University of South Australia

Institute for Telecommunications Research

Connected. Reliable. Real Solutions.

Annual Report 2011

Vision

Advancing human knowledge in the transmission, processing and use of information, enabling high impact technologies that deliver economic, social, cultural, environmental and health benefits.

Mission

To conduct world class fundamental research, partnered with industry, to deliver leading edge technologies in a vibrant research education environment.

Values

Technology transfer

Leveraging basic research outcomes, we value the applied and experimental development of new technologies and delivery to market in partnership with industry.

International

We value researchers and research outcomes that are internationally renowned and we conduct our business on the international stage.

Engagement

We engage internationally and locally with end users, industry, government agencies, and like-minded research and engineering organisations.

Collaboration

We value multidisciplinary collaborative research leading to outcomes far beyond what we can achieve on our own.

High quality research

We value internationally competitive research undertaken by active researchers at the forefront of their fields.

Education

We believe our high values and long lasting achievements are delivered through high quality, industry-relevant education and training of higher degree students and staff.

Impact and benefit

We expect our research outcomes to have high impact and to deliver benefit to society.

End user context

We value breakthrough fundamental research that enables new technologies, applications and commercialisation opportunities.

Contents

Director's Report
Professor Alex Grant

In November 2010 the Institute was awarded $5M under the highly competitive Australian Space Research Program for a $12M program of research. The project aims to deliver key concepts and technologies for a new low earth orbit microsatellite system that will provide cost-effective two-way communications to remote sensors and devices. During 2011 this large-scale program of research and development began in earnest with engagement across the entire Institute. Together with our partners, COM DEV (Canada), SAGE Automation, Defence Science and Technology Organisation (DSTO), Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Institute of Marine Science (AIMS), we have made great progress in areas ranging from very high level system design, right down to the details of payload, terminal and waveform design. A very healthy, growing, portfolio of intellectual property is being produced by the Institute of Telecommunications Research (ITR) team.

ITR has a long history of success in attracting highly competitive research funding from the Australian Research Council (ARC). This continued in 2011 with the award of two Discovery Projects and a Postdoctoral Fellowship.

ITR's Dr Ingmar Land and Dr Roy Timo, together with ARC Future Fellow Sarah Johnson (Newcastle), Prof Sergio Verdu (Princeton) and Prof Gerhard Kramer (Technical University of Munich), were awarded $320,000 to tackle fundamental problems of data compression. The team aim to dramatically increase the performance of existing networks and enable new applications through the design of novel data compression algorithms that exploit sensor correlation. Dr Land accomplished the rare feat of winning two ARC Discovery grants in one year. Together with Prof Jinhong Yuan and Assoc Prof Robert Malaney (University of NSW), and Prof Lars Rasmussen (KTH Sweden), the team was awarded $300,000 to develop innovative new physical layer security techniques for wireless networks.

Building further on our base of high quality fundamental research, the Institute is now home to three ARC Fellows. In 2011 Dr Khoa Nguyen received an inaugural ARC Discovery Early Career Researcher Award. With a success rate of less than 10 percent, these fellowships are intensely competitive. Dr Nguyen will be working on robust wireless communications for control systems.

Another highlight of 2011 was the ConnectSafe field trial and on-road demonstration of dedicated short range communications for cooperative safety and traffic management. This Australian-first project was conducted in partnership with ITR spin-off company Cohda Wireless and was sponsored by the South Australian Motor Accident Commission with support from the Department of Transport, Energy and Infrastructure (DTEI).

We welcomed ITR's second Director's Fellow, Dr Robby McKilliam, who completed his doctoral work at the University of Queensland. Dr McKilliam adds new capabilities in the area of signal processing, estimation theory and communications.

Finally, ITR continued to shine in the area of high-quality publications. The most recent publication audit revealed that the Institute published over 80 percent of its journal papers in the highest ranked journals. Of particular note in 2011 was not one, but two invited papers in the prestigious Proceedings of the Institute of Electrical and Electronics Engineers (IEEE).

ITR is an exhilarating and energetic place to be at the moment. Large-scale, high-impact research and development programs and high quality fundamental research continue to be our defining features.

Professor **Alex Grant**
Director

Advisory Board Report
Mr Neil Bryans

As one of UniSA's highest performers, ITR continues to attract high quality postgraduate students with numbers on the rise from international students. Our reputation as a centre of choice for postgraduate telecommunications research is reaping rewards with international student enrolments.

A number of international visitors were hosted throughout the year, collaboration continues to be a key value as international and domestic networks are harnessed and maintained.

Board member Professor Caroline McMillen was farewelled after some five years of invaluable service serving on the Board since 2006. We wish Caroline all the best in her new endeavours and would like to thank her for her invaluable contribution over the years. We look forward to welcoming Dr Gregory Clark to the Board in 2012.

It has been a productive year and I look forward to continuing as Chairman of the Advisory Board and to watching the Institute's continued growth.

Neil Bryans
Chairman, Advisory Board

Research Sector

Flexible Radios and Networks

Associate Professor Linda Davis

Wireless broadband, mobile phone and internet, broadcast television, remote sensing, environmental monitoring, public safety, emergency services coordination, defence communications and surveillance … different communications technologies and networks suit different applications. But the goal is the same: simple, scalable and sustainable networks with seamless interconnectivity for the user.

The Flexible Radios and Networks sector focuses on advanced technologies and implementations to deliver flexible, adaptable operation and improved user experience.

Key Research Areas

Flexible Radios and Networks research and development includes:

- Cooperative communications,
- Hybrid networks: fixed, mobile wireless, satellite, wire-line,
- Vehicle-to-vehicle, dedicated short-range communications (DSRC),
- Network coding for routing and security,
- Compression of distributed data,
- Energy-efficient algorithms and architectures,
- Cross-layer optimisation, and
- Reconfigurable and software defined radio (SDR).

The activity in this sector represents a range of pure fundamental and applied research as well as technology development. ITR has experts in WLAN and IEEE 802, 3GPP 3G/4G LTE, DVB-T and emerging standards. We also work with and develop custom technologies and protocols.

Technologies of particular interest going into 2012 include reliable transmission for wireless control, source coding and compression of distributed data, physical layer security, energy-efficient transmission, and software defined radio for satellite and terrestrial applications.

Vehicular Communications

DSRC continued to be a hot-topic in vehicle-to-vehicle communications with safety applications for smart cars and smart infrastructure. This technology has the potential to significantly reduce the road toll. Using wireless links, vehicles are able to communicate with each other and key infrastructure. Sponsored by the South Australian Motor Accident Commission, ITR partnered with Cohda Wireless and the Department for Transport, Energy and Infrastructure to conduct the first Australian on-road trial of DSRC for safety and traffic management in May-Oct 2011.

Software Defined Radio

The South Australian Networking Laboratory (SANLab) projects were successfully completed in May 2011. A highlight for the SANLab team was the nomination of Australian Submarine Corporation (ASC) and SANLab for the Innovator Award at the Defence Industry's 2011 Defence Teaming Centre Awards. SANLab (2009-2011) was a partnership between ITR, the Centre for Defence Communications and Information Networking at the University of Adelaide, BAE Systems, Cisco and the ASC, and primarily funded through the South Australian Premier Science and Research Fund. Its legacy continues to provide facilities and capabilities to assist Defence and industry research in developing innovative and leading edge wireless networking solutions.

The SDR research team welcomed Dr David Haley in 2011. With a strong industrial research background, Dr Haley is spearheading research and development at ITR for application of SDR technology to ground terminal and satellite payload applications as part of the Space-Based National Wireless Sensor Network project.

ITR's SDR research also continued to attract strong interest and research contracts from Australian and international industry. Research by Dr Ying Chen and Associate Professor Linda Davis was recognised at the 2011 Wireless Innovation Forum European Conference with a top-10 paper on Communications Technologies and SDR. Our researchers also hosted several student interns who were working on SDR using GnuRadio and Universal Software Radio Peripheral (USRP) technology.

Representing a range of pure fundamental and applied research, as well as technology development.

Coding, Information Theory and Security

In March ITR hosted IEEE's distinguished lecturer in Information Theory, Professor Sergio Verdu, from Princeton University USA. Professor Verdu has ongoing collaboration with several ITR researchers including Dr Siu-Wai Ho, Dr Ingmar Land and Dr Roy Timo. Supported by a UniSA Early Career Research Travel Grant, Dr Timo spent three months, from November, working with Professor Verdu and his team in Princeton on non-asymptotic information theory.

Dr Siu-Wai Ho hosted a visit from Dr Calvin Chen, Alcatel-Lucent Bell Labs Paris, in April.

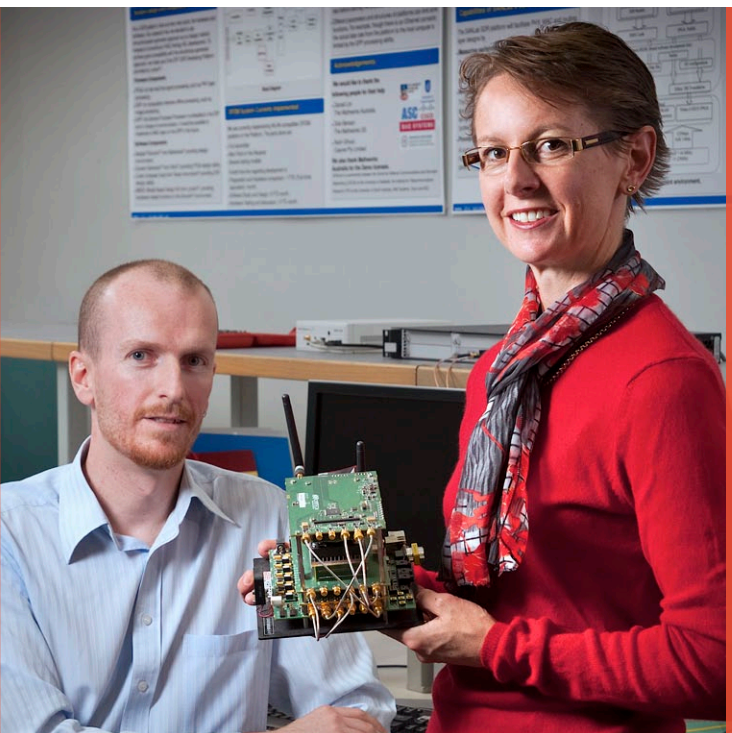
In July Dr Terence Chan was Technical Program Committee Co-Chair for the 2011 IEEE International Symposium on Network Coding.

Dr Robby McKilliam joined as the ITR Director's Fellow in August 2011. His research expertise is number theory (particularly lattice theory) and its application to signal processing, estimation theory and communications.

Associate Professor Yongyi Mao from University of Ottawa visited with Dr Terence Chan for three months from September. Their research focuses are on channel coding for fading channels. Professor Mao presented a tutorial on graphical models emphasizing its applications on probabilistic inference and code design.

Space-Based National Wireless Sensor Network

Many key researchers were willingly drawn into the substantial research program associated with the Space-Based National Wireless Sensor Network project. Contributions include coding and signalling, signal acquisition and synchronization, multi-user detection, multi-antenna and polarization techniques and SDR. Detailed information about this project can be found on page 16.



Dr **David Haley**

Associate Professor **Linda Davis**

Looking Forward

2011 was a particularly successful year for our researchers who were awarded several prestigious and substantial research grants for research in 2012 and beyond. These include:

- Dr Ingmar Land and Dr Roy Timo: Compression of distributed data: bridging the gap between theory and practice – a $320,000 ARC Discovery project in collaboration with Dr Sarah Johnson (Newcastle), Prof Sergio Verdu (Princeton) and Prof Gerhard Kramer (Munich).
- Dr Ingmar Land and Prof Lars Rasmussen (KTH Sweden): Physical layer security techniques for multiuser wireless networks – a $300,000 ARC Discovery project hosted at UNSW in collaboration with Prof Jinhong Yuan and Assoc Prof Robert Malaney.
- Dr Khoa Nguyen: Reliable transmission for wireless control – a $375,000 Discovery Early Research Career Award (DECRA) Fellowship (one of only four at UniSA).
- Assoc Prof Linda Davis: Passive radar – research professional development scholarship from the Government of South Australia supporting collaboration with Mr James Palmer and Mr Stephen Howard (DSTO), Assoc Prof Vaughan Clarkson and Mr Konstanty Bialkowski (University of Queensland).
- Dr Lin Luo: Energy-Efficient Multicarrier Transmission – Australian Technology Network Germany Academic Exchange (ATN-DAAD) grant for collaboration with Professor Hermann Rohling at Hamburg University of Technology.

Research Sector

High Speed Data Communications

Professor Bill Cowley

While fibre-based links now provide most of our wired communications for fixed terminals, there is a growing demand for gigabit wireless communications to either replace some traditional fixed terminal applications, provide higher speed connectivity to mobile terminals or enable information rich services to remote areas with limited fibre infrastructure.

Very high speed wireless communications are delivered by a number of technologies depending on the application. Each has constraints that provide challenges relating to areas such as spectrum usage, power and size of terminal to name a few. The High Speed Data Communications team provides system and device level solutions to service the increasing need for gigabit communications.

Key Research Areas

High Speed Data Communications research and development includes:

- Free Space Optical (FSO) Communications – As we run out of RF bandwidth, FSO links offer an alternative method of realising gigabit links for satellite downlinks or terrestrial applications. FSO links are, however, affected by atmospheric scintillation, in a similar fashion to fading on RF channels. ITR is applying novel signal processing and coding methods to dramatically improve the performance of FSO communications.
- Indoor Wireless Communications – Gigabit millimetre-wave wireless local area networks. At 60 GHz, more than 5 GHz of ISM bandwidth is available for short range gigabit wireless systems. ITR has recently collaborated with partners to design and test components of these next-generation WLAN systems.
- Gigabit Satellite Communications – Higher resolution satellite imagery demands higher speed downlinks. ITR has developed a next generation ground station demodulator for earth-resource satellites capable of gigabit data rates.

Free Space Optical

Radio frequency spectrum is becoming increasingly crowded as the demand for higher bandwidth wireless communication services increases. FSO communications transmits data at very high rates using 'eye-safe' infrared signals. ITR's research into broadband communications focuses on new techniques suitable for FSO or hybrid FSO/RF communications, plus more traditional approaches for high-speed satellite and terrestrial RF communications.

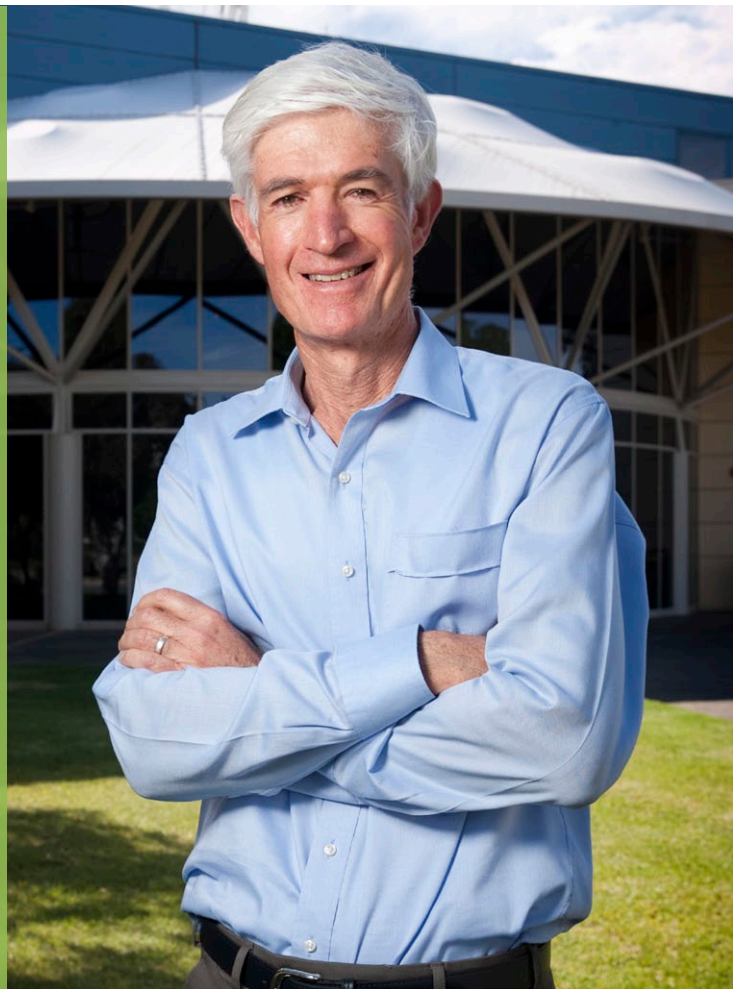
In 2011 we completed a project funded by The Sir Ross and Sir Keith Smith Fund and Cisco Systems, "Channel Coding for High-Speed Free-Space Optical and Radio

Addressing the increasing demand for gigabit wireless communications.

Frequency Communications", and started new demonstration projects in this area with both DSTO and the German Aerospace Agency (DLR). While FSO links have great potential for both terrestrial and satellite broadband communications, they are affected by fading caused by small changes in the refractive index of the atmosphere as well as meteorological effects such as clouds and fog. ITR is applying advanced channel coding methods that can provide huge benefits to the reliability of FSO communications. Additionally, adaptive techniques that vary the transmission to suit current channel conditions are being explored.

ITR has been working in several aspects of FSO communications including the underlying FSO channel and its capacity under various models of channel fading, modulation and coding. Some of this work was published in an IEEE special issue of the Journal on Selected Areas in Communications.

We continued to collect and analyse signals from our 12 km test range to measure RF/FSO channel statistics. Real-time FSO transceiver work has continued with a real-time design tested both on the bench and over the 12 km link.



Professor
Bill Cowley

High Speed Wireless Firmware Development Project

ITR assisted the Commonwealth Scientific and Industrial Research Organisation (CSIRO) with firmware development in their Ngara project that aims to provide wireless broadband communications to rural areas of Australia. ITR developed firmware components required for the very high-speed wireless backhauls. The implementation of the project exemplifies both ITR's ability to deliver high-speed signal processing systems and collaboration with other research institutes. The project uses a model-based design approach for FPGA implementation that complements ITR's other SDR research. Achieving data rates above 5 Gb/s, this is strong validation of the model-based design approach.

Satellite Communications Projects

ITR continued to support the high-speed Earth Resource Satellite Demodulator (ERSDEM) project. ERSDEM uses parallelism and pipelining, implemented in large FPGAs to achieve this performance. The current ERSDEM-3, capable of Gbit data rates, was designed during a recent ARC Linkage Project and since then ITR has assisted Satellite Services BV in the Netherlands to commercialise this product.

Research Sector

Satellite Communications

Associate Professor Adrian Barbulescu

ITR research aims to increase the reliability, spectral efficiency and flexibility of satellite communications with a particular focus on multiuser systems. These technical innovations deliver entirely new categories of economic delivery of services to remote users.

In addition, the Satellite Communications sector boasts satellite ground station facilities offering both S-Band and X-Band capabilities – one of only a few available in the southern hemisphere. The 3.0m steerable S-band antenna, and 6.8m steerable X-band antenna, and corresponding ground station equipment are available to provide services to various clients for applications such as earth resource data reception and launch vehicle tracking.

Space-Based National Wireless Sensor Network

Satellite communications researchers and engineers are designing a new system architecture, waveforms and signal processing methods for the support of large populations of remote sensors and devices.

More information about this project can be found on page 16.

Low-cost satellite services using flexible satellite communication payloads in multiuser applications.

Associate Professor
Adrian Barbulescu

SDR for Space Applications

One of the key advantages of SDR platforms is their flexibility in using various resources: the general purpose processor (GPP), the digital signal processor (DSP) or the FPGA. The target implementation of an algorithm is in either C/C++ language (that will use the GPP and/or DSP resources) or VHDL code (that will be used in the FPGA).

The overall aim is to reduce the time taken from research to implementation, in particular for demonstrating a new concept or a new architecture. From software simulations to code running in real time, the focus has been on identifying the optimum path to take.

This approach towards an automated translation, and less hand code design, allows more time and resources to be spent on key research issues such as waveform optimisation and robust synchronisation under significant high levels of interference. More efficient utilisation of ITR's strong research capabilities means higher productivity and better service for our customers.

X-Band Satellite Reception Facility

Our tracking facility has continued to be used to acquire images downloaded from the Spot 4 and Spot 5 satellites. Now in its 9th year of daily service, dish tracking performance has remained high. 2011 saw upgrades to our station reception equipment to the ITR-developed ERSDEM-3, capable of multiple channel reception.

S-Band Reception Facility

ITR provided tracking services for the second Autonomous Transfer Vehicle (Johannes Kepler) launch to the International Space Station in February. Under contract to the French Space Agency, CNES, ITR's role is essential as part of the small global network of tracking stations providing critical real-time data for this mission. The facility was also used by commercial clients for tracking other low earth orbit satellites.

Space Strategies

ITR has participated in a number of projects involving analysis of satellite communications equipment usage and obsolescence planning, as well as providing input into satellite requirements for Synthetic Aperture Radar applications. These form part of ITR's continuous involvement with industry, finding solutions to current problems but also identifying space-related strategic directions.

Research Sector

Computational and Theoretical Neuroscience

Dr Mark McDonnell

The Computational and Theoretical Neuroscience Laboratory is a grouping of research staff, students and interdisciplinary collaborators whose primary aim is to explore and explain how electrical and chemical signals are used in the brain to both represent and process information.

The Laboratory's researchers apply engineering approaches to answer fundamental scientific questions about information processing in neurobiology. A particular emphasis is on reverse-engineering the biophysical mechanisms exploited by neurons and networks of neurons to "communicate" with each other and to perform computations.

Amongst the many research outcomes, the ultimate aim is to develop new methods for biologically inspired artificial intelligence.

Developing new methods for biologically inspired artificial intelligence.

Dr **Mark McDonnell**

Key Research Areas

The Laboratory's research aims to achieve the following outcomes:

- Produce mathematical and computational models of biological systems that lead to new knowledge in neuroscience,
- Formulate testable hypotheses regarding computation and communication in neural systems,
- Design and develop new methods and tools that are useful for model development and hypothesis testing, and
- Create new biomedical engineering and biologically inspired technology.

Dr Mark McDonnell, Laboratory Principle Investigator, continued working on an ARC Discovery Project that included a five-year Australian Research Fellowship. Titled "Communication and information storage mechanisms in complex dynamical brain networks," the project focuses on explaining why repetitive oscillations are often observed in measurements of brain signals. Findings will potentially lead to innovative ideas for future medical bionics and brain machine interfaces.

Dr **Ingmar Land**

Five refereed journal papers and one refereed conference paper were published in 2011 including a review article featured in Nature Reviews Neuroscience about electrical noise in the nervous system.

The team also continued to grow as we saw the commencement of new PhD student Daniel Padilla.

The Laboratory continues to harness and expand its extensive collaborative links both within Australia and internationally. Highlights included visits by Professor Priscilla Greenwood, University of British Columbia Canada, Dr Pierre-Olivier Amblard, Centre National de la Recherche Scientifique France, and Associate Professor Bruce Graham, University of Stirling UK. Dr McDonnell visited and worked with collaborators at University of Melbourne and Flinders University and presented invited seminars at the Computational Brain Workshop, Melbourne, and at Brain Sciences, University of New South Wales.

In November, Dr McDonnell was awarded a six-month Endeavour Research Fellowship from the Australian Federal Government Department of Education, Employment and Workplace Relations to visit and work with Professor Lawrence Ward at University of British Columbia in 2012.

Dr McDonnell was Chair and Organiser of a two-day symposium held as part of the Institute of Electrical and Electronics Engineers Intelligent Sensors, Sensor Networks and Information Processing (IEEE ISSNIP) conference held in Adelaide during December. The Symposium brought together International and domestic researchers in the area of Biomimetic Sensors and Neuronal Information Processing.

Competitive Research Grants

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

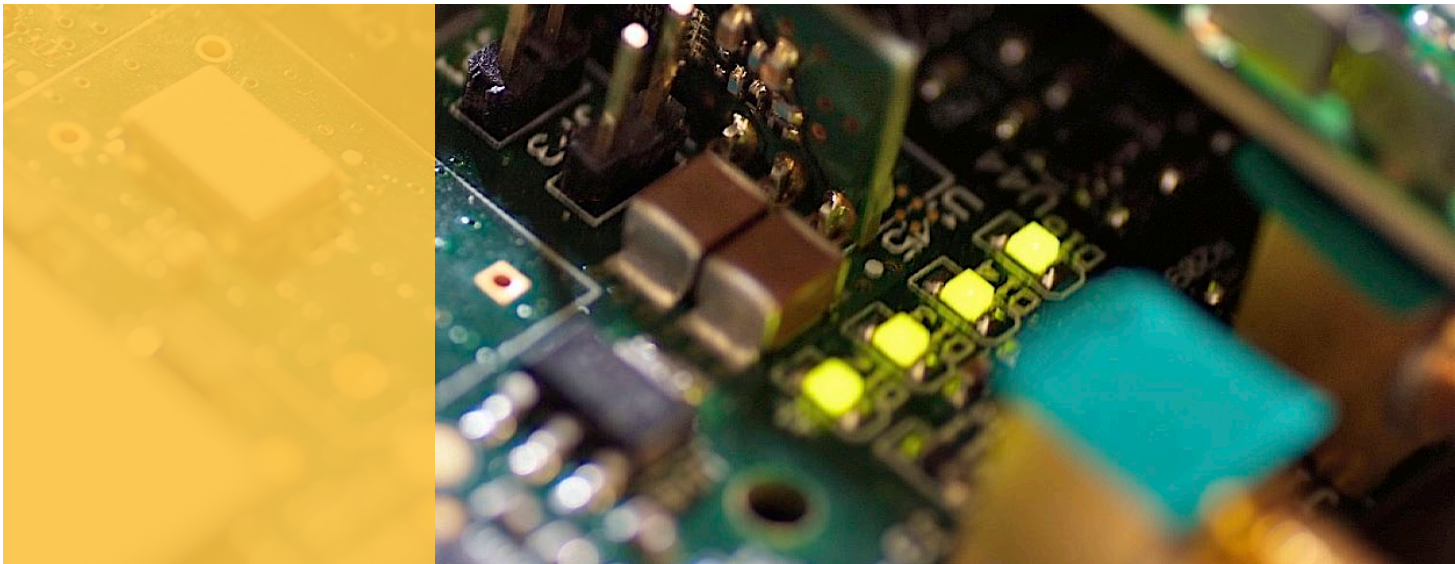
Dr Terence Chan and Professor Alex Grant: 2010–2013
Australian Post Doctoral Fellowship Dr Siu Wai Ho: 2010–2013

It is vital to provide efficient and robust communications in networks. 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, 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/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 Discovery: Adaptive Broadband Wireless Communication

Professor Bill Cowley: 2008–2010 (extended to 2011)

The performance of broadband wireless communication networks is limited by available resources such as frequency, bandwidth and transmission power. Also, the time varying features of wireless communication channels adversely affect performance. Transmission schemes adapting to instantaneous channel characteristics can significantly improve performance. The aim of this project is therefore to determine fundamental limits for broadband wireless communication systems and to develop practical adaptive transmission schemes for achieving these limits. A theoretical design framework for practical adaptive schemes will be developed, resulting in fundamental contribution to information theory and new designs for future broadband wireless applications.

ARC Discovery: Efficient Data Transport Using Network Coding

Professor Alex Grant and Dr Terence Chan: 2008–2012

This research aims to understand the relation between resource allocation and service quality in communication networks. Network coding changes the way we think about networks by allowing network nodes to perform coding, rather than just routing. Performance increases are predicted for distributed storage, content distribution and multimedia streaming. The project focuses on network coding to increase throughput and to reduce management overhead in wired and wireless multimedia networks. Targeted outcomes include contributions to network coding theory, deeper understanding of performance, complexity and resource trade-offs, practical network coded data transport schemes, and new network designs which balance the available resources to deliver required quality of service.

ARC Discovery: Efficient Transmission Strategies for Cooperative Wireless Ad Hoc Networks

Dr Ingmar Land and Professor Lars Rasmussen: 2009–2011

This project investigated new methods for cooperation in wireless networks, with a focus on coding strategies for wireless relaying. These technologies offer the potential to greatly improve the performance and coverage of fourth generation wireless data networks. The proposed research is in areas of great commercial interest, addressing new directions and technologies for future wireless networks. Applied development of the outcomes will lead to valuable intellectual property for commercial exploitation.

Dr **Badri Vellambi** (left) and Dr **Terence Chan**

Industry Sponsored Projects

Co-Channel Speaker Separation – Speech Enhancement by Acoustic Beam Forming

In this project an array of several microphones, together with suitable amplifiers and a sampling system with PC interface, were used to explore the performance of signal processing techniques for noise suppression by beam forming. Signals were recorded in real acoustic environments, such as teleconference scenarios, and processed offline. The degree of wanted signal enhancement, plus the effects of reverberation and speaker movement, was explored.

The South Australian Networking Laboratory (SANLab)

SANLab is primarily funded through the South Australian Premier Science and Research Fund. ITR is in partnership with Defence Communications and Information Networking (CDCIN) at the University of Adelaide, BAE Systems, Cisco and ASC. The project assisted the Defence community in developing innovative and leading edge solutions and capability in MANET technologies. A key focus for ITR is the development of capability in the area of software defined radio.

Ms **Wendy Clark**
Principal Ground Station Operator

Coding for Hybrid Free Space Optical/ RF Channels

Funded by the Sir Ross and Sir Keith Smith Fund, this project targeted FSO communication links as a broadband link alternative for both terrestrial and satellite broadband communications where radio frequency spectrum is limited. Unfortunately FSO links are affected by atmospheric scintillation and poor weather, such as clouds and fog. ITR is applying advanced coding methods to dramatically improve the performance of FSO communications, including the use of multiple optical channels and hybrid approaches using both RF and FSO channels so that as the quality of individual channels varies, the best overall performance can be obtained.

Ngara Backhaul Project

Funded by CSIRO, this project involved implementing an outer transceiver using high speed FPGAs as part of a larger development program being undertaken by CSIRO. The project demonstrated a 5Gbit/s wireless backhaul.

Arithmetic Operators to Enhance Digital Signal Processing Performance

This investigation studies fundamental attributes of FPGA processors and associated issues that contribute to overflow, underflow and bias that may occur in computations.

Satellite Communications for Remote Users

ITR conducted investigations regarding the quality of service for users located in various remote sites that utilise satellite communications. Bandwidth requirements, latency, jitter, packet loss and network quality for the overall satellite link were measured and analysed.

Dedicated Short Range Communications Trial

ConnectSafe Adelaide is Australia's first field trial and on-road demonstration of DSRC for cooperative safety and traffic management. The ConnectSafe trial was conducted from May – Oct 2011 by ITR and Cohda Wireless. It was sponsored by the South Australian Motor Accident Commission with support from the DTEI.

Running for six months, a fleet of ten DSRC-equipped vehicles recorded periodic snapshots of their position, speed, heading and acceleration. This data was uploaded to roadside equipment located at the DTEI Traffic Management Centre. Snapshots were taken every few seconds, and were also triggered by events such as heavy braking, and stop-start conditions. This information provided valuable information about road conditions and traffic flow, congestion, road safety 'black spots', intersection queue lengths and travel times. In May 2011 on-road demonstrations gave participants first-hand experience of co-operative safety applications including intersection collision warning, emergency electronic brake light and road worker alerts. These demonstrations were widely reported in the international media.

ATV Satellite Tracking Services

In February ITR provided tracking services from its S-band steerable tracking facility at Mawson Lakes, South Australia, for the second Autonomous Transfer Vehicle (Johannes Kepler) 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 SPOT-4 and SPOT-5 satellites. This is now the ninth year of providing such a service.

International Space University

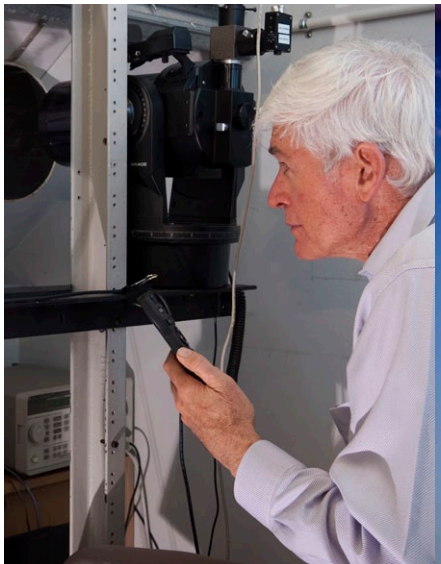
ITR has provided lectures and workshops in satellite communications for the very successful Southern Hemisphere Space Studies Program (SH-SSP). UniSA and the International Space University ran this five-week multi-disciplinary live-in program at the beginning of 2011 and will do so again in 2012.

Improving Frequency Assignment Strategies

This research project aims to improve the understanding of frequency assignment strategies that are immune to intermodulation distortion.

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 at effective methods for rates in the 100 Mbit/s regime.



Space-Based National Wireless Sensor Network

The concept of a cost-effective Space-Based National Wireless Sensor Network is to address Australia's needs for ecosystem management, monitoring of climate change, defence and national security, and support of industries such as mining and agriculture. This delivers clear national benefit in alignment with Australia's stated research priorities.

Many remote sensors and devices have modest data rate needs and do not require broadband real-time communications. This market is not well served by existing satellite services, which are either too expensive, do not provide suitable data capabilities, or are receive only.

ITR was awarded $5 million in November 2010 under the Federal Government's priority program – Australian Space Research Program (ASRP). Matched with an investment from partners, including COM DEV (leading manufacturer of space hardware in Canada), SAGE Automation, as well as DSTO, CSIRO and AIMS, the total funding and contributions is over $12.5 million for the 2.5 year project.

The project aims to demonstrate a proof-of-concept system that is capable of filling the market gap in the area of cost-effective data gathering for remote, low data rate applications. The program looks at the overall system development and design, as well as the ground and space segment aspects, including the demonstration of new algorithms enabling very cost effective services for large numbers of sensor terminals.

In this first year of the project the focus was to identify specific end user applications that would benefit from the availability of such a system. In March 2011 a consortium workshop was held at ITR to bring together all project partners specifically for this purpose. The outcome of this workshop was the identification of a number of potential end user applications which included environmental monitoring, mining and agriculture and defence and national security. A set of user requirements for the system was then defined and these have formed the foundation for all project activities moving forward.

A key strategic objective of the project is the use of SDR tools and techniques in the development. SDR platforms have the capability of being software reconfigurable such that they can support different functionality and provide flexible operation. In the case of SDR-based systems, the payload, for example, can be reconfigured in software to support a number of different missions, thus eliminating the need to launch a new dedicated satellite for each mission.

A development methodology was derived to provide an efficient way to utilise a common code based amongst all system entities, thus reducing risk and implementation time. State of the art waveforms and algorithms have been designed in order to maximise the performance of the system in line with the user requirements. These are now being optimised through the use of a custom-built simulation model.

University of South Australia | Institute for Telecommunications Research

COM DEV

SAGE Deliver certainty

Australian Government | Australian Institute of Marine Science

Australian Government Department of Defence Defence Science and Technology Organisation

CSIRO

Ms **Chinthani Uduwerelle**

Dr **Gottfried Lechner**

Publications

Book Chapters

W. Malik and A. Pollok, "MIMO Techniques for High-rate Communications", *Reliable Communications for Short-range wireless systems,* UK, pp. 113-132, 2011

T. Chan and R. W. Yeung, "Probabilistic Inference Using Function Factorization and Divergence Minimization", *Towards an Information Theory of Complex Networks,* Springer, Boston, pp. 47-74, 2011

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A M. Shahriar, R. Qureshi and M. Atiquzzman, "Performance of Prefix Delegation Based Route Optimization Schemes for NEMO", *Wireless Personal Communications: an international journal,* vol. 56, pp. 469-490, 2011

L. Lai, S-W. Ho and H V. Poor, "Privacy-Security Trade-Offs in Biometric Security Systems - Part II: Multiple Use Case", *IEEE Transactions on Information Forensics and Security,* vol. 6, no. 1, pp. 140-151, 2011

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M N. Khan and W. Cowley, "Signal Dependent Gaussian Noise Model for Free Space Optical Communications", *Australian Communications Theory Workshop,* (Melbourne, Australia), pp. 142-147, January 2011

W. Huang, S-W. Ho and T. Chan, "Finite Session Codes in Asynchronous Channel", *Australian Communications Theory Workshop,* (Melbourne, Australia), pp. 77-82, January 2011

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G. Zhu, L. Davis, T. Chan and S. Perreau, "Trade-offs in Energy Consumption and Throughput for a Simple Two Relay Network", Australian Communications Theory Workshop, (Melbourne, Australia), pp. 37-42, January 2011

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R. Arablouei, K. Dogancay and S. Perreau, "MIMO-DFE Coupled with V-Blast for Adaptive Equalization of Wideband MIMO Channels", *European Signal Processing Conference,* (Barcelona, Spain), pp. 639-643, August 2011

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M. Girnyk, M. Xiao and L. Rasmussen, "Myopic Multi-Hop Transmission Strategies in Layered Wireless Networks", *IEEE International Symposium on Personal, Indoor and Mobile Radio Communications,* (Toronto, Canada), pp. 1-5, September 2011

I. Ali, A. Pollok, L. Luo and L. Davis, "A Low Complexity Receiver for T-transform based OFDM Systems", *IEEE International Symposium on Personal, Indoor and Mobile Radio Communications,* (Toronto, Canada), pp. 1-5, September 2011

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S-W. Ho, L. Lai and A. Grant, "On the Separation of Encryption and Compression in Secure Distributed Source Coding", *IEEE Information Theory Workshop,* (Paraty, Brazil), pp. 653-657, October 2011

T. Chan and S-W. Ho, "2-Dimensional Interval Algorithm", *IEEE Information Theory Workshop,* (Paraty, Brazil), pp. 633-637, October 2011

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B N. Vellambi and I. Land, "Communicating Degraded Message Sets over Multi-access Channels with Degraded Encoder State Information", *IEEE Information Theory Workshop,* (Paraty, Brazil), pp. 437-441, October 2011

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Conference Papers
Non-Refereed

L. Davis, D. Haley, A. Pollok and Y. Chen, "Satellite Links and Software Defined Radio for Remote Communicative and Sensor Date Gathering", *Defence Applications of Signal Processing,* (Coolum, Australia), pp. 1-5, July 2011

M. Rice, "Space Based Signal Processing to Enhance the Detection and Relay of Ground Originated Signals", *Defence Applications of Signal Processing,* (Coolum, Australia), pp. 1-5, July 2011

Please note this list has not been audited

Staff and Board

Staff

Director	**Prof Alex Grant**
Business Manager	**Mr Jeff Kasparian**
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 Research Professor	**Assoc Prof Kutluyil Dogancay**
Senior Research Fellows	**Dr Terence Chan**
	Dr David Haley
	Dr Ingmar Land
	Dr Mark McDonnell
	Dr Sylvie Perreau
ITR Director's Fellows	**Dr Siu Wai Ho**
	Dr Robby McKilliam
Research Fellows	**Dr Ying Chen**
	Dr Jahangir Hossain
	Dr Gottfried Lechner
	Dr Lin Luo
	Dr Khoa Nguyen
	Dr Andre Pollok
	Dr Ramanan Subramanian
	Dr Sudharshan Srinivasan
	Dr Roy Timo
	Dr Badri Vellambi
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	Mr Marc Lavenant
	Mr Trevene Leonard
	Mr Ricky Luppino
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	Mr Mirko Smiljanic
	Mr Hidayat Soetiyono
Business Analyst: Finance and Project Systems	**Ms Sandy Sherry**
Human Resources and Student Coordinators	**Ms Amanda Johnston**
	Mrs Sarah Armour
Marketing and Communications Coordinator	**Mrs Penny Reidy**
Personal Assistant to Director	**Ms Christine Bennett**

Adjunct Staff

Emeritus Professor	**Emeritus Prof Michael Miller**
Adjunct Research Professors	**Prof Ken Lever**
	Prof Lars Rasmussen
	Prof Lang White
Adjunct Associate Research Professors	**Dr Paul Alexander**
	Dr John Asenstorfer
	Dr Mark Rice
Adjunct Senior Research Fellows	**Dr Daniel Floreani**
	Dr Nick Letzepis
	Dr Steven Pietrobon
	Dr Peter Shoubridge
	Dr Weimin Zhang
Adjunct Research Fellows	**Dr Nicolangelo Iannella**
	Dr Benny Johnson
	Dr John Tsimbinos

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Executive Director Counter Terrorism & Security Technology Centre, DSTO

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Deputy Vice Chancellor & Vice President – Research & Innovation, UniSA

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General Manager, Information Economy, Science and Information Economy Directorate DFEST

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Research Leader Military Communications Branch, Communications, Command and Control Division, DSTO

Dr David Skellern
Chief Executive Officer, NICTA

Mr Jeff Kasparian
Business Manager, ITR

Visitors

Visitors

Dr Pierre-Olivier Amblard	National Centre for Scientific Research (CNRS), France
Mr Konstanty Bialkowski	University of Queensland, Australia
Dr Chung Shue Chen	Alcatel-Lucent Bell Labs, France
Dr Dirk Giggenbach	German Aerospace Centre (DLR), Germany
Associate Professor Bruce Graham	University of Stirling, UK
Mr Ken Grant	DSTO, Australia
Prof Priscilla Greenwood	University of British Columbia, Canada
Mr Stewart Heitmann	University of New South Wales, Australia
Dr Shiro Ikeda	Institute of Statistical Mathematics, Japan
Dr Sarah Johnson	University of Newcastle, Australia
Assoc Prof Yongyi Mao	University of Ottawa, Canada
Prof Lars Rasmussen	Royal Institute of Technology (KTH), Sweden
Dr Chee Wei Tan	City University, Hong Kong
Prof Sergio Verdu	Princeton University, USA
Prof Janet Wiles	University of Queensland, Australia

Internship Students

Johannes Wechsler	University of Erlangen, Germany *Supervised by Dr Ingmar Land*
Fabrizzio Massaro	Karlsruhe Institute of Technology, Germany *Supervised by Prof Bill Cowley and Dr Gottfried Lechner*
Denis Filimonov	Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland *Supervised by Dr Lin Luo*
Thomas Hedde	Telecom Bretagne, France *Supervised by Dr Siu Wai Ho*
Gregoire Payen de La Garanderie	Telecom Bretagne, France *Supervised by Dr Mark McDonnell and Dr Sylvie Perreau*
Edward Ross	Adelaide University, Australia *Supervised by Dr Mark McDonnell and Dr Sylvie Perreau*
Migel Dileepa Tissera	UniSA, Australia *Supervised by Dr Mark McDonnell*

Work Experience

Bao Nguyen	UniSA, Australia *Supervised by Dr David Haley*
Yinyue Qiu	University of Wollongong, Australia *Supervised by Dr David Haley*
Jilong Zhang	Adelaide University, Australia *Supervised by Dr David Haley*
Iain Dickson	UniSA, Australia *Supervised by Dr Siu Wai Ho*
Aoi Tanaka	UniSA, Australia *Supervised by Dr Siu Wai Ho*
Malaka Senanayake	UniSA, Australia *Supervised by Dr Siu Wai Ho*

Students

Name	Research Topics
Mr Imran Ali	Signal Processing for Capacity Improvement of Multiuser-MIMO-OFDM Communication Systems
Mr Reza Arablouei	Partial Update Techniques for Adaptive Memo Channel Equalisation
Mr Hamid Dadkhahi	Wireless Network Coding
Mr Volkan Dedeoglu	Positioning and Target Tracking In Sensor Ad-Hoc Networks
Mr Rajan Kadel	Codec Design for Block Fading Hybrid FSO/RF System
Mr Muhammad Khan	Fundamental Limits of Hybrid FSO/RF Communications
Ms Afsana Khatoon	Channel Modelling and Adaption for Hybrid Free-Space Optical And Radio Frequency Communications
Ms H.K.Jeewani Kodithuwakku	Decoder-Aided Synchronization for Code Division Multiple Access (CDMA) Satellite Communications
Mr Asanka Kekirigoda Mudiyanselage	Visible Light Communications
Mr The Anh Ngo	Releasing Congestion in Mesh Networks by Relays
Mr Daniel Padilla	Computational Neuroscience
Mr Abdullah Parvez	Software Payload Reliability for Multi-Mission Satellites
Mr Brenton Prettejohn	Consensus Formation and Robustness in Complex Dynamical Networks
Ms Nayeema Sadeque	Relaying for Physical-Layer Security
Mr Daniel Salmond	Impact of Delay and Robustness on Network Coding
Mr Assefa Teshome	Biometric Security Systems with Privacy Protection
Mr Satyajitsinh Thakor	Network Coding Capacity Bounds
Ms Thuy Tran	Acoustic Beamforming Methods for Speech Separation
Mr Mike Tran	Information Theoretic Security for Networks

Name	Research Topics
Ms Chinthani Uduwerelle	Information Theoretic Approach to Network Security
Mr Vince Wang	Reliable and Efficient Coding for Asynchronous Satellite Communications
Ms Anuradha Wickramasooriya	Channel Code and Precoder Design for MIMO Wiretap Channels
Mr Udara Wijetunge	Stochastic Routing Optimisation in Wireless Sensor Networks
Mr Sean Wong	Modelling Brain Function with Hierarchical Temporal Memory Suprathreshold Stochastic Resonance
Mr Ahmad Zarikah	Wireless Network Coding
Mr Josh Zheng	Information Theoretical Analysis of Dataflow in Vehicular Networks

Name	Masters Topics
Mr Paul Hirschausen	Advanced Modem Algorithms for Wideband High Frequency applications
Mr Shamim Ahmed Joarder	Energy Minimisation in CDMA Based Mobile Ad-Hoc Networks
Mr Nick Lawrence	Polarisation Diverse Low Earth Orbit Satellite Communications
Mr Kagiso Magowe	Information Theory for Distributed Storage
Mr Jerry Zhu	Energy Efficient Communication Networks
Mr Ahmad Zubair	Security in Cognitive Radio Networks

2011 Theses: Masters (Research) and Doctoral

The Completion of Requirements was certified by the University of South Australia's Research Degrees Committee for the following ITR Postgraduate Research student in 2011.

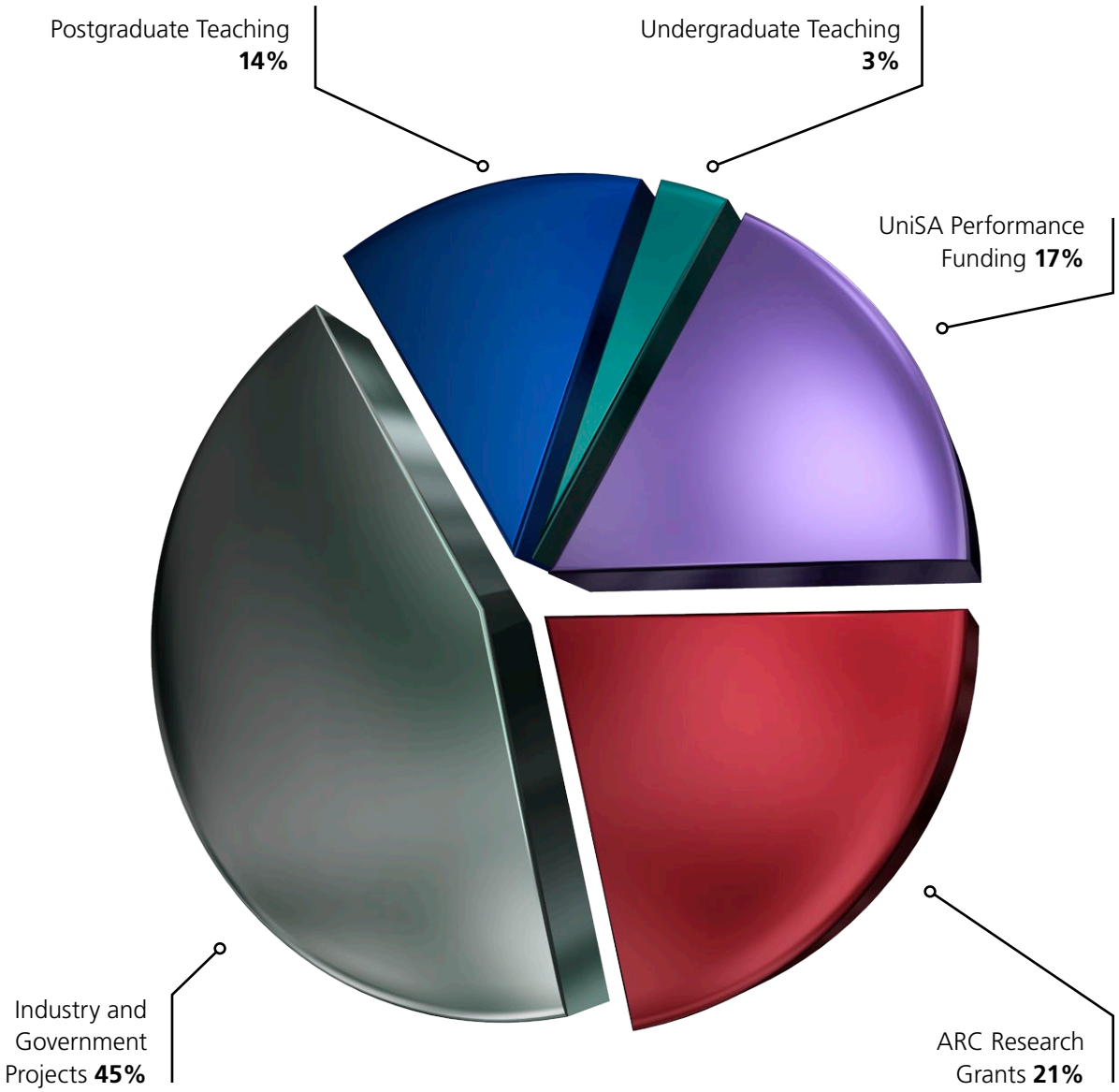
Mr Shamim Ahmed Joarder **Master of Engineering (Telecommunications)**	Energy Minimisation in CDMA Based Mobile Ad-Hoc Networks

Research Students
Ms **Xiao Gao** and
Mr **Daniel Padilla**

Research Students
Mr **Volkan Dedeoglu** and
Ms **Thuy Tran**

Income Profile

2011 Revenue: **$4.541 million**



Foundations and Success

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 research foci were mainly in the areas of 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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