University of South Australia

Institute for Telecommunications Research

Connected. Reliable. Real Solutions.

unisa

Experience. The Difference.

Information is fundamental to our existence. Effective transmission, storage, processing and use of information is not only an economic driver, but is also central to our social networks and human cultural exchange. Access to information is a key to every nation's political and economic development. It is the very foundation upon which human knowledge and scientific endeavor is built.

Welcome from the Director

Formally established in 1994, the Institute for Telecommunications Research (ITR) builds on antecedent organisations going back more than 25 years. With over 60 dedicated research staff and students, ITR is the largest University research institute in Australia that specialises in wireless and satellite telecommunications.

Our research staff and postgraduate students work with their international collaborators to tackle the fundamental mathematical aspects of modern telecommunications. They also work together with our highly skilled engineering team to deliver new communications technologies that are only made possible by breakthrough science. This is a unique characteristic of the Institute - strong connections between theory, application and commercialisation.

Since its foundation, the Institute has had a long and proud history of working with local and international industrial, defence and government partners to deliver commercial-grade hardware and software solutions for challenging communications problems. This ranges from remote sensing using satellites for climate change and earth resource monitoring through to Gigabit indoor wireless communications, and saving lives through vehicle-to-vehicle communications. Our ultimate focus is to make the world a better place through novel use of information.

Professor Alex Grant
Director ITR

ITR foundations and success

The Institute for Telecommunications Research (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 of Electronic Engineering, where its research foci were mainly in the areas of modulation and coding, and satellite and mobile communications.

Today, 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 ensure our work has a high degree of relevance to the problems facing the wireless communications industry.

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

The mission of the Institute for Telecommunications Research is to conduct world class fundamental research, partnered with industry to deliver leading edge technologies in a vibrant research education environment.

Values

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

Education
We believe that our highest value and longest lasting achievements are delivered through high quality, industry relevant education and training of higher degree students, engineers and professional 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.

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 organisations.

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

Our research expertise

ITR is an internationally recognised research organisation, specialising in research and technology development for wireless communications. This includes both fixed and mobile, satellite and terrestrial based applications.

ITR conducts its research in four main areas:

Satellite communications

Satellite communications remains the technology that provides key communication infrastructure for many applications across diverse industries, concerning not only economical but environmental and national security issues too. This is why ITR is putting in a constant effort to be at the forefront of this technology by developing its capability to design, implement and test satellite equipment under more and more stringent constraints on power and availability, and increased bandwidth requirements.

Recent achievements include:

- Optimisation of waveform design for high levels of interference
- Development of robust synchronisation algorithms
- Efficient implementation of complex receivers in FPGA hardware
- High quality satellite image receiving operations.

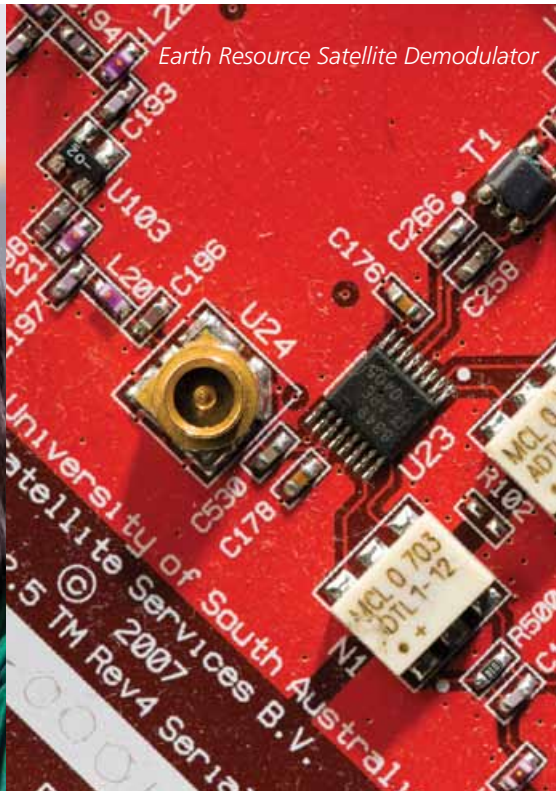
High speed data communications

Our society has an insatiable demand for bandwidth. While optical fibre is an excellent solution for fixed terminals in urban areas, this still leaves great demand for gigabit wireless communications, either to mobile terminals or remote areas with limited fibre infrastructure.

Providing very high speed wireless communications can be challenging, given requirements for small, low power terminals and the limited availability of radio frequency spectrum. In addition, the use of low gain antennas in many mobile communications systems leads to multipath channels that require more complex modulation and coding schemes.

Recently, ITR worked on a range of projects addressing the need for high speed digital communications systems. These include free space optical and hybrid radio frequency plus free space optical links, short range gigabit wireless networks in the millimetre band and a gigabit earth station demodulator for remote sensing satellites.

PhD student Afsana Khatoon working on the Free Space Optical project



Earth Resource Satellite Demodulator

Flexible networks

Communications and sensor networks are becoming ubiquitous, demanding versatile and flexible communications technologies to underpin commercial, defence and specialised applications such as:

- Voice communications
- Data transfer and internet browsing
- Remote sensing
- Defence communications and surveillance
- Emergency services deployment
- Network security.

The overarching purpose of flexible networks is to deliver seamless interconnectivity for the user, and simple, scalable and sustainable networks.

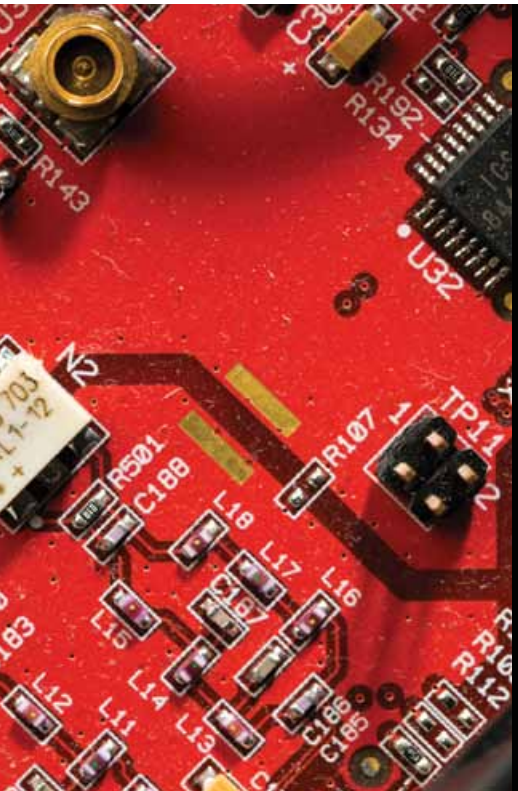
The flexible networks research area draws on research and engineering expertise in emerging wireless standards, system analysis and simulation, information theory, communication theory, signal processing, protocol design and optimisation, and software and firmware implementation. Research, development and commercial projects in this area include:

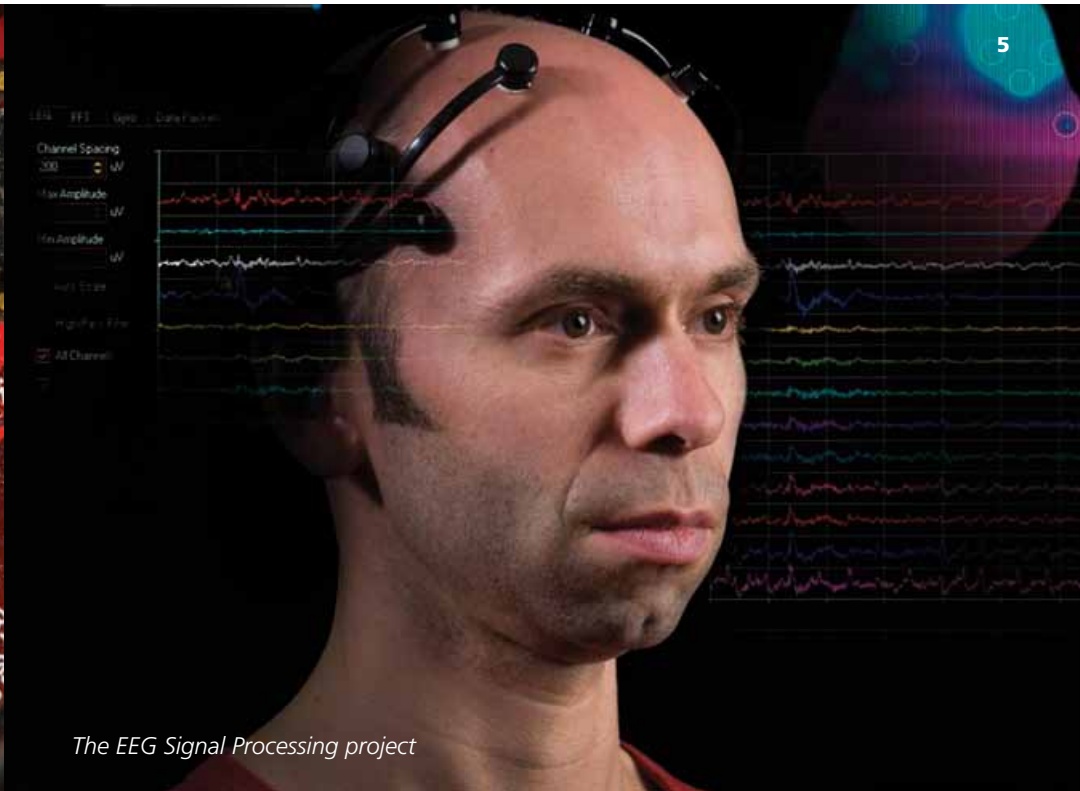
- Ad-hoc and mesh networks
- Hybrid fixed and mobile wireless, satellite and wireline networks
- Cooperative communications
- Vehicle-to-vehicle, dedicated short range communications
- Routing and security using network coding
- Cross-layer optimisation
- Power efficient algorithms and architectures
- Flexible and reconfigurable radio implementations
- Software defined radio.

Computational and Theoretical Neuroscience

The Computational and Theoretical Neuroscience Laboratory works collaboratively with experimental neuroscientists and biologists around the world. The Laboratory provides expertise in mathematical modelling, signal processing and computational techniques to fundamental and applied scientific and medical research. Its secondary focus is working with engineers and mathematicians to develop associated research that is inspired by these projects.

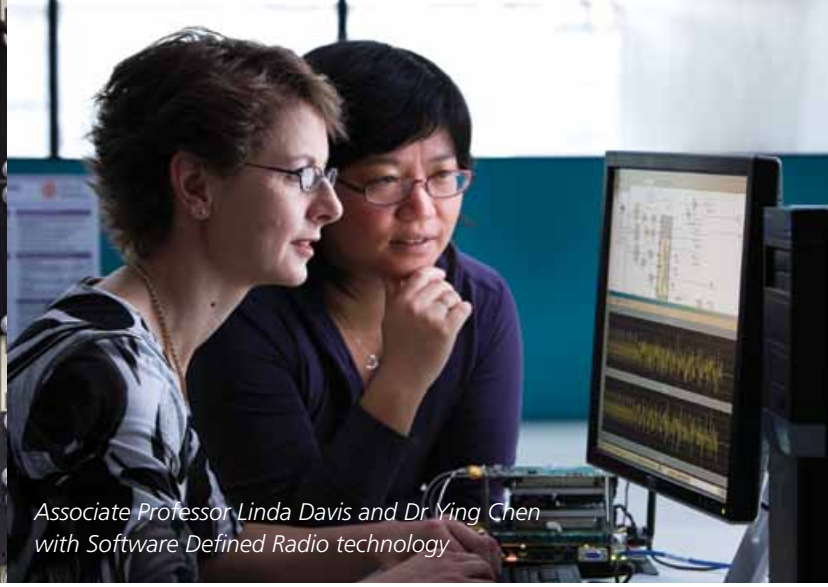
A particular emphasis is on reverse engineering the biophysical mechanisms exploited by neurons and networks of neurons to "communicate" with each other, and perform computations. The mathematical and engineering expertise of staff at ITR provides an environment conducive to new ideas and techniques for investigating hypotheses about intra-organism communications using the most appropriate tools and methods.





The EEG Signal Processing project

Multi-user detection (MUD)



Associate Professor Linda Davis and Dr Ying Chen with Software Defined Radio technology

Our research showcase

Multi-user detection

Multi-user detection (MUD) offers an effective way to mitigate multiple access interference degradation in wireless communications systems. It introduces a means of estimating and removing interference from unwanted signals at the receiver. The reduced interference leads to an increase in capacity for the system, as well as alleviating the near-far problem, since strong user interference can be removed from the weaker user signals.

ITR has been developing its own intellectual property in the MUD space by extending the current libraries in MATLAB, C and VHDL programming languages with scores of basic MUD modules. This allows ITR to quickly customise various blocks according to the specific customer needs and speed up the delivery time of a new proof of concept product. The flexible MATLAB framework enables quick waveform optimisation function of system traffic constraints for both civil and military environments in particular.

Software defined radio

In the competition to provide higher speed, better quality and more secure wireless communications to the community, manufacturers are rushing to evolve their products with up-to-date research outputs. The conventional circuits design technology however have meant a long design circle and a short product life circle, leaving many out-of-date electronics wastes behind each technology evolution.

A reusable and reconfigurable software defined radio platform equipped with fast programmable devices can provide a longer product life circle. In addition, a new algorithm for hardware design methodology has been developed, significantly shortening the time required to transfer research to real world products.

ITR is applying the new methodology to software defined radio platforms to deliver low cost, flexible and quick solutions for satellite, military and general telecommunications research groups and industry partners.

To build a system that can be easily reconfigured as wireless broadband modem, mobile, GPS, satellite modem or military communications systems with the latest technology, Associate Professor Linda Davis and her team have been exploring the combination of the new methodology to the software defined radio platform. This software defined radio platform with fast prototype technology is constructing the path to a more flexible, cheaper and greener telecommunications system.

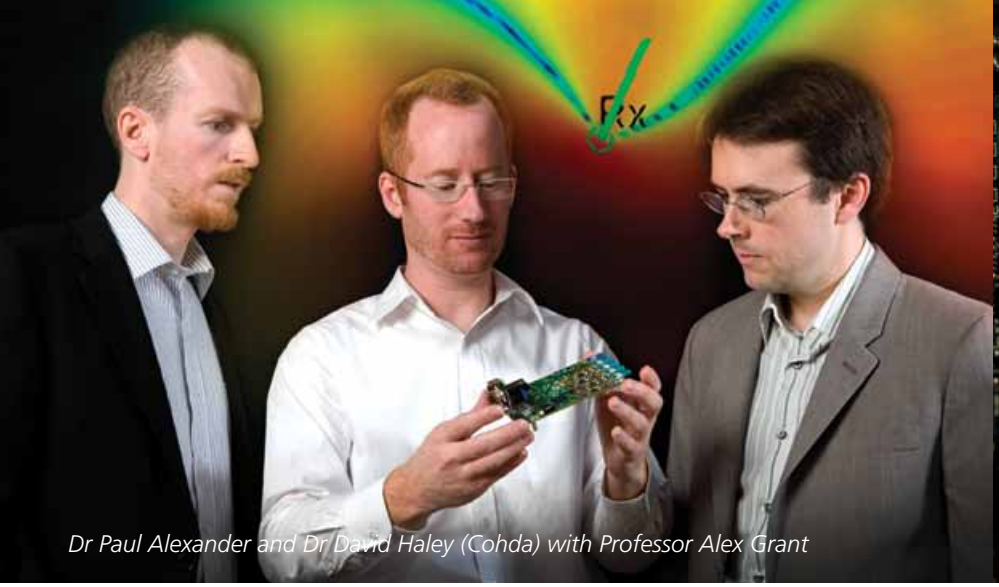
Cochlear implant enhancement

Cochlear implants are surgically implanted biomedical prosthetics that can restore hearing to the profoundly deaf. They mimic the way that normal hearing functions, via a microphone that links to an array of electrodes implanted in the inner ear. Electrical current produced by the electrodes evokes electrical activity in the auditory nerve, and conveys information to the brain, where it is interpreted as sounds.

An unresolved problem in the design of cochlear implants is how many electrodes achieve best hearing performance in patients. It is efficient to avoid using more electrodes if doing so does not provide improved hearing. Whether an improvement can be gained by inclusion of more electrodes depends crucially on physical properties such as distance of the electrode array from the auditory nerve, and the way current spreads from the electrodes.

In collaboration with the University of Melbourne, ITR has developed an information-theoretic approach for predicting the optimal number of electrodes as the distance from the electrode array to the auditory nerve varies. The approach is based on mathematical models of the cochlea and electrode current spread, combined with characterisation of the auditory nerve as a communication channel.

Future technologies may allow the electrode array to be placed closer to the nerve, and the research predicts that this would allow more electrodes, smaller currents and the transmission of more detailed information about sounds to the auditory nerve.



Dr Paul Alexander and Dr David Haley (Cohda) with Professor Alex Grant


ERSDEM3

Our collaborative and commercial showcase

Iterative Connections

Iterative Connections, an ITR spin-off company, was born out of research and engineering work performed in the area of turbo coding. The resultant technology S-TEC™ not only offers superior error performance, but also turbo encryption for added security. S-TEC™ is now successfully being licensed to overseas organisations choosing to use this leading edge technology to enhance their satellite products' performance and competitiveness.

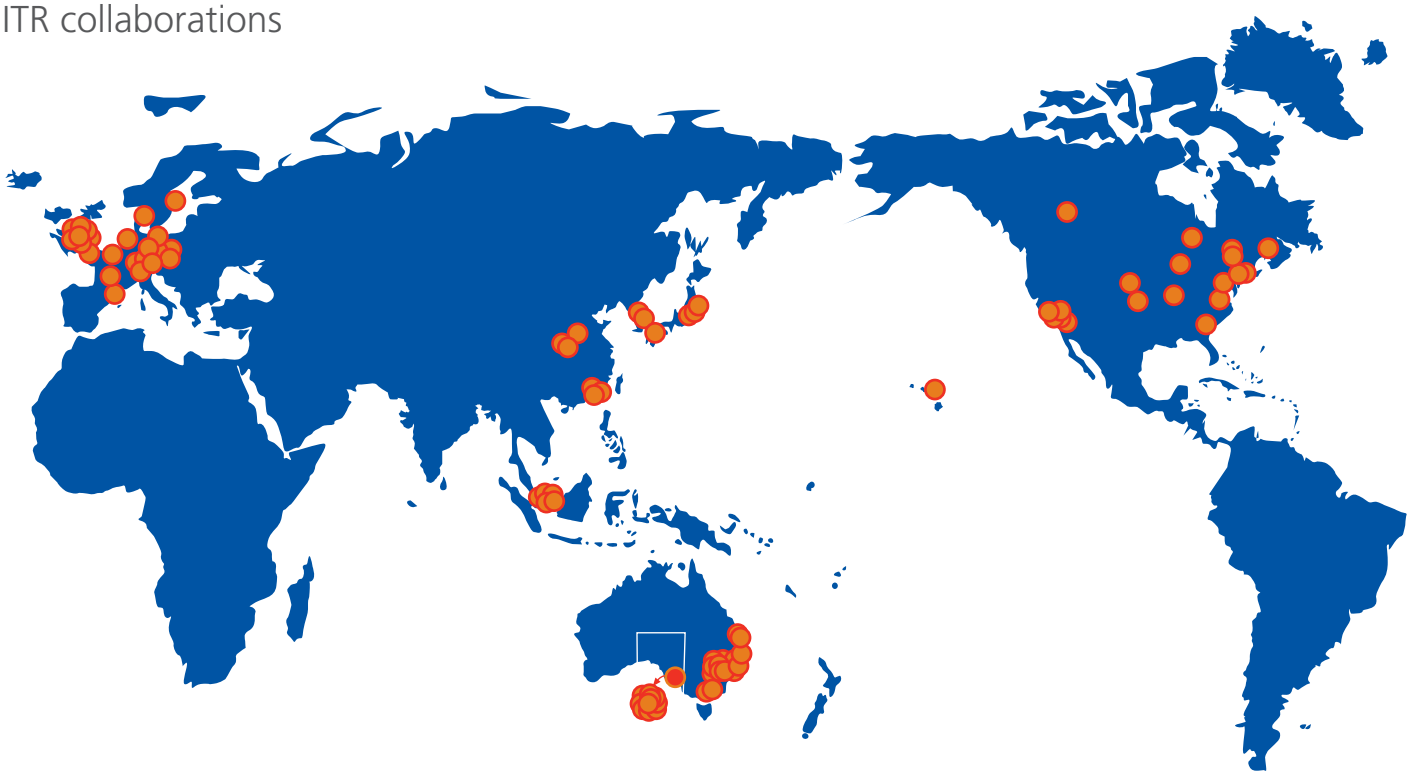
Cohda Wireless

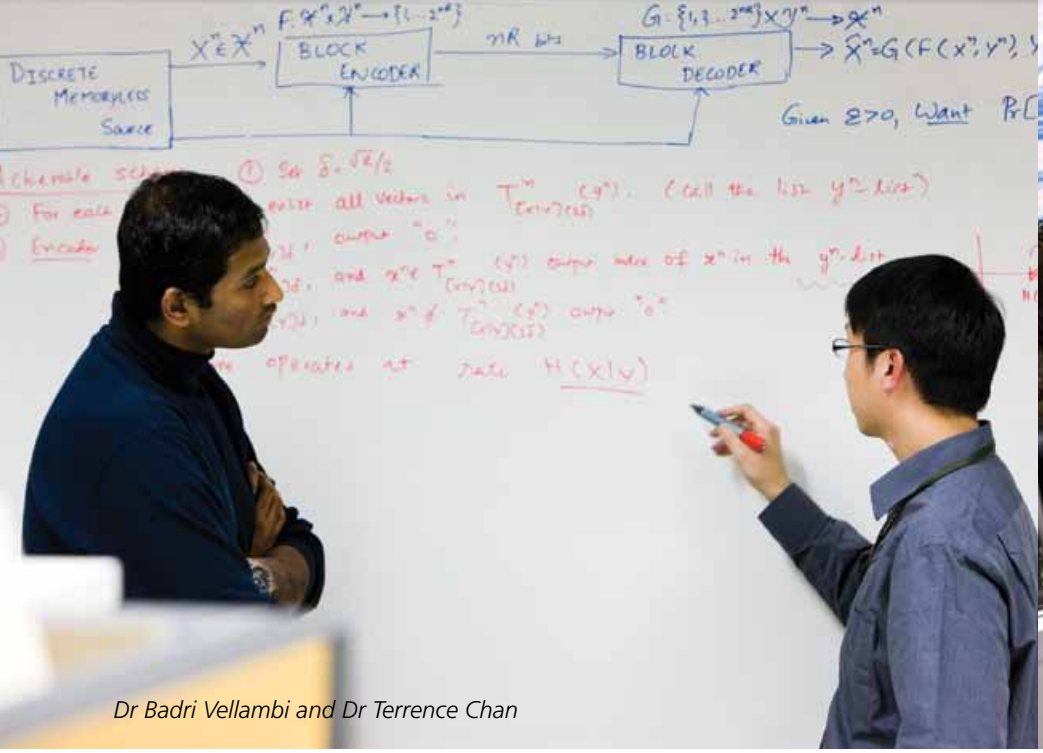
Cohda Wireless used ITR developed signal processing techniques as the basis for successful start up in 2003. It is today developing technology that enhances mobile broadband wireless performance via advanced digital signal processing technology. This young and dynamic company maintains strong links to ITR and UniSA, and stands to make a real difference in the area of efficient, reliable mobile broadband communications.

High rate satellite demodulator

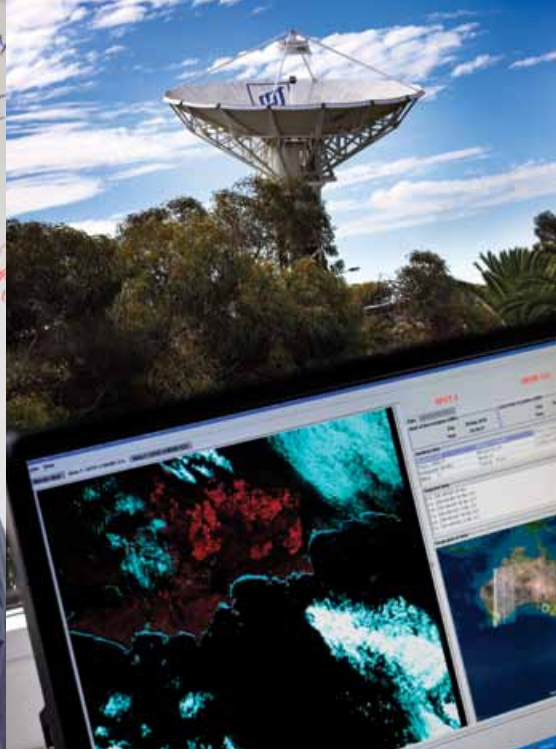
ITR has maintained strength in signal processing developments that have been applied to the area of satellite modems. For over 15 years this work has included the earth resource satellite demodulator (ERSDEM) market, and ITR has teamed with Netherlands based Satellite Services BV (SSBV) to expand their product range to include high speed earth resource satellite receivers. The development with SSBV has been so successful that a third generation product ERSDEM-3 has been developed, capable of simultaneous multichannel reception and data rates up to 1 Gbit/s. The product is currently being finalised ready for sale.

ITR collaborations





Dr Badri Vellambi and Dr Terrence Chan



Our research achievements

ITR combines teams of researchers, engineers and managers to provide a range of services and outcomes that meet the needs of industry, government and academic stakeholders.

ITR helps to solve problems through a variety of methods, ranging from the use of advanced mathematical techniques and analysis, through to simulation, proof of concept demonstration, and ultimately to product and service realisation.

We have a long history of working closely with industry to provide leading edge solutions. Examples include:

- Contribution to development of Inmarsat services, including C, D, M and BGAN
- World first commercial satellite implementation of turbo codes
- Bandwidth efficient microwave modems
- Commercial implementation of 1 Gbit/s, multi-channel satellite demodulator
- On-board satellite communications payload development.

Our experience extends to commercial spin-off companies. These include Iterative Connections who provide high bandwidth efficiency error correction technology, and Cohda Wireless who have successfully developed very robust modem technology with primary application to mobile vehicle-to-vehicle and vehicle-to-infrastructure applications.

PhD student Vince Wang, Professor Alex Grant and Dr Lin Lu

Engage with us

Working with ITR

ITR have successfully worked with industry and government for over 20 years and understand what is important to business success.

There are a number of ways that your organisation can engage with us. This can be through consultancy, collaborative or contract research agreements customised to the particular program of work. We can also work with you to help assess whether leveraging government funding may be possible. In each case intellectual property ownership and use are agreed to ensure all your needs are met.

Our commercialisation and product success

Through our history of collaborative projects with industry, ITR has produced a number of outcomes that have been taken up by industry. These include software, firmware and hardware, as well as access to patent outcomes and other intellectual property.

There are a number of ways your organisation can work with ITR to achieve commercialisation success, ranging from ITR taking the lead on project commercialisation with UniSA's ITEK Pty Ltd, to your company taking the lead, given that you may have extensive experience or a preference to do so. We have worked with several models in the past and would be happy to discuss them with you.

Our facilities

ITR has laboratory facilities incorporating significant computing power for simulation work, as well as general development tools and test equipment. In addition we have the following facilities:

- **Advanced Prototyping Laboratory:** This enables rapid transition from the development of theoretical and algorithmic outcomes to proof of concept demonstration using advanced software tools and hardware development platforms
- **South Australian Networking Laboratory (SANLAB):** A South Australian Government joint initiative with the University of Adelaide working in the area of mobile ad-hoc networks. ITR's principal focus is in the area of software defined radio
- **Satellite Ground Stations:** ITR has developed and commercially operates two satellite facilities – a 6.8m steerable X-band receive antenna and a 3.0m steerable S-band transmit/receive system

Our people

ITR is able to construct expert teams to provide solutions and advice. Our staff comprise a strong mix of researchers, engineers and managers who have experience working collaboratively with national and international organisations. It is this diversity in expertise that allows ITR to put together a team that directly matches the needs of our client – every step of the way.

ITR staff and PhD students

Our education excellence

Graduates of ITR have launched successful careers across the globe in industry and academia. Being a part of the largest university based telecommunications research centre in Australia enables our students to work on solving some of the most exciting and challenging issues facing modern communications.

Based in Adelaide, you'll be immersed in a vibrant international research community. You will automatically be part of a global network of academic, industry and commercial partners at the forefront of the telecommunications field.

When you graduate, you'll be equipped with the knowledge, experience and connections to work for the world's best companies and organisations in telecommunications.

A research degree at ITR can also continue your journey into academia. Whether you are looking to stay local or go global, there are opportunities to pursue post-doctoral fellowships, and inspire the next generation of communications specialists.

ITR education advantages

Our experience: We work in collaboration with authorities in the telecommunications research and technology field.

Our facilities: We have modern telecommunications laboratories, with advanced equipment and facilities.

Our global perspective: We collaborate with researchers around the world and students are encouraged to undertake part of their candidature overseas at universities where ITR has established links.

Our reputation: ITR graduates are in demand in Australia and overseas. Join an institute internationally recognised for its research achievements and education excellence.

Our links and partnerships: Researchers work closely with industry, so students have the opportunity to promote their research and interact closely with industry partners.

Our support: Students have access to tax-free scholarships and top-up grants. We also offer prospective postgraduate candidates internship and work experience opportunities, providing a unique opportunity to get hands-on experience.

Our success: Our award winning Institute has produced graduates that have founded technology companies, established careers with global organisations including Cisco and Inmarsat, and progressed their academic careers with some of the world's most reputable universities. ITR graduates are high achievers and have won several prestigious awards including Young Tall Poppy, Young Entrepreneur of the Year, and Engineer of the Year. The Institute fosters a collaborative and multidisciplinary environment for students, with a focus on delivering results for the real world.

"Cohda is now a global market leader in vehicular broadband communications. The strength of our ongoing relationship with ITR is an important part in maintaining this leadership – through effective R&D capability."

Peter Harris, Chief Operating Officer, Cohda Wireless

"The most important advantage for me studying at ITR was the enthusiasm, encouragement and support provided by supervising staff."

Peter Shoubridge, Research Leader, Defence Science Technology Organisation

"The ITR team working on the Theatre Broadcast System were outstanding. They demonstrated professionalism, commitment and most importantly flexibility as the need to meet the needs of deployed forces grew. From a contractual basis, they not only met but exceeded the requirements under the contract."

Gary Moran, formerly Department of Defence

"I have been attracted to ITR because of its international reputation in research and teaching excellence. I like the friendly team and supported supervision in the Institute which provides motivation and encouragement for continuous learning."

Rajan Kadel, ITR PhD student

"As Australia develops a national broadband network, ITR has unparalleled opportunity to influence some of the technology and operational decisions which will need to be made over the next 5 years."

Brett Biddington, formerly CISCO

ITR Fast Facts

Director: Professor Alex Grant

Established: 1994

Personnel: 20 researchers, 17+ engineering and technical support

Students: 20+

Annual turnover: Approx A$5m

Facilities: Major facilities at the Mawson Lakes campus include Advanced Prototyping Laboratory, Mobile Ad-hoc Networking Laboratory and satellite ground station facilities

Host to: The Australian Research Council Communications Research Network (ACoRN)

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