 320km. The satellites will measure a range of parameters in the largely unexplored lower thermosphere and ionosphere. ITR is collaborating with the University of Adelaide to develop hardware and software for the communications payload and ground station subsystems, in addition to novel inter-satellite communication systems.

# COMPETITIVE RESEARCH GRANTS

## ARC Discovery: Robust Transmission, Identification and Key Agreement in Communications Networks

**Dr Terence Chan and Professor Alex Grant: 2010–2013; Australian Post Doctoral Fellowship Dr Siu Wai Ho: 2010–2013**

Networks rely heavily on efficient and robust communications. This project aims to determine the fundamental limits and costs of robust transmission, identification and key agreement in unreliable or compromised networks. The research will propose a new approach based on network coding to embed reliability in the core of the network. Expected outcomes of the research, which will impact the information and communication technology industry, are contributions to the theory of provably robust networks and efficient and robust data transmission, and identification and key agreement schemes in networks.

## ARC Discovery: Communication and Information Storage Mechanisms in Complex Dynamical Brain Networks

**Australian Research Fellowship: Dr Mark McDonnell: 2010–2014**

Repetitive oscillations are often observed in measurements of brain signals. While mathematical approaches have discovered how these oscillations arise in brain networks from complex interactions between large numbers of neurons, their role in brain function remains a largely unresolved and fundamentally important question. A novel approach will assess the hypothesis that oscillations allow communication of information between separate brain regions. Mathematical and computational models of modulation, and memory storage and retrieval, in oscillatory brain networks will be produced, and assessed, using communications-engineering metrics. Findings will potentially lead to innovative ideas for future medical bionics and brain-machine interfaces.

## ARC Linkage: Satellite Data Communications for Remote Sensing and Broadband Connectivity

**Professor Alex Grant, Associate Professor Linda Davis, Dr Nick Letzepis, Dr Ingmar Land and Mr N Cirillo: 2009–2012, extended to 2015 (Joint Project with Thiss Technologies Pty Ltd)**

The remote, distributed location of many of Australia's primary industries precludes the use of consumer oriented terrestrial wireless broadband services. In many instances, satellite communications provides the only feasible means of connectivity for telemetry, supervisory control and data acquisition, tracking and fleet management. Meteorology, remote sensing, irrigation, mining, oil and gas exploration, and fisheries are just a few examples of high value applications of particular significance to Australia. This project will develop bandwidth efficient satellite communications technologies that greatly reduce cost and pave the way toward new market opportunities for broadband access and telemetry applications.

## ARC Discovery: Early Career Researcher Award - Reliable Transmission for Wireless Control

**Dr Khoa Nguyen: 2012–2014**

The application of wireless communications in automation and control brings substantial benefits to industry, including low installation and maintenance cost, low failure rate and flexibility. However, current wireless communication technologies are not designed for control applications. This project aims at developing novel communication technologies for control systems. These technologies will revolutionise wireless control systems in terms of efficiency, reliability and applicability. The expected outcomes are: Information-theoretic limits of communications in control applications, which provides guidelines and benchmarks for system designs; and practical and efficient communication technologies for control applications.

## ARC Discovery: Physical Layer Security Techniques for Multiuser Wireless Networks

**Professor Jinhong Yuan, Associate Professor Robert Malaney, Dr Ingmar Land, Professor Lars Rasmussen (Joint Project with University of New South Wales and KTH Royal Institute of Technology Sweden)**

In this project we will develop novel physical layer security theories and techniques that will dramatically increase the secrecy and robustness of wireless communications. More specifically, our new designs will exploit the variability of wireless channels as a means of ensuring the secrecy of wireless communications. Our solutions accommodate threat models that are more realistic and far beyond those previously studied. It is expected that the innovative security techniques we propose will be used to substantially improve existing network security measures and open up a new frontier of opportunities for future wireless networks.

## ARC Discovery: Compression of distributed data: Bridging the gap between theory and practice

**Dr Ingmar Land, Dr Sarah Johnson, Dr Roy Timo, Professor Gerhard Kramer: 2012 – 2014 (Joint Project with University of New South Wales and Technische University of Munich)**

Modern digital communication and storage relies on the compression of data, and the ideal data compression approach is different for each application. While excellent data compression techniques exist for applications such as image compression, those for correlated sources, for instance sensor networks, are far from ideal. This project aims to develop optimal data compression techniques for these systems, by exploiting a recently-discovered link between compression and error correction codes. The new compression algorithms developed by this work will significantly increase the efficiency and lifetime of a wide range of communications systems.

## ARC Discovery: Foundations of future wireless network

**Professor Alex Grant: 2013 - 2015**

Future wireless networks must reliably deliver higher and higher data rates to increasingly mobile terminals. Demand is driven not only by increasing use of mobile broadband on portable computing platforms, but by the proliferation of machine-to-machine applications. The fundamental impediment to delivery of these desired features (in a way that efficiently uses scarce radio spectrum) to outdoor mobile users is the harsh nature of the mobile radio channel. This project will deliver mathematical foundations and key technologies for future wireless communications networks which will provide reliable, low-cost, high speed, spectrum efficient communications to highly mobile users.

## ARC Linkage: Safer Roads through Wireless Communications

**Professor Alex Grant, Dr Robert McKilliam, Dr Paul Alexander (Joint Project with Cohda Wireless)**

Dedicated short range communications is an emerging industry standard for vehicle-to-vehicle and vehicle-to-infrastructure wireless communication. Using this technology, vehicles can share their position, speed and heading for the purposes of collision avoidance. The aim of this project is to further increase the safety benefits of these systems, by adding radar capabilities which leverage the existing communication signals. This novel concept of joint communications/radar has the advantage of piggybacking on existing wireless signals, re-using spectrum and requiring no new hardware or antennas. This will deliver new road safety technologies which will ultimately make roads safer for all Australians.

## NHMRC: Persistent Firing in Cortical Interneurons: Mechanisms and Potential Anticonvulsant

**Assoc Professor John Bekkers, Dr Mark McDonnell 2013 – 2015 (Joint Project with Australian National University)**

The normal brain treads a fine line between too much electrical activity (epilepsy) and too little (sedation). We have discovered a class of brain cell that seems to behave like a sentinel, monitor brain activity for signs of epilepsy. If a seizure occurs, this cell switched on an electrical brake that dampens excess activity. In this project we will study how this brake works and whether it really can inhibit seizures. Our research may lead to better treatments for epilepsy.

## Premier's Research & Industry Fund: Advanced Communications Payload for the QB50 Satellite.

**Professor Bill Cowley 2013-2015 (Joint project with University of Adelaide)**

2013 saw ITR commence a new project to design and develop a communications payload for the international low earth orbit satellite project QB50. This network of 50 cubesats, each weighing between one and two kilograms, will be launched in 2015 and orbit at an altitude of 320km. The satellites will measure a range of parameters in the largely unexplored lower thermosphere and ionosphere. The University of Adelaide and UniSA are jointly developing one of the cubesats. ITR is responsible for the communications payload and ground station subsystems, in addition to novel inter-satellite communication systems. The development of a flexible payload with low mass and low power consumption are key objectives.

# OUR PEOPLE

## ITR staff

**Director**
Prof Alex Grant

**Business Manager**
Mr Jeff Kasparian

**Institute Manager**
Mr Larry Pereira

**Professor of Communications Signal Processing**
Prof William Cowley

**Associate Research Professor of Satellite Communications**
Assoc Prof Adrian Barbulescu

**Associate Research Professor of Wireless Communications Technologies**
Assoc Prof Linda Davis

**Associate Professor**
Assoc Prof Terence Chan

**Senior Research Fellows**
Dr David Haley
Dr Sui Wai Ho
Dr Ingmar Land
Dr Gottfried Lechner
Dr Mark McDonnell

**Research Fellows**
Dr Ying Chen
Dr Robby McKilliam
Dr Khoa Nguyen
Dr Andre Pollok
Dr Ramanan Subramanian
Dr Roy Timo
Dr Badri Ravisankar Vellambi
Dr Tony Vladusich

**Technical Staff**
Mr Colin Biggs
Mr Terry Kemp
Mr Marc Lavenant
Mr Ricky Luppino
Mr Hidayat Soetiyono

**Administrative Staff**
Mrs Sarah Armour
Ms Christine Bennett
Mrs Amanda Johnston
Mr Peter Lulham
Ms Sandy Sherry
Ms Abbie Thomas

**Ground Station Operators**
Mrs Wendy Clark
Mr Trevene Leonard
Mr Thomas Schneider

## ITR adjunct staff

| | |
|---|---|
| Prof Mike Miller | Emeritus Professor |
| Prof Yuri Abramovich | Research Professor |
| Dr Paul Alexander | Associate Research Professor |
| Dr Gerald Bolding | Senior Research Fellow |
| Dr Daniel Floreani | Senior Research Fellow |
| Assoc Prof David Grayden | Associate Research Professor |
| Dr Nicolangelo Iannella | Research Fellow |
| Dr Benny Johnson | Research Fellow |
| Prof Frank Kschischang | Research Professor |
| Dr Nick Letzepis | Senior Research Fellow |
| Prof Ken Lever | Research Professor |
| Prof Haibin Liu | Research Professor |
| Dr Sylvie Perreau | Senior Research Fellow |
| Dr Steven Pietrobon | Senior Research Fellow |
| Prof Lars Rasmussen | Research Professor |
| Dr Mark Rice | Associate Research Professor |
| Assoc Prof Albert Sung | Associate Research Professor |
| Dr John Tsimbinos | Research Fellow |
| Dr Andrew Zhang | Senior Research Fellow |
| Dr Weimin Zhang | Senior Research Fellow |

# ITR Visitors

| Name | Home University | Supervisor/Host |
|---|---|---|
| Bingchang Zhou | Northwestern Polytechnical University, Xian Shaanxi, China | Dr Mark McDonnell |
| Professor Ken Lever | University of South Australia | |
| Arno Stefani | Friedrich-Alexander-Universität Erlangen-Nürnberg | Dr Siu Wai Ho |
| Quan Yu | City University of Hong Kong | A/Prof Terence Chan |
| Mahdi Jalili | RMIT & Sharif University of Technology | Dr Mark McDonnell |
| Li Dong | Hong Kong Baptist University, Hong Kong | Dr Mark McDonnell |
| Dr Bruce Graham | University of Stirling (UK) | Dr Mark McDonnell |
| Sarah Johnson | School of Electrical Engineering and Computer Science, University of Newcastle | Dr Gottfried Lechner |
| Dr Tara Hamilton | University of New South Wales | Dr Mark McDonnell |
| Dr Chee Wei Tan | City University of Hong Kong | A/Prof Terence Chan |
| Christoph Pacher | Austrian Institute of Technology | Dr Gottfried Lechner |
| Nan (Jonas) Yang | The University of New South Wales | Dr Ingmar Land |
| Alex Graell i Amat | Chalmers University | Dr Gottfried Lechner |
| Dr Satyajit Thakor | The Chinese University of Hong Kong | A/Prof Terence Chan<br>Professor Alex Grant |
| Prof Hermann Rohling | Department of Telecommunications, Hamburg University of Technology | Dr Ingmar Land |
| Matthias Heitz | Hamburg University of Technology | Dr Ingmar Land |
| Rajitha Senanayake | University of Melbourne – recipient of AusCTW Best Student Paper Award | A/Prof Linda Davis |

ITR PhD graduate Dr Satyajit Thakor (below left) was the recipient of this year's Michael Miller Medal. The medal was named in honour of Institute for Telecommunications Research Founding Director Emeritus Professor Michael Miller (below right). Each year ITR presents this Medal to the student with the most outstanding PhD thesis. The award is based on creativity and originality of the research as demonstrated by the thesis, the student's comprehension of the field as demonstrated by the thesis, the significance and utility of the research as a contribution to, or as an application of, knowledge, and impact of the thesis through the number and level of international publications and presentations.

Dr Thakor's thesis was titled *Characterization and Computation of Network Coding Capacity Bounds*. Since completing his doctorate, he has been employed at the Institute for Network Coding at the Chinese University of Hong Kong.

# OUR STUDENTS

## Current Students

| Student Name | Principal Supervisor | Research Title |
|---|---|---|
| **PhD** | | |
| AKHLAQ, Assad | Robby McKilliam | Lattice theory for communications and signal processing |
| ALI, Imran | Linda Davis | Alternative transforms for multicarrier communications systems |
| GAO, Xiao | Mark McDonnell | Information theoretic approaches for finding optimal electrode placements in cochlear implants and bionic eyes |
| KEKIRIGODA MUDIYANSELAGE, Asanka | Alex Grant | Modulation and coding techniques for visible light communication systems |
| KHATOON, Afsana | Bill Cowley | Estimation, Adaption and Channel Modelling of Free-Space Optical Links |
| MOEZZI, Bahar | Mark McDonnell | A computatoinal model of the differences in neural activity within the auditory brainstem due to electrical versus normal acoustic stimulation |
| NAHID, Abdullah-Al | Terence Chan | Outage analysis for integer forcing virtual MIMO systems |
| NGUYEN, Bao | David Haley | Physical-layer network coding in satellite communications |
| NGUYEN, Ngoc | Kutluyil Dogancay | Interference-tolerant waveform design for multistatic radar |
| NOOR-A-RAHIM, Md | Khoa Nguyen | Channel coding for delay universal transmission |
| PADILLA BAEZ, Daniel | Mark McDonnell | Biomimetic machine learning for auditory information processing based on the hierarchical temporal memory model of the mammalian neocortex |
| QIU, Yinyue | David Haley | Energy efficient wireless communications for implantable medical devices |
| RAMAMURTHY, Balachander | Bill Cowley | MIMO in satellite communications |
| SADEQUE, Nayeema | Ingmar Land | Physical layer precoding strategies for secure mimo communications |
| SALAH, Mohmed | Bill Cowley | Adaptive free space optical transmission methods |
| SCHMERL, Brett | Mark McDonnell | Modelling the impact of complex synaptic connectivity topologies on cortical neuronal dynamics |
| TEBBI, Mohammad | Terence Chan | Distributed storage networks |
| UDUWERELLE, Herath Mudiyanselage Chinthani Kumari Nishanthi | Terence Chan | Design of error-free and secure communication systems |
| WANG, Gungsong | Alex Grant | Complexity constrained design of sparse graph codes |
| WANG, Siyi | Mark McDonnell | Communication in hostile radio frequency environments using diffusion |
| WIJETUNGE, Udara | Sylvie Perreau | Stochastic routing in wireless sensor networks |
| YASIR, Muhammad | Badri Vellambi | Indoor positioning system using visible light communications |
| ZHANG, Nan | Khoa Nguyen | Distributed source streaming for delay-constrained applications |
| ZHANG, Qun | Terence Chan | Information theory in optical fiber communications |

| **Masters** | | |
|---|---|---|
| HIRSCHAUSEN, Paul | Linda Davis | Advancing HF communications |
| MORSHED, Khaled mahbub | Ingmar Land | Coding schemes for lossless compression of binary sources with coded side-information |
| TESHOME, Assefa | Siu Wai Ho | Biometric authentication systems with privacy protection |
| TISSERA, Migel | Mark McDonnell | Enhancing biological plausibility of large scale functional neural networks using spike-timing based dynamic representations |

# Students Completed in 2013

| Name | Thesis Title | Type | Supervisor |
|---|---|---|---|
| ARABLOUEI, Reza | Reduced-complexity adaptive filtering techniques for communications applications | PhD | Dr Kutluyil Dogancay |
| DEDEOGLU, Volkan | Energy efficient data gathering and target tracking in wireless sensor networks | PhD | Prof Alex Grant |
| KADEL, Rajan | Full-diversity codes for block-fading channels | PhD | Dr Gottfried Lechner |
| KHAN, Muhammad | Adaptive hybrid FSO/RF communication systems | PhD | Prof Bill Cowley |
| KODITHUWAKKU, H.K. Jeewani | Timing synchronization in multiuser CDMA communications | PhD | Dr Robby McKilliam |
| PRETTEJOHN, Brenton | Understanding the underlying similarities shared by complex systems: a study of consensus formation, and neuronal network dynamics, through the application of complex network simulations. | PhD | Dr Mark McDonnell |
| TRAN, Thuy | Acoustic beamforming for speech separation | PhD | Prof Bill Cowley |
| PARVEZ, Abdullah | Ontology-based conceptual payload design | Masters by Research (Telecommunications) | Assic Prof Adrian Barbulescu |
| WICKRAMASOORIYA, Anuradha Lakmuthu | Channel code design for the wiretap channel | Masters by Research (Telecommunications) | Dr Ingmar Land |

# Internship students

| Name | Home University | Supervisor/Host |
|---|---|---|
| Jialong Duan | Telecom Bretagne, France | Dr Siu Wai Ho |
| Julien Starozinski | Ecole Centrale Nantes (ECN), France | Mr Marc Lavenant |
| Maryam Ehsani Banafti | Khajeh Nassireddin Toosi University of Technology | Dr Ingmar Land |
| Iqbal Hussain | Communications Theory Lab, KTH Royal Institute of Technology | Dr Ingmar Land / Prof Lars Rasmussen |
| Devesh Garg | Indian School of Mines, India | Dr Siu Wai Ho |

# Work experience students

| Name | Home University | Supervisor/Host |
|---|---|---|
| Jun Li | UniSA | Dr Siu Wai Ho |
| Bao Nguyen | UniSA | Dr David Haley |
| Thomas Schneider | UniSA | Dr Ingmar Land |
| Thomas Stratfold | Adelaide University | Dr Robby McKilliam |
| Fangning Wu | ANU | Dr Siu Wai Ho |
| Xiaoke Yang | Adelaide University | Dr Robby McKilliam |
| Martin Nobis | Adelaide University | Dr Gottfried Lechner |
| Peter Roush | Adelaide University | Prof Bill Cowley |

# Minor Thesis students

| Name | Home University | Supervisor/Host |
|---|---|---|
| Jun Li | UniSA | Dr Siu Wai Ho |
| Mohd Tarmizi Bin, Hashim | UniSA | Dr Siu Wai Ho |

# PUBLICATIONS

## C1 - Refereed Journal Article

Prettejohn, B, Berryman, M & McDonnell, M, (2013), *'A model of the effects of authority on consensus formation in adaptive networks: Impact on network topology and robustness'*, Physica A - Statistical Mechanics and its Applications, 392, (4), 857-868, (0378-4371), 2013

Khan, M N & Rizvi, U, (2013), *'Antenna Beam-Forming for a 60 GHz Transceiver System'*, Arabian Journal for Science and Engineering. Section B: Engineering, 38, (9), 2451-6464, (1319-8025), 2013

Mohan, A, McDonnell, M & Stricker, C, (2013), *'Interaction of short-term depression and firing dynamics in shaping single neuron encoding',* Frontiers in Computational Neuroscience, 7, 1-14, (1662-5188), 2013

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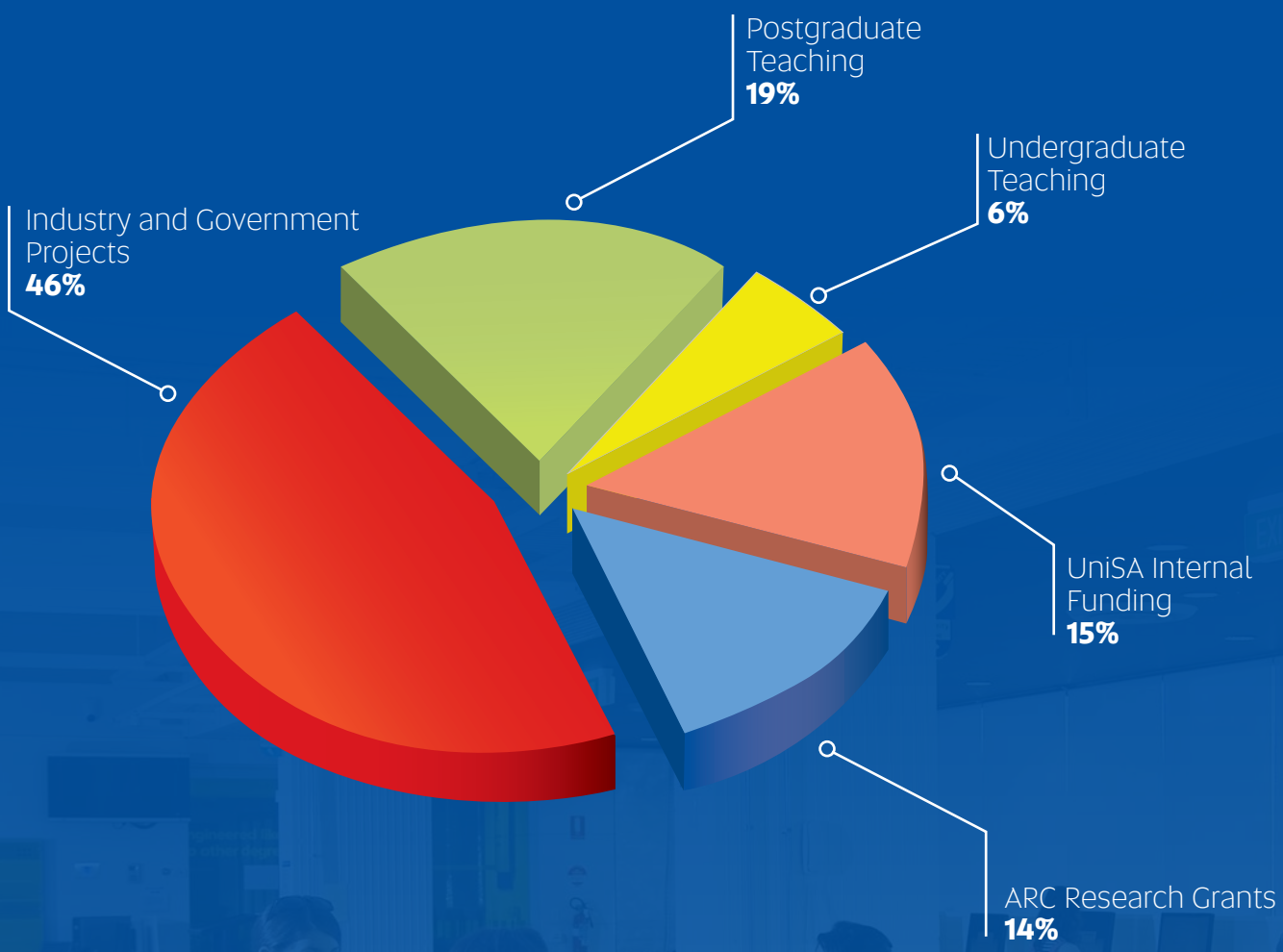
# REVENUE

## 2013 Revenue: Total $4.4m



# ITR'S STORY

ITR was founded in 1994 and, at that time, was one of only two key research concentrations at UniSA. ITR originated from the Digital Communications Group that commenced in the mid-1980s within the School of Electronic Engineering, where its main research was on modulation and coding, and satellite and mobile communications.

Today, as Australia's largest university-based group specialising in wireless communications, fundamental and applied research, proof of concept development and commercialisation activities all play an important part in ITR's success. Strong national and international relationships and collaborations with the telecommunications business community ensures our work has a high degree of relevance to the problems facing the wireless communications industry.

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