ACHIEVEMENTS REPORT 2012-13

COOPERATIVE RESEARCH CENTRE FOR SPATIAL INFORMATION

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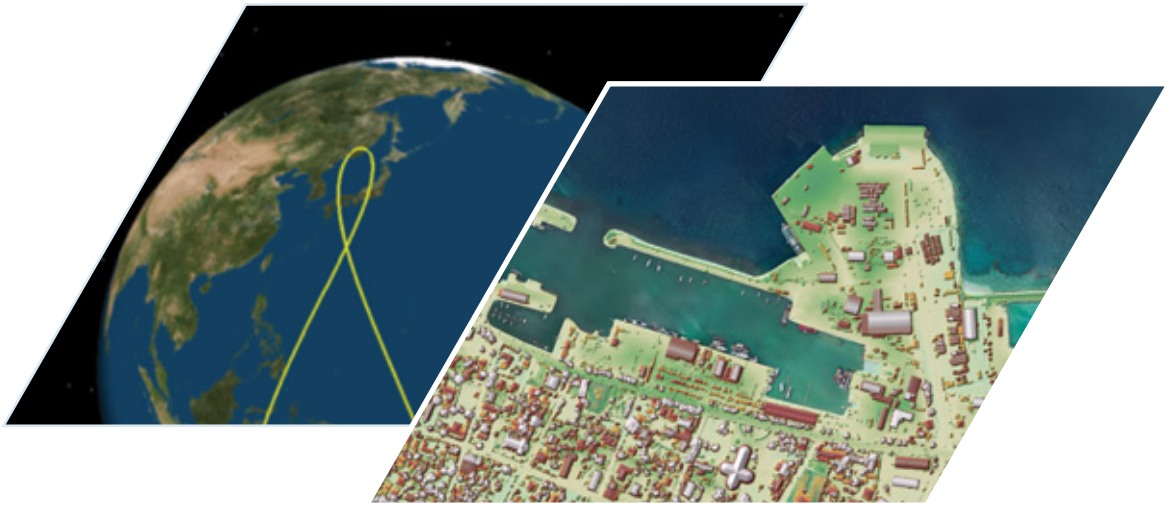


The front cover image is a digital surface model (DSM) generated by airborne LiDAR showing the port area in of Nuku'alofa, Tonga. This aerial fusion of LiDAR data and imagery was captured as part of the Capacity-Building and Coastal-Modelling in the Pacific Region project led by CRCSI on behalf of the Australian Government. For more information see the featured project summary on page 34.

An Australian Government Initiative

Established and supported under the Australian Government's Cooperative Research Centres Program.

CONTENTS

AT A GLANCE

The CRC for Spatial Information is a joint venture of government, academic and private sector organisations established in 2003 under the Australian Government's CRC Program.

The spatial information industry is one of the fastest growing in the world.

The CRCSI undertakes user-led research involving spatial technologies to solve complex problems of national significance for Australia and New Zealand.

The spatial information sciences include positioning (GPS and other Global and Regional Navigation Satellite Systems), remote sensing from satellites, aircraft and ground based vehicles, geographic information systems analyses, and spatial infrastructure strategy.

CRCSI is tackling three major challenges

- Solving the technical challenges that will permit Australia and New Zealand to use all seven of the world's global and regional navigation satellite systems so that we can deliver 2cm positioning accuracy to anybody, anywhere outdoors in real time. This will support the development of Australia's new National Positioning Infrastructure Strategy.
- Developing our research capability to enable Australia and New Zealand to lead the world in automatically generating spatial information products from terrestrial, airborne and satellite sensors, and from existing data sources.
- Identifying and solving the research issues that will enable the operators of the Australia and New Zealand Spatial Marketplace to construct the infrastructure and operate the marketplace. This will enable CRCSI partners to create value-added applications using semantic web technologies.

CRCSI research will lead to major innovation and productivity advances in key industry sectors

- agriculture, natural resources as influenced by climate change
- defence and security
- energy and utilities
- health
- sustainable planning for urban development

CRCSI is committing projected resources (cash and in-kind) of $160m, and growing, over the period 2010-2018.

Our 100 partners include federal and state government agencies, universities, companies and overseas research organisations.

The CRCSI has a vital partnership with over 50 companies through our international SME consortium '43pl'.

75% per cent of our total expenditure is directed to the research program, with the remainder used for business development, the education program and administration.

Our values emphasise collaboration in our relationships, creation of excellence in our research, and being transformational in our impact.

We currently have 88 full time equivalent researchers and staff, drawn from around 300 individuals, and 40 PhD candidates.

EXECUTIVE SUMMARY

The CRCSI highly values our great collaborative network of partners and the role we all play in striving to realise our vision of spatially enabling Australia and New Zealand. We now have vital relationships with 102 partners comprising; companies, government agencies, universities, and research organisations. These relationships epitomise one of the main objectives of the Australian Government's Cooperative Research Centre Program – strength through collaboration.

As the current suite of research programs begin to mature there have been some very pleasing developments. There were two world firsts; integrating GPS and Chinese BeiDou global navigation satellite signals, and demonstrating the use of Japanese QZSS LEX signals in delivering real-time, centimetre accurate, precise positioning. Both help underpin the development of Australia's National Positioning Infrastructure strategy and realising billions of dollars of benefits to the economies of our two nations in the coming years.

Encouraging progress was made in a number of other areas of research including: the development of spatial infrastructures and their contribution towards improving spatial data supply chains in the emerging semantic web environment; improving our understanding of the use of terrestrial and airborne lidar; estimating biomass in agriculture and forests; automation of aircraft flight and scanning missions; developing tools to allow ready access and use of the substantial national health databases; and developing tools at precinct level to improve urban planning and renewal in energy and carbon constrained economies.

Other achievements included: fulfilling leadership roles in several national and international conferences; 90 publications and successfully completing the CRC Program's Performance Review of the CRCSI which undertook a tough examination of all aspects of our operation.

We were delighted that several of our researchers were recognised for their contributions to science through the receipt of prestigious awards. Two of these were recent alumni of the CRCSI. We highly value our role in fostering young scientific talent. We took on another nine postgraduate students this year and now have 43 current or completed postgraduates since 2010.

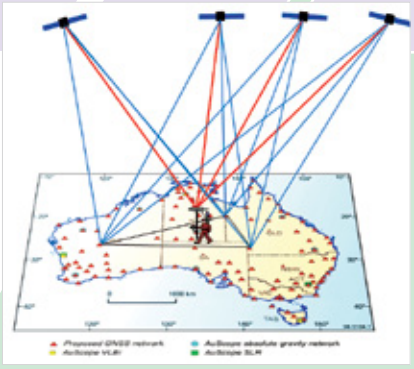
The CRCSI's annual three day conference in Brisbane attracted over 250 delegates and is a yearly highlight for our partners. After 10 years of operation we are eagerly anticipating our first 'overseas' conference to be held in Christchurch, New Zealand in November 2013. This is genuine recognition of the importance that we, the Australia-New Zealand CRCSI, place on our bilateral relationship.

Emeritus Professor Mary O'Kane, Chair, CRCSI Board.

Dr Peter Woodgate, Chief Executive Officer, CRCSI.

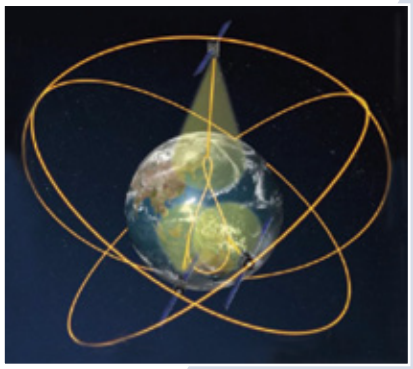
Nathan Eaton (NGIS), Matthew Hammond (NGIS), Laura Gerstenberg (DIICCSRTE) and Nathan Quadros (CRCSI) in Nuku'alofa,Tonga for the training and capacity building scoping mission for the Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP) Coastal Inundation Project. The project's goal is to develop the capacity within Tonga, Papua New Guinea, Vanuatu and Samoa to manage and use LiDAR data.

HIGHLIGHTS 2012-13



3D positioning in obstructed environments enhanced through satellite integration.

A world-first in integrating GPS and Chinese BeiDou satellite signals to demonstrate the benefits in Australia of precise, real-time positioning in obstructed environments. The research proved that the hybrid solution integrating the high elevation BeiDou satellites allows instantaneous precise positioning to be achieved and should find beneficial application in challenging areas such as open-pit mines, urban canyons and high multipath environments where a single constellation solution (e.g. GPS only) would normally fail.

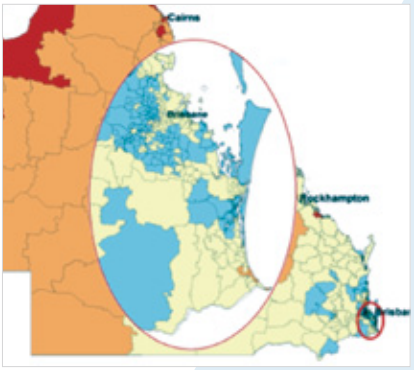


Australian/Japanese collaboration accelerates progress toward development of a national positioning infrastructure.

A further world-first in demonstrating the use of the Japanese QZSS LEX signal in delivering real-time, centimetre accurate precise point positioning (PPP) in Australia. This research involves a collaboration between the CRCSI research team and colleagues at the Japanese Aerospace Exploration Agency (JAXA) and will ultimately lead to an "Australian-made" LEX message for testing. The use of a satellite based delivery system points towards a strategy for providing a truly national positioning infrastructure, not limited by the vagaries of mobile phone coverage.

Valuable improvements to remote-area powerline inspection planes by CRCSI researchers.

Previously CRCSI researchers reported efficiency gains through improved cornering control of aircraft during power line inspection operations. This year, the same team has delivered a further productivity improvement of up to 20% reduction in flight times through the implementation of intelligent 3D dynamic flight path planning routines. Not only has this ground breaking research delivered multi million dollar operational savings for the project partners, it has importantly secured higher levels of operational safety for the pilots involved.



Spatial awareness can deliver higher rates of cancer survival.

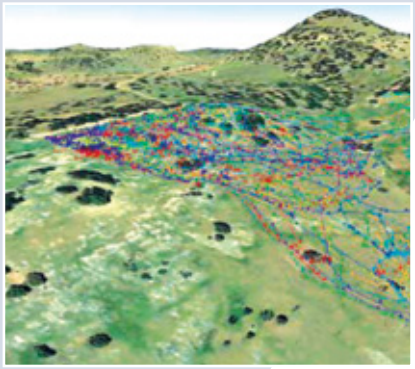
Research in conjunction with Cancer Council Queensland has demonstrated that where a person lives has a measurable impact on whether they will survive a diagnosed cancer. In fact approximately 8% of breast and colorectal cancer deaths within five years of diagnosis in Queensland can be attributed to spatial variation, otherwise known as "spatial inequalities". The research considered the influence of factors such as proximity to treatment services and cancer stage at diagnosis, and found that greater access to breast screening and diagnostic facilities in remote areas can decrease spatial inequalities in cancer survival. This is the first time that such information has been produced in an Australian context. The research findings will equip health agencies to identify and address spatial inequality.

Spatial Support yields improved urban planning decisions.

New spatial software tool, ENVISION, identifies ageing middle suburbs for redevelopment, enabling sustainability 'makeovers' for Australian cities. Available initially through the AURIN portal, this spatial decision support system developed by CRCSI researchers will help governments to minimise urban sprawl and its negative social, economic and environmental effects.

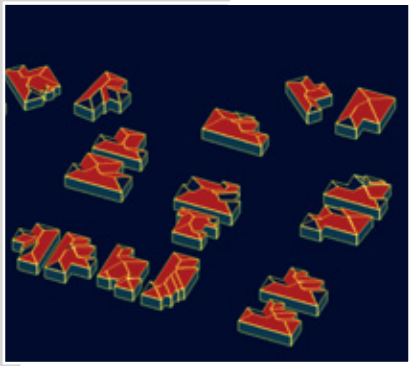
'On-the-fly' fertiliser predictions likely to improve large-scale crop/pasture farming.

CRCSI researchers have used optical and thermal sensors on low-flying aircraft to remotely infer available soil water for plants. This data has the potential to be used to tailor fertiliser rates to the plants' real-time needs, thereby substantially improving crop-yield.



Realisation of a 3D-image enhances automated feature extraction capability.

CRCSI researchers first began working on 3D-imaging in 2010. The research involves the integration of co-registered imagery and range (LiDAR) data to facilitate new automated feature extraction techniques to deliver enhanced operational performance and efficiency. This year, CRCSI implemented the theory of Mutual Information drawn from health imaging, and new algorithms for automated building extraction and roof modelling have been developed and shown to perform to high levels of accuracy.



CRCSI researchers win numerous awards for excellence.

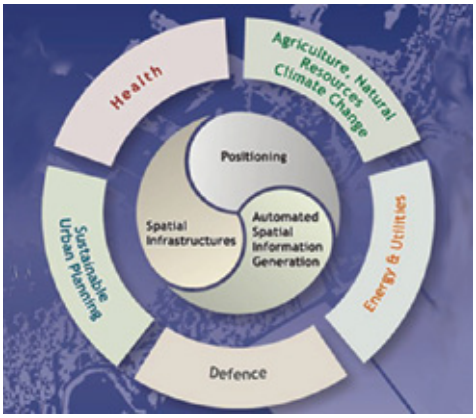
A range of institutions in the field awarded CRCSI researchers of all levels, from Professors to Early Career Researchers and postgraduates, for their outstanding contributions. Awards were given to CRCSI researchers for a variety of achievements, from 'professional of the year' accolades, to project-specific technology and innovation awards.

STRATEGIC PLAN

Our strategic plan sets out the key objectives of the CRCSI:

The Vision

The CRCSI will be widely recognised for its high impact, collaborative research that leads to accelerated industry growth, improved social wellbeing and a more sustainable environment.



Structure of the CRCSI Research Program. The three core research programs are shown in the centre, and the five end-user applications programs are shown around the outside.

Strategic Objectives

Precise Positioning Program

To conduct research that solves the signal processing and economic impediments to the creation of a sparse, continental-scale, precise positioning multi-GNSS network operating at 2cm (x and y) accuracy.

Automated Generation of Spatial Information Products Program

To develop the research capability to enable CRCSI and its partners to become Australia's leading centre for automated processing of information from terrestrial, airborne and satellite platforms and from existing data sources.

Infrastructure for an Australia New Zealand Spatial Marketplace Program

To identify and solve the research issues that will enable the operators of the Australia and New Zealand Spatial Marketplace to construct the infrastructure, operate the marketplace and enable CRCSI partners to create value-added applications with new technologies.

Applications Program

To include but not be limited to the realisation of high impact use of the CRCSI's research in the following areas: Agriculture and Natural Resources affected by Climate Change, through the creation of a biomass and carbon monitoring system for high resolution and high frequency application on farms and through improved environmental monitoring; Defence, by adapting the emerging capabilities of CRCSI's research portfolio; Energy Utilities, to enable remote monitoring of the condition of built assets in near real time; Health, by helping agencies to spatially enable their clinical databases; and Urban development, to build new tools, paradigms and theories including the agglomeration economy and greyfield regeneration to support sustainable urban development.

Education Program

By 2012 the CRCSI will have a plan to improve the skilled capability of the Australian and New Zealand workforces by working with the education providers. As a priority by 2018 the CRCSI will have graduated at least 50 PhDs with its university partners.

Industry Development and Sustainability Program

To establish a program of assistance for its partners, in particular 43pl, that helps them find ways to develop and exploit CRCSI IP, and to establish a program for 43pl members in particular and the industry generally that helps them improve the management of their internal innovation and R&D programs. These programs seek to encourage investment in R&D by spatial businesses.

Commissioned Research

Commissioned research is expected to generate an additional $10M of activity in the CRCSI (from January 2010) tackling complex research needs involving multiple partners from both the public and the private sectors. Initially, most of this research will be taken on around the existing core expertise. In time this will grow into new areas of expertise.

GOVERNANCE AND MANAGEMENT

The CRCSI is an unincorporated joint venture (UJV) governed, managed and operated by a single unlisted public company limited by guarantee, Spatial Information Systems Research Limited (SISR), which is wholly owned by the UJV. SISR acts as trustee of the CRCSI Intellectual Property, employs the management staff, undertakes contract research work and otherwise manages the Centre's operations.

The Board of SISR is also the Board of the CRCSI UJV. Seven of our major partners have chosen to be members. They are 43pl, Curtin University, the Department of Environment and Primary Industries (VIC), Land and Property Information (NSW), Landgate (WA), Queensland University of Technology, and the University of New England.

There are 74 formal partners in the CRCSI from the government, private and research (university) sectors with a further 28 organisations committed through project agreements or letters. Partners have been formed into three Colleges, one representing each of these three sectors; 43pl (with 47 SMEs), the Research and Education College (primarily universities), and the Government Agencies College managed by ANZLIC (the Australia New Zealand Land Information Council made up of government agencies at Federal, State and Territory levels). The Colleges help represent the views of their respective members especially in the formation of policy, the development of strategy, nominations of candidate directors to the Board and the admittance of new participants. They also provide a vital mechanism for two-way feedback and communication.

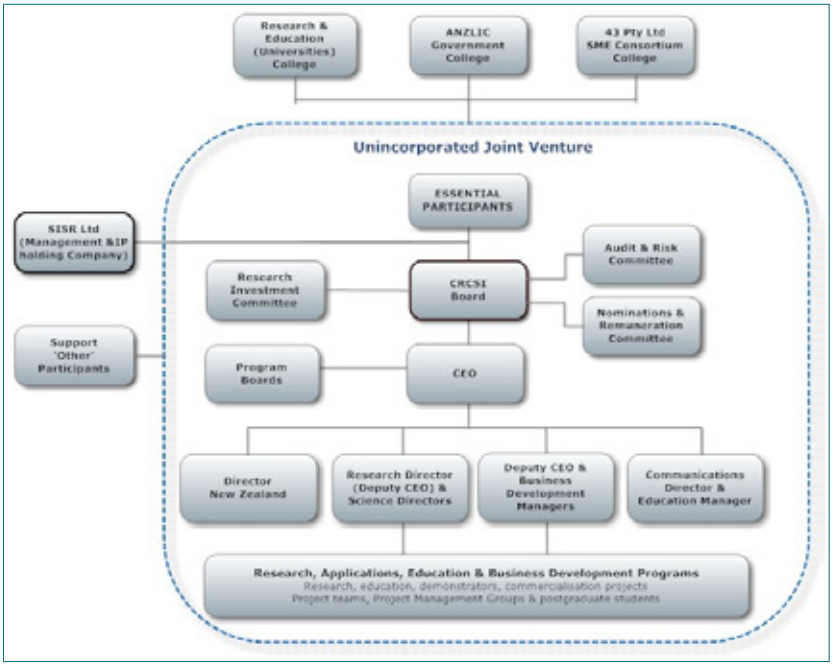
The seven-member Board is responsible for the governance and operations of the CRCSI and SISR. The Board has adopted formal protocols detailing its functions and responsibilities. These are reviewed annually.

While the Board has overall control of the CRCSI, it has delegated a range of its powers, duties and responsibilities to its committees and executive management team.

The Board is advised by the Research Investment Committee, the Audit & Risk Committee, the Nominations and Remuneration Committee and Program Boards for most of the CRCSI's research and applications programs.

Management comprises an Executive and support staff, as well as Program Science Directors, Program Managers, and Project Leaders. Program Boards are program-wide panels tasked with the responsibility of reviewing the strategic direction of the research programs and making recommendations to the CRCSI Board with regard to the continuation, expansion, change in direction or termination of projects in their program. These Boards are chaired by a lead end-user and meet several times a year.

Governance Structure of CRCSI

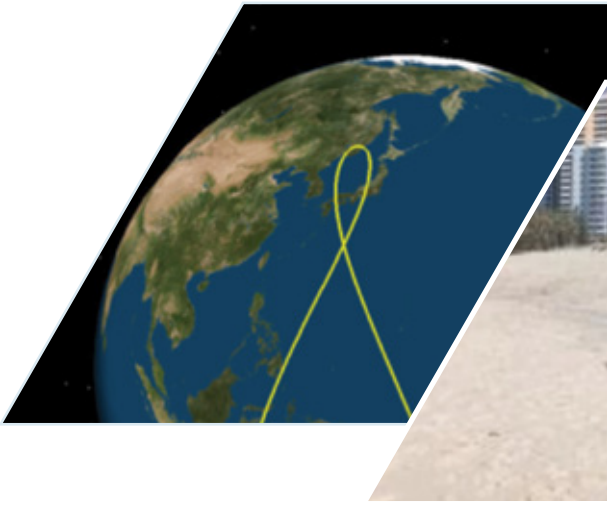


POSITIONING PROGRAM

The Positioning Program is structured around the delivery of the Analysis Centre Software (ACS), which will combine research project outputs into a unified software platform for utilisation by partners. The ACS will optimally process multi-GNSS data streams to support the Program's vision of "instantaneous GNSS/RNSS positioning, anywhere, anytime, with the highest possible accuracy and the highest possible integrity" to be realised through the National Positioning Infrastructure (NPI). A second key deliverable for the Program, likewise critical to realising the NPI, will be the design of a dynamic reference frame for positioning in Australia and New Zealand. Partners have recognised the need for a new approach to reference frame definition necessitated by the requirement to support ubiquitous, precise positioning across a growing user community.

Professor Peter Teunissen, Science Director.

The program has established a high profile both nationally and internationally with researchers actively participating in major conferences and scientific working groups as well as providing invited and keynote presentations. Visiting researchers from China and Europe have been hosted by the program and have made notable contributions to the research activities. The program produced two book chapters, eight refereed journal papers and eight refereed conference papers in 2012-13. The Science Director for the program is Professor Peter Teunissen, an ARC Federation Fellow at Curtin University and one of the world's most highly-regarded researchers in this area of science. The Chair of the Program Board is Dr Chris Pigram, CEO of Geoscience Australia, one of Australia's most senior science policy makers in this area.



QZSS has an asymmetric orbit in the shape of a 'figure 8' ©JAXA

PROJECTS

Title, Lead Researcher	Partners
New Carrier-Phase Processing Strategies for Achieving Precise and Reliable Multi-Satellite, Multi-Frequency GNSS/RNSS Positioning in Australia – Prof Peter Teunissen (Curtin University)	Delft University of Technology, University of New South Wales, RMIT University, Queensland University of Technology, Geoscience Australia, Curtin University, Septentrio, AAM Group, Landgate, GP Sat Systems, Omnistar, Leica Geosystems
Next Generation Australian and New Zealand Datum – Prof Chris Rizos (University of New South Wales)	Land Information (New Zealand), Department of Environment and Resource Management (QLD), University of New South Wales, Department of Environment and Primary Industries (VIC), Land and Property Information (NSW), Landgate, Geoscience Australia
Regionally Enhanced Orbits and Clocks to Support Multi-GNSS Real-Time Positioning – Prof Yanming Feng (Queensland University of Technology)	Wuhan University, Queensland University of Technology, AAM Group, Landgate, Leica Geosystems, Department of Environment and Resource Management (QLD), Sinclair Knight Merz, Ergon Energy Corporation, Department of Environment and Primary Industries (VIC), Fugro Satellite Positioning
GNSS Measurement and Quality Control: Initiating the development of a test track for positioning system validation and certification – Dr Allison Kealy (University of Melbourne)	University of Melbourne, Department of Environment and Primary Industries (VIC), Geoscience Australia, ThinkSpatial
Spatial Information Applications in Rural Australia Stage 1: Identifying barriers to the adoption of network RTK positioning for controlled traffic farming – Dr Don Yule (CTF Solutions)	Department of Environment and Primary Industries (VIC), Land and Property Information (NSW), Fitzroy Basin Association, CTF Solutions
High-Accuracy Real-time Positioning Utilising the Japanese Quasi-Zenith Satellite System (QZSS) Augmentation System – Dr Suelynn Choy (RMIT University)	RMIT University, Department of Environment and Primary Industries (VIC), Land and Property Information (NSW), Geoscience Australia, University of New South Wales

First live demonstration of the QZSS LEX signal in Australia at the IGNSS Symposium on Surfers Paradise in July 2013. Mr. Kazuhiro Yoshikawa and Ms. Yaka Wakabayashi from JAXA.

HIGH-ACCURACY REAL-TIME POSITIONING UTILISING THE JAPANESE QUASI-ZENITH SATELLITE SYSTEM (QZSS) AUGMENTATION SYSTEM

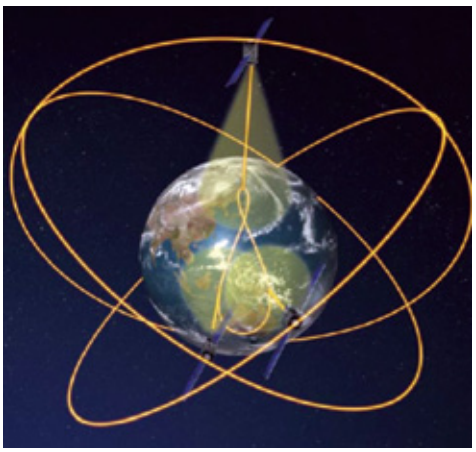
First live demonstration of the QZSS LEX signal in Australia at the IGNSS Symposium on Surfers Paradise. Ms. Yaka Wakabayashi from JAXA performing 'Michibiki-drawing'. 'Michibiki' is the nickname of the first QZSS satellite.

SUMMARY

The Quasi-Zenith Satellite System (QZSS) is a Japanese regional satellite navigation system (RNSS) designed to complement GPS and Galileo by transmitting navigation signals that are both compatible and interoperable with those of both systems. The orbit configuration of QZSS means that satellites are visible at high elevation angles, overcoming the problem of obstruction of low elevation GPS and Galileo satellites in environments that challenge traditional satellite positioning capabilities (such as urban canyons, open-pit mines and forested areas). While built primarily for users in Japan, the QZSS orbit design means the system offers significant advantages to Australian users as well.

In addition to its navigation signals, QZSS will transmit two augmentation signals. The L1-SAIF (Sub-metre Augmentation with Integrity Function) signal provides wide-area differential corrections, allowing sub-metre accuracy, coupled with integrity data for safety of life services. The LEX (L-band Experimental Signal) signal is unique to QZSS and is designed to enable higher accuracy (centimetre- to decimetre-level) positioning for real-time applications.

The aim of this project is to evaluate the capability and feasibility of using the QZSS LEX signal to deliver a high accuracy real-time positioning service to Australian users. For this purpose experimental augmentation information to be broadcast on the QZSS LEX signal will be generated in Australia to test the viability of delivering a real-time Precise Point Positioning (PPP) capability. The research addresses the need for a communications capability that can facilitate high-accuracy national positioning, unconstrained by the present limitations of mobile telecommunications.



Multiple QZSS satellites on the quasi-zenith orbits ©JAXA

Highlights

The project engages researchers from RMIT University and the University of New South Wales and represents a significant collaboration with the Japan Aerospace Exploration Agency (JAXA). As a first step, the research team has evaluated the performance of the LEX signal in Australia (specifically Melbourne) in terms of its availability and the quality of the position solution. Tests conducted in March 2013 used a low accuracy PPP message generated by JAXA. More recent research has evaluated the newer Multi-GNSS Advanced Demonstration tool for Orbit-and-Clock Analysis (MADOCA) message, also generated by JAXA, but based on a denser network of ground tracking stations and improved modelling algorithms for the orbit and clock parameters. All tests have considered both static and kinematic performance.

The March 2013 experiments revealed that the LEX signal is available 60% of the time when the QZSS satellite is above 30° elevation, while there is over 90% availability when the satellite is above 40°. The quality of the PPP solution using the pre-MADOCA LEX message was limited by the lower accuracy of the satellite orbits and clocks, with achievable PPP accuracy in real-time at the decimetre level.

It is expected that the MADOCA message will deliver accuracy improvements to the sub-decimetre level and testing is currently underway to validate this expectation.

Availability limitations currently experienced with the LEX signal should be overcome as the constellation moves to full operational capability (four satellites) by the end of the decade.

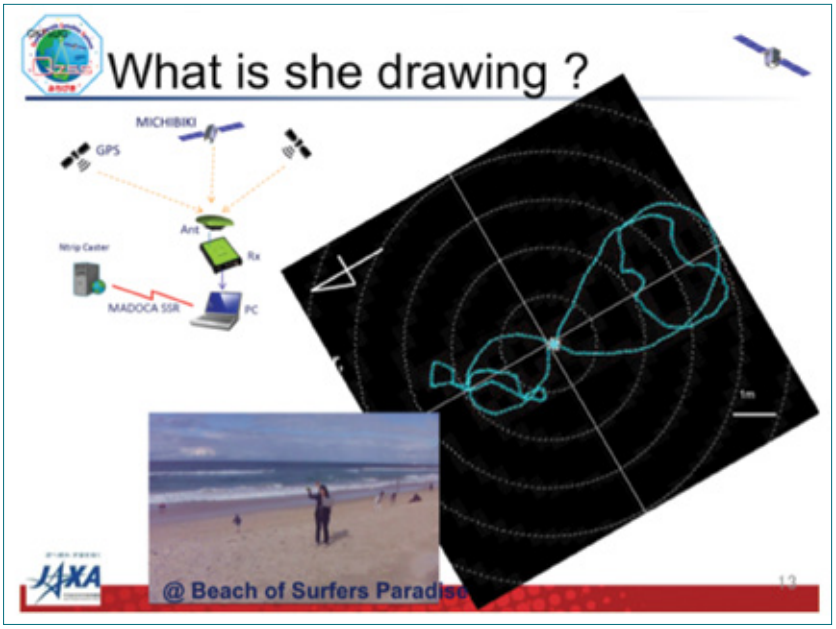
An objective of this project is to design an "Australian-made" LEX message that will support real-time PPP implementation in Australia, as envisaged under the broader objectives of the CRCSI's Positioning Program. The PPP-RTK approach, which lies at the heart of the Program, aims to deliver instantaneous, ambiguity-resolved, centimetre-accurate positioning anywhere, anytime, in support of Australia's vision for a National Positioning Infrastructure (NPI).

The CRCSI team is the first to use and evaluate LEX signal performance in Australia. This has been made possible through a specially designed LEX decoder made available to the project team by JAXA. The collaboration with JAXA will also facilitate the future uploading and subsequent testing of the "Australian-made" LEX message, the creation and testing of which will take place in early 2014.

In partnership with JAXA, CRCSI researchers performed the first live demonstration of the QZSS LEX signal in Australia at the International Global Navigation Satellite Systems Society (IGNSS) Symposium in Surfers Paradise, in July. Conference attendees witnessed LEX-based positioning via a live video stream into the symposium auditorium and a parallel real-time map display of the receiver trajectory. This demonstration was significant in that it showed for the first time in Australia how the QZSS LEX signal could potentially be used as a satellite-based augmentation system in support of precise real-time positioning.

Next Steps

The project is scheduled for completion in at the end of 2014. The primary focus of research in coming months will be to design, generate and upload an "Australia-made" LEX message and then to run a series of trials and experiments to evaluate the downlinked message and its performance in supporting PPP activities in Australia. These elements of the project will require substantial support from JAXA who will facilitate uploading of the test message to the QZSS satellite and its subsequent download for testing purposes. It is expected that a number of issues will arise in the generation and validation of an "Australian-made" LEX message. Perhaps foremost amongst these will be the question of message latency. Unacceptably long delays between generation and delivery of the message to users will devalue its usability. For the purposes of testing, it is planned to use real-time orbit and clock products generated by IGS to create the new message. This will allow the concept to be tested and technical issues to be resolved. Ultimately, however, the plan is to generate the message using regionally-enhanced orbit and clock products derived using outcomes from other CRCSI research activities. The ultimate goal is to enable PPP-RTK, should the LEX signal prove to be an appropriate mechanism to do so.



Live demonstration of the QZSS LEX signal at the IGNSS Symposium showing 'Michibiki-drawing'.

AUTOMATED SPATIAL INFORMATION GENERATION PROGRAM

Professor Clive Fraser, Science Director.

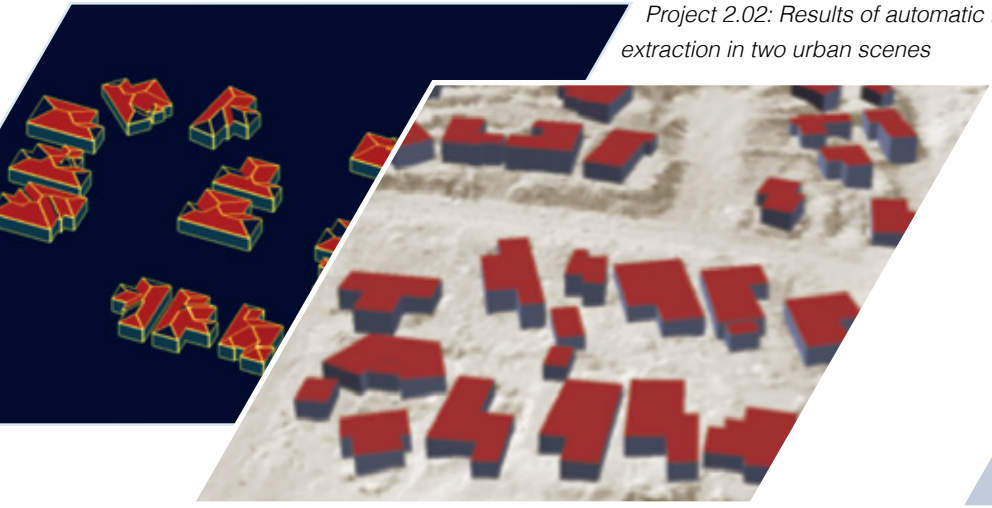
This research program comprises six projects focusing on different aspects of the general research problem of automated feature extraction and 3D object/scene reconstruction and modelling from remote-sensing systems, especially space-borne, aerial and terrestrial imagery, and airborne and terrestrial laser scanners. Two of these projects concentrate on metric quality feature extraction, with one having a terrestrial sensor system focus and the other aimed at satellite and airborne imaging and ranging systems. The third project aims at woody-vegetation classification in Australian forests using advanced remote-sensing technologies. A fourth project focuses on the production of quality assurance software for LiDAR surveys, and a fifth project, funded by the ARC, aims to automate building-change detection and semi automate building-map updates through the use of multispectral imagery and height data. The final project relates to commissioned research in close-range photogrammetry and is directly supported by the Australian Geospatial Organisation.

Developments in feature extraction produced in this Program's research are implemented in software such that they can be tested and evaluated by both industry partners and collaborating research teams. The CRCSI-developed Barista software, which has attracted international commercial usage, provides a useful operational platform for implementing and testing research outputs, thus allowing end-users to engage directly and in a timely fashion with the research activity.

Research excellence is evidenced by the international profile of the research team and the substantial international engagement that occurs through project publications, conferences, scientific exchanges and participation on international review panels. In addition, within the reporting period the six project teams produced seven book chapters, six refereed journal papers, 28 refereed conference papers, and won international awards. The Science Director for this Program is Professor Clive Fraser, a Professorial Fellow at the University of Melbourne and one of Australia's most senior researchers in this area of science, with a highly regarded research reputation internationally.

PROJECTS

Title, Lead Researcher	Partners
Multimodal Data Acquisition and Feature Extraction from Multi-Sensor Terrestrial Mobile Mapping Systems – Prof Geoff West (Curtin University)	Whelans, Curtin University, AAM Group, Landgate, Lester Franks, Vekta, Fugro, Department of Environment and Primary Industries (VIC), Land and Property Information (NSW), Fusion GIS, Geomatic Technologies, Department of Transport (VIC)
Feature Extraction from Multi-Source Airborne and Spaceborne Imaging and Ranging Data – Dr Chunsun Zhang (RMIT University)	University of Melbourne, Landgate, Department of Environment and Resource Management (QLD), Land and Property Information (NSW), Geoscience Australia, Ergon Energy, AAM Group, Geomatic Technologies, Fugro, Sinclair Knight Merz, Vekta, Geoimage, Terranean Mapping Systems
Australian Woody-Vegetation Landscape Feature Generation from Multi-Source Airborne and Spaceborne Imaging and Ranging Data – Dr Andrew Haywood (Department of Environment and Primary Industries, VIC)/ Prof Simon Jones (RMIT University)	Department of Environment and Primary Industries (VIC), RMIT University, Department of Environment and Resource Management (QLD), Department of Trade & Investment, Regional Infrastructure and Services (NSW)
Development of a Standard Software Procedure and Tool to Quality-Assure Elevation Data – Dr Nathan Quadros (CRCSI)	Landgate, Land and Property Information (NSW), Department of Environment and Primary Industries (VIC), Department of Environment and Resource Management (QLD), Geoscience Australia
Building-Change Detection Using Imagery and Height Data – Dr Mohammad Awrangjab (Monash University)	Monash University



Project 2.02: Results of automatic building extraction in two urban scenes

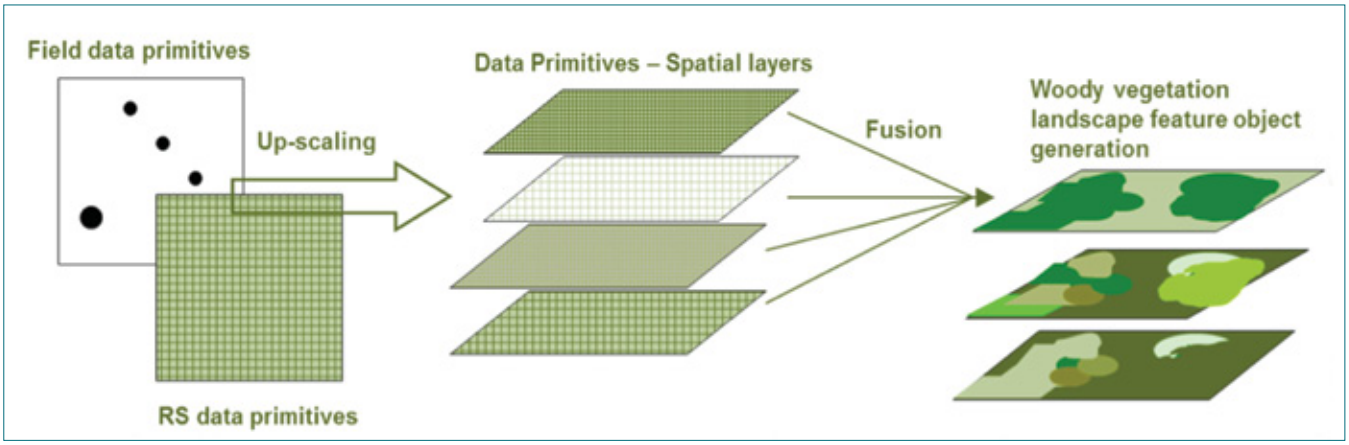
AUSTRALIAN WOODY-VEGETATION LANDSCAPE FEATURE GENERATION FROM MULTI-SOURCE AIRBORNE AND SPACE-BORNE IMAGING AND RANGING DATA

SUMMARY

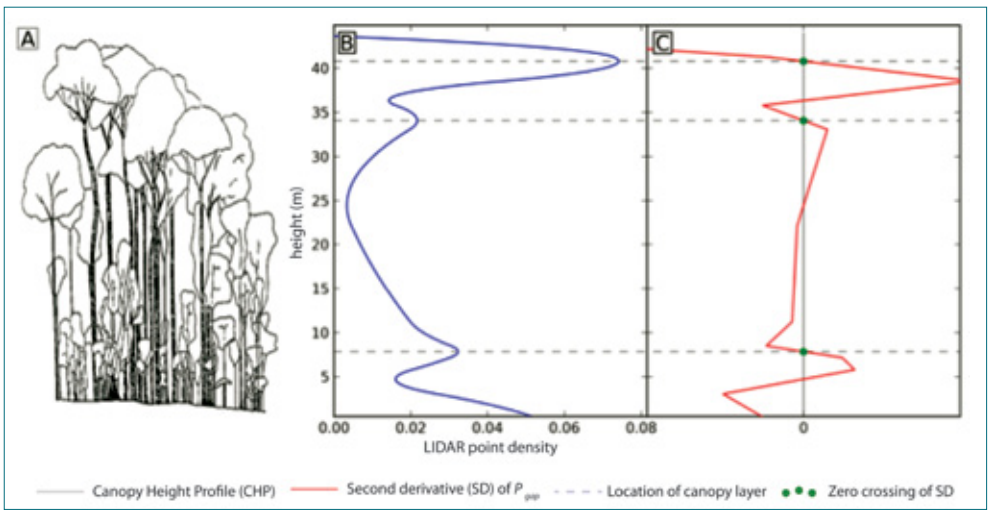
This project will produce computational tools and field and data analysis procedures, and will develop guidelines to aide technical staff (including remote-sensing and GIS-analysts and spatial data managers) from Australian government land management agencies and other organisations that are required to undertake sustainable land management activities in woody-vegetation environments.

The ultimate outputs of the research will be tools and procedures with which to autogenerate landscape-level woody-vegetation features (such as spatial layers) from field- and remote-sensing scaled-up woody-vegetation data primitives. The generated landscape features will be designed to be highly correlated with end-user land manager landscape metrics.

The landscape feature layers will be generated by end-users such as government land agencies, and will be attributed and combined to produce woody-vegetation metrics (for markers such as forest canopy health, above and below ground carbon, and flora diversity). In turn, these metrics can be assessed to inform decision-making around sustainable land management, in areas such as carbon accounting, biodiversity and ecosystem health and fire management.



Project objective schema consisting of up-scaling data primitives from ground to landscape layers to be after combined into landscape features.



Forest vertical profile representation. A. Sample forest, B. Density of points recorded per height describing how dense the vegetation is from ground to top-of-canopy (i.e. vertical profile), C. Second derivative used to determine the height corresponding to each peak (i.e. average height of the canopy layers).

Highlights

- Three Victorian reference areas were selected as study sites due to their representativeness of Australian woody-vegetation systems. Passive and active airborne sensors have flown over these areas, acquiring imagery synchronously, while a group of researchers collected structural and biophysical vegetation data on the ground.
- The first project deliverable gives a full account of the selected descriptors of Australian woody vegetation. This deliverable received a high level of acceptance among state and national agencies.
- Novel techniques have been developed to characterise height and canopy vertical profiles using LiDAR imagery. These techniques allow derivation of the number of vegetation layers present and their location within the canopy.

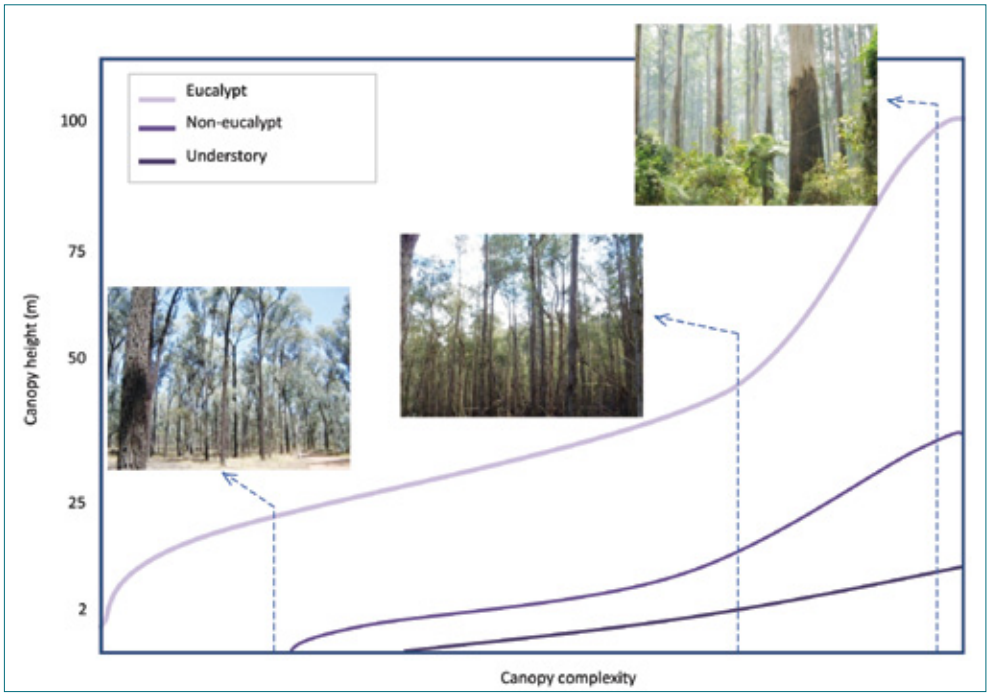
Next Steps

During the final phase, the project team will work on creating automatic tools to derive the selected descriptors at the landscape scale. These tools will be tested in the Victorian study sites as well as in other study sites located in QLD and NSW.

All the tools created are to be used in open-source software to make them completely accessible by the state agency remote-sensing departments.

The woody-vegetation descriptors will be derived at a large scale to obtain patterns or features characterising woody vegetation in large areas.

Project assistant Tapasya Arya measures the fraction of projected canopy foliage using a densitometer along star transects.



Representation of canopy complexity present at the three study sites used for this project: Open woodland with no understorey/mid-storey; Mixed-species foothills forest with medium canopy height and complex mid and understorey; and tall closed canopy with very tall canopy and high complexity of mid and understorey.

SPATIAL INFRASTRUCTURES PROGRAM

Following the release of the Spatial Infrastuctures Program Research Strategy (SIPRS) in 2012, the Program team travelled extensively and continued to workshop with stakeholders to develop a common understanding of the required research. The Research Strategy sets out to improve the organisation, access and use of spatial data in Australia and New Zealand. Feedback on the SIPRS, both locally and internationally, has been encouraging.

The main research activities will include Semantic Web (Web 3.0), Artificial Intelligence and Supply Chains, as these areas will allow the capabilities of spatial infrastructures to be taken beyond existing manual methods for providing data, apps and services to more automated methods for dealing with data and processes.

Professor Geoff West, Science Director.

A recently approved Project, "Semantic Web Technologies for Next Generation Spatial Infrastructures", is underway and will cover search-and-discovery and federated data integration, as demanded by end-users. The main aim is to enhance current Spatial Infrastructures by improving the user experience, making many of the operations more seamless and improving access to spatial resources (such as data, applications and services).

A new project titled "Big Data Solutions for Environmental Monitoring" sees the Spatial Infrastructures Program and the Agriculture, Natural Resources, and Climate Change Program joining forces to identify and target the strategic information technology challenges for managing Big Data. At the same time this joint project will enable preparation for the near future, when Australia can expect to receive huge volumes of Earth observation data each day from earth observation satellite systems such as Sentinel-2 and Himawari-8, as well as from commercial suppliers and new satellites. The challenge for the Spatial Infrastructures Program in this context is identifying and exploring methods for automating and optimising data management, querying, analysis and visualisation of these very large, geographically extensive time-series (geo-temporal) datasets to allow them to be exploited by end-users.

Leading on from the earlier Alignment Study (2011-2012), Program 3 is currently focusing on developing a supply chain proposal that will include activities identified within the Research Strategy, namely orchestration of services, crowd-sourcing and licensing. The focus will be on development of tools to automate supply chains and extend the current volunteered geographic information research to integrate into supply chains. The Program produced two refereed conference papers in 2012-13.

PROJECTS

Title, Lead Researcher	Partners
Semantic Web Technologies for Next Generation Spatial Infrastructures – Prof Geoff West (Curtin University)	Department of Environment and Primary Industries (VIC), Curtin University, Landgate, NGIS Australia, Amristar Solutions, PSMA Australia
Unlocking the LANDSAT Archive for Future Challenges – Glenn Frankish (Lockheed Martin)	Lockheed Martin, Geoscience Australia, VPAC, Australian National University
Alignment Analysis of Spatial Data Supply Chains for SDIs – Maurits van der Vlugt (Mercury Project Solutions)	Mercury Project Solutions, Landgate

UNLOCKING THE LANDSAT ARCHIVE FOR FUTURE CHALLENGES

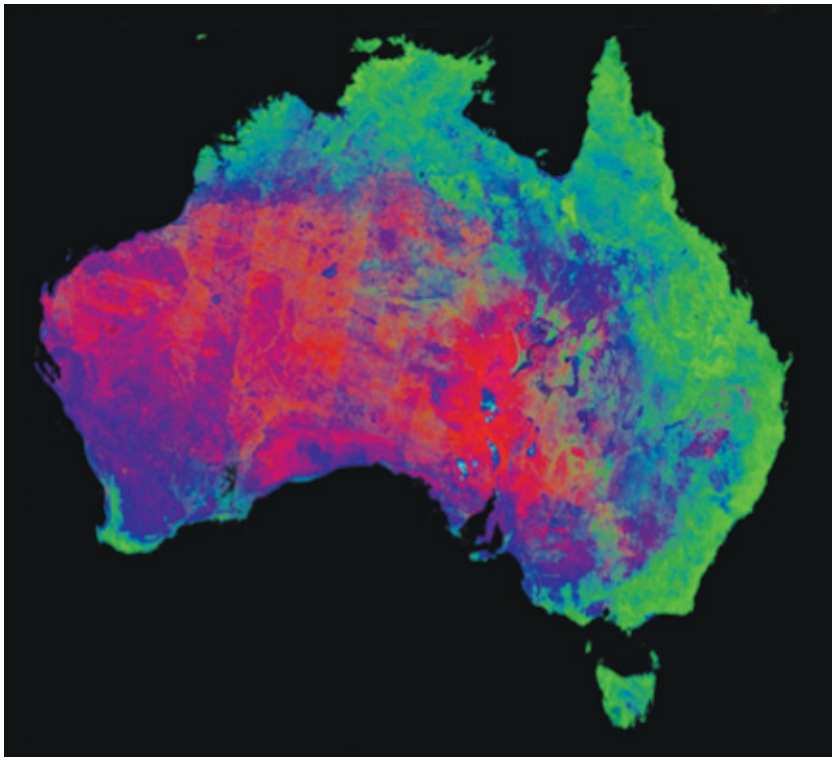
SUMMARY

Unlocking the LANDSAT Archive for Future Challenges (ULAFC) is a Space Science and Innovation project that received $3.5 million in funding through the Commonwealth Australian Space Research Program. It brought together a consortium comprising CRCSI, Geoscience Australia, Victorian Partnership for Advanced Computing (VPAC), Lockheed Martin Australia, and the Australian National University's National Computation Infrastructure (NCI). The fundamental aim of ULAFC was to improve access to Australia's archive of LANDSAT data, and to provide an analysis capability for delivery of environmental information to inform and support government policy. The project aimed to produce the following outcomes

- International standard national infrastructure for delivering Australia's Earth Observation (EO) data
- The delivery of satellite imagery based environmental datasets in time series in a form usable by researchers, policy makers and private sector
- An open standard reference framework for the communication of gridded satellite data products
- An open platform for the development of future satellite processing needs of the partners.

The project drew upon previous CRCSI work in developing a National Nested Grid (NNG) data specification as well as software for storing raster data, the Raster Storage Archive (RSA).

Image courtesy of Geoscience Australia



Highlights

There have been six functional LANDSAT satellites spanning the period from 1972 to the present. With the current LANDSAT 5 and 7 missions, the LANDSAT program constitutes the longest running enterprise for acquisition of imagery from Earth observation satellites. These images are a unique resource for global change research and applications in agriculture, cartography, geology, forestry, regional planning, surveillance, education and national security. Australia has participated in the LANDSAT program since the late 1970s, and has collected a substantial proportion of the data from LANDSAT over our region of the globe. However, the system of processing EO data has previously been time and labour intensive, and made more complex when scientific applications required the combination of data from more than one sensor. The key to addressing the processing bottleneck was a suitable framework with which to process satellite data, remove artefacts and provide national satellite image grids at the resolutions required.

The project successfully established a large-scale data processing and science capability for EO data at NCI and Geoscience Australia,

and has processed over 360TB of data during the project. While the team's focus has been on the recent portions of Australia's LANDSAT holdings, the project has investigated the required methodologies for processing further back in time, and has begun extending the datasets beyond the original scope of the project.

The ULAFC Program developed the processes, the underpinning standards and the infrastructure to standardise the information products from the LANDSAT Archive. As the standardised products are published, managers and scientists working in the environment, agriculture and natural resources domains have access to consistent baseline information of Australia to monitor and predict the impact of natural and man-made changes on the Australian environment as a whole.

The National Nested Grid specifications, on which the Australian Reflectance Grid 25 is based, is a particularly significant achievement as the first Australian standard that allows data from different jurisdictions to be generated/re-sampled to a consistent grid ready for integrated modelling and analysis on a regional and national scale. This work was conducted in conjunction with the Australian and New Zealand Land Information Council (ANZLIC).

The RSA, which is an open-source, low cost, scalable raster data storage software, developed in collaboration between the CRCSI and the ULAFC Program, provides an ideal platform to support both academic and operational management of raster data in resource/environment monitoring, reporting and modelling. This platform is designed on a "Software as a Service" philosophy and built on mainstream open standard-compliant products, and is well suited for use by jurisdictional agencies and collaborating researchers on common eResearch platforms. Victoria's Department of Environment and Primary Industries is currently piloting a version of the RSA with a view of implementing it as a corporate application.

Next Steps

Project partners have a number of next steps.

For Geoscience Australia and NCI

- Processing of data back to 1988, allowing deeper studies over time
- Developing methods to calibrate data from the new LANDSAT-8 Satellite data for the High Performance environment
- Developing a collaborative environment for researchers to access the data
- Assessing the suitability of the ULAFC work as a model for an operational Earth Observation Satellite infrastructure.

For CRCSI

- Integrating ULAFC capabilities with other infrastructures in Australia and New Zealand, to support semantic web-based research into the next generation spatial infrastructure
- Encouraging the use of RSA gridded data-management software (recently published as open-source code) by scientists and spatial data managers/developers
- Ongoing refinement of data guidelines.

For Lockheed Martin

- Ongoing development of spectral science capabilities, machine learning and EO data processing.

For VPAC

- Further utilisation of the RSA solution as a commercial service.

RESEARCH APPLICATIONS PROGRAM

This Program comprises five separate applications areas that build on the capabilities of Programs 1-3 and apply research in chosen sectors.

AGRICULTURE, NATURAL RESOURCES AND CLIMATE CHANGE PROGRAM Much of this Program's research activity – through the "Biomass Business" project – is focused on the estimation of biomass in an agricultural context using terrestrial, airborne and satellite-borne remote-sensing technologies. The intention is to improve the ability of farmers to determine biomass in the landscape for forage availability for grazing stock, and to assist croppers to assess plant requirements for water and nutrients. A third objective is to allow the estimation of standing carbon at farmscape level as an input to a future carbon-trading scheme. The second project tackles the problem of estimating soil moisture and vegetation status from a mix of satellite-borne and airborne radar remote-sensing technologies.

Professor Kim Lowell

Biomass Business engages a number of researchers and partner organisations in Queensland, NSW and WA, and collaborations with NASA are a prominent feature of the project. A total of three refereed journal papers and three papers in refereed conference proceedings have been produced by the research teams in 2012-13.

Professor Kim Lowell, from the University of Melbourne and an internationally recognised biometrics specialist, is the Program's Science Director. The Program Board is chaired by Dr Matt Adams, Manager of Satellite Remote Sensing Services, Landgate (WA).

Part of the eFAS team with one of the ROAMES aircraft (left to right: Duncan Greer, Troy Bruggemann, Jason Ford, Ryan Fechney and George Curran).

DEFENCE PROGRAM This is a different type of Program to the others within CRCSI. Suggestions coming from Defence agency partners for research activities at the time of the bid were subsequently withdrawn due to changing Defence priorities. During 2012-13, Defence agencies (primarily the Australian Geospatial Organisation) were largely content to keep a watching brief on research activities across CRCSI without direct engagement in any major projects. They did, however, continue to directly support a commissioned research project in close-range photogrammetry.

ENERGY PROGRAM This Program is comprised of a single project, focused on the spatial information priorities of electricity distribution companies, in particular Ergon Energy. The research has developed an enhanced flight assist system (eFAS) to deliver substantial efficiency gains in the aerial acquisition of spatial information covering power line assets. The area of application of the technology covers 97% of Queensland and more than one million square kilometres of land and works, where highly detailed data is captured via airborne sensing. Ergon estimates that there have been cost benefits of up to $14M annually from using the Remote Observation Automated Modeling Economic Simulation (ROAMES) technology opposed to more conventional surveying methods.

Mr James Bangay

The Program Director is Mr James Bangay, General Manager at ROAMES and former Director of Strategy at Ergon Energy.

PROJECTS

Title, Lead Researcher	Partners
AGRICULTURE, NATURAL RESOURCE MANAGEMENT & CLIMATE CHANGE	
Biomass Business – Prof David Lamb (University of New England)	Milne Agrigroup, Department of Environment, Climate Change & Water (NSW), University of New England, Sundown Pastoral, Curtin University, AgLab, Twynam Investments, Eco Logical Australia, Landgate, Superair, University of Melbourne, Lockheed Martin, Geoscience Australia, VPAC, Australian National University
Towards Operational Monitoring of Key Climate Parameters from Synthetic Aperture Radar – Prof Kim Lowell (CRCSI)	University of Melbourne
ENERGY & UTILITIES	
Enhanced Flight Assist System for Automated Aerial Survey of Powerline Networks – Dr Jason Ford (Queensland University of Technology)	Ergon Energy, Queensland University of Technology

Professor Clive Sabel

HEALTH PROGRAM This Program involves the development by an interdisciplinary research team of new systems and methodologies for spatially analysing health service datasets. The research extends spatial science and complementary activities encourage end-user engagement across the health sector. The long term objective is for health agencies across Australia and New Zealand to adopt spatial technologies and to incorporate spatial data thus obtained into health service planning and research, which will in turn increase health sector effectiveness and improve quality of life. The program will also expand the spatial health industry and create new skills and services. The past year has seen a growth in partnerships and collaborative research opportunities in the field, including the joint appointment with Curtin University Department of Spatial Science of a Health Research Fellow, Dr Ori Gudes. New research in the field of geocoding started in 2012, and external infrastructure funds were secured to support the spatial data management of core Western Australian health datasets.

Professor Geoff Jacquez

The Science Directors are Professor Clive Sabel from the University of Bristol (UK) and Professor Geoff Jacquez from the State University of New York (USA), with Ms Narelle Mullan from Curtin University as Program Manager. The Program Board is chaired by Professor Tarun Weeramanthri, WA's Chief Health Officer and Executive Director, Public Health and Clinical Services.

Professor Peter Newman

SUSTAINABLE URBAN PLANNING PROGRAM This Program consists of three projects, and aims to facilitate enhanced access to and use of diverse spatial information resources (data and software tools) to support improved professional and community engagement, decision-making and investment decisions in the redevelopment of the middle suburbs of Australia's major cities. The outcome will be a "greening of the greyfields"; in other words, a more sustainable, socially and environmentally acceptable, planned and executed process of redevelopment of the middle suburbs.

The research program is led by two internationally regarded researchers, namely Professor Peter Newman (Curtin University, also a Director of Infrastructure Australia), and Professor Peter Newton (Swinburne University). The Program Board is chaired by Dr Mike Mouritz, (Executive: City Futures at the City of Canning, WA).

In the reporting period, the research teams have produced one book, six book chapters and nine refereed conference papers.

PROJECTS

Title, Lead Researcher	Partners
HEALTH	
Geo-visualisation of Health Information – Prof Geoff West (Curtin University)	Spatial Vision, Telethon Institute for Child Health Research (WA), Department of Health (WA), Landgate, Curtin University, ESRI Australia, Sinclair Knight Merz
Spatial-Temporal Modelling of Cancer Incidence, Survival and Mortalit – Prof Kerrie Mengerson (Queensland University of Technology)	Cancer Council Queensland, Curtin University, Queensland University of Technology, Department of Health (WA), Telethon Institute for Child Health Research (WA), University of Sydney
Health Geocoding Evaluation and Identification of Geocoding Research Priorities – Diana Rosman (Department of Health (WA)) and James Boyd (Curtin University)	Curtin University, Department of Health (WA), Landgate, Critchlow
Urban Planning Geovisualisation eResearch Tools – Prof Geoff West (Curtin University)	AURIN
Geographic Variations in Natural Disaster Impact and Spatial Links to Non-Injury Related Health Outcomes – Prof Simon Kingham (University of Canterbury)	University of Canterbury, Curtin University, Department of Health (WA), Canterbury District Health Board
SUSTAINABLE URBAN PLANNING	
Greening the Greyfields: A Spatial Information Platform for 21st-Century Sustainable Urban Planning – Prof Peter Newman (Curtin University)	Curtin University, Department of Planning (WA), Landgate, Swinburne University, City of Canning (WA), Department of Planning & Community Development (VIC), Manningham City Council
Using Augmented Reality as an Urban Design Tool – Mark Billinghurst (University of Canterbury)	University of Canterbury, ZNO
Understanding Barriers, Bottlenecks and Opportunities for Adoption of Spatial Information Tools in Land-Use Planning in Australia and New Zealand: A Visual Analytics Usability Approach – Assoc Prof Christopher Pettit (University of Melbourne)	University of Melbourne, Landgate, Swinburne University, Department of Environment and Primary Industries (VIC)

GEO-VISUALISATION OF HEALTH INFORMATION

SUMMARY

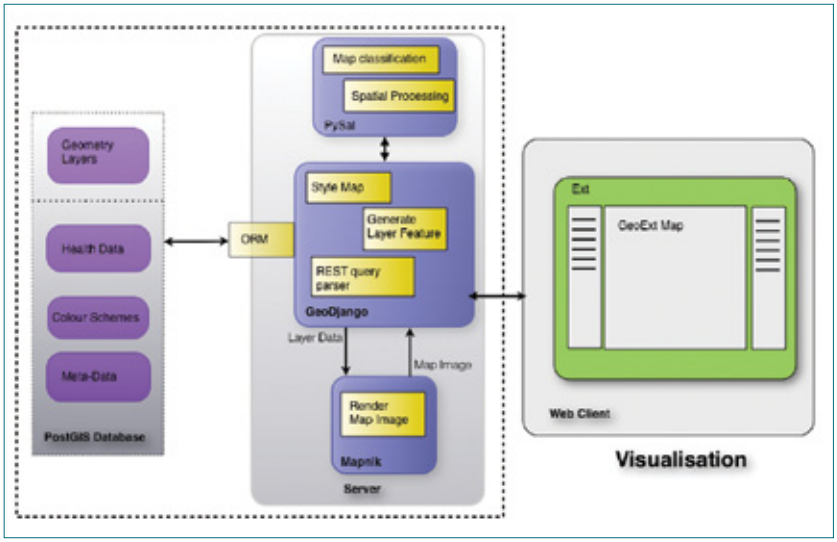
There is a need in health services both nationally and internationally to discover gaps in health service delivery and identify populations of greatest health risk, and to communicate these identified gaps and risks to program leaders, decision makers and health researchers so that they can make informed and evidence-based decisions.

Data consisting of unit records of various forms as well as a number of different geographies is processed and aggregated to chosen geographies for display. Analysis and visualisation techniques are being developed to communicate spatio-temporal health information and results of analysis to many different types of end-user in and around the health sector. The geo-visualisation system, Epidemiology and Public Health Analysis (EPIPHANY), deals with many different datasets, is capable of complex processing, and will deliver useful results whilst taking into account the need to preserve privacy in relation to the data. A wide range of different visualisation techniques will be used either individually or in combination to satisfy user needs.

EPIPHANY has replaced client-sided processing with server-sided processing with a thin-client front-end. It has been focused on web-based delivery using a number of open-source software modules and standards.

The last year has seen EPIPHANY developed to the point that demonstrations of the capability of the system were able to be made to a number of different potential users including the West Australian Department of Health (Epidemiology and Environmental Health), the Telethon Institute of Child Health Research, Australian Primary Health Care Research Institute at the Australian National University (ANU), the Department of Environment and Primary Industries in Victoria (DEPI (Vic)), co-researchers in the CRCSI Health Program at Queensland University of Technology (QUT), Sinclair Knight Merz (SKM), Insight GIS, the National Health Performance Authority, and the CRC for Capital Markets. It is being explored for the Envision project in the CRCSI research Program: Sustainable Urban Development. These are not all health related organisations, reflecting that the system is not only suitable for dealing with confidential health information but also other information that can be commercially sensitive. A workshop was held on the system and other aspects of geo-visualisation of health information at the recent CRCSI Roadshow in Perth, and the system was favourably received at these events.

Architecture showing data and processing on servers and visualisation on the client



Highlights

Two instantiations of EPIPHANY have been explored in the last year. The original system has been extensively modified to make it agent-based, and more flexible and dynamic. Further visualisations have been included, as well as the ability to link, and simultaneously display, more than one visualisation. One example is a table of data and a parallel axis visualisation

(a way of displaying multi-dimensional data). Another example is a map and scatter plot. Highlighting data on one visualisation results in the same data being highlighted on the other.

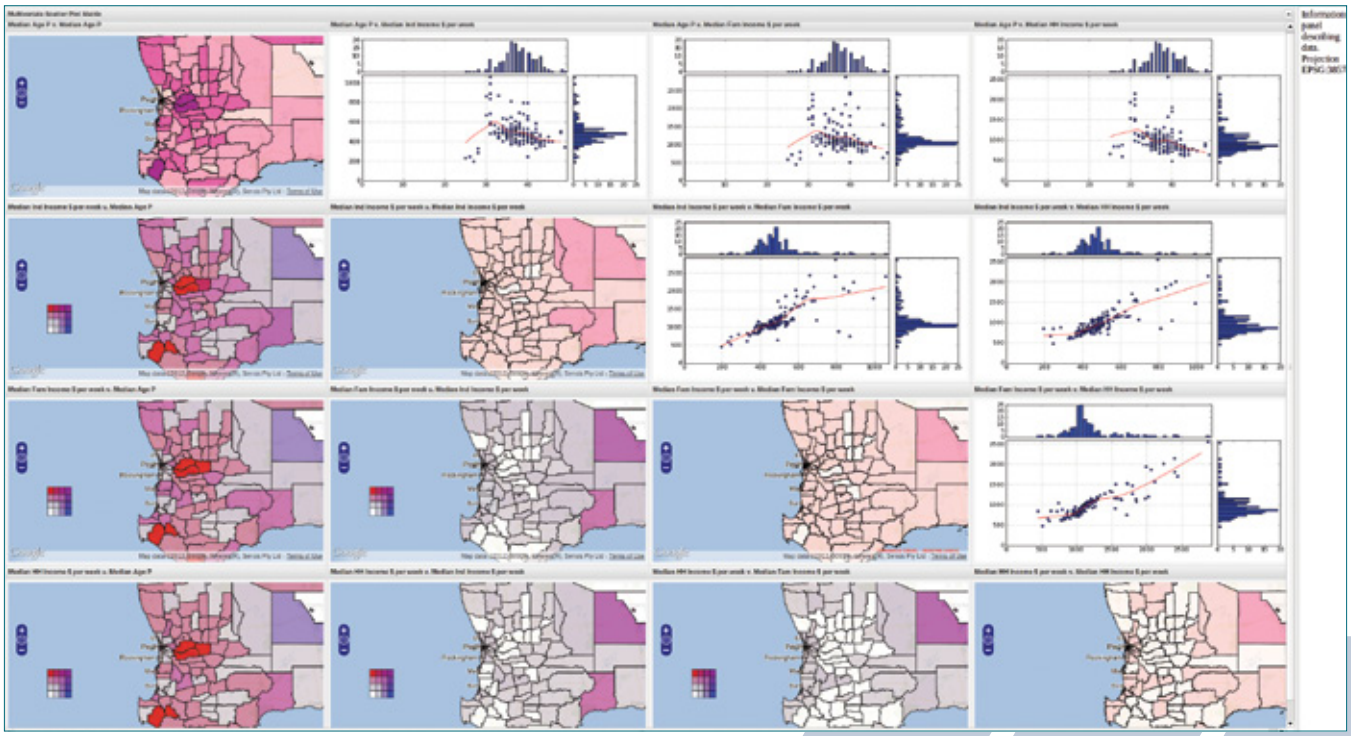
The system can now generate temporal visualisations of many forms with the capacity for linkage (such as with maps and scatter plots changing over time).

The main concepts of EPIPHANY were presented at an invited talk at the recent International Symposium on Digital Earth in Kuching, Malaysia. This was well received with some keen interest generated around the dynamic privacy concept for spatial data.

Associated with the project is the generation of a server-sided module for linking with the AURIN portal. Health data is now accessible by authorised researchers via the AURIN portal in a secure manner acceptable to the West Australian Department of Health. This is a substantial advance in the potential application of the system now that data being provided across the internet has been demonstrated, and should lead to increased adoption of EPIPHANY for a wide range of users.

The next steps include

- Applying for a patent on aspects of the system, in particular methods for the dynamic application of privacy constraints to the results of the spatial analysis before displaying to the client.
- Deploying EPIPHANY into the West Australian Department of Health and in particular the Epidemiology Department. Testing and enhancing functionality will involve a tight feedback loop between the main developer and users. Potential utilisation will be explored with other health organisations.
- Ongoing exploitation with other organisations including DEPI (Vic.), ANU, QUT, Insight GIS and SKM. This reflects the generality of the developed technology and the desire of many organisations to control access to their confidential data while allowing results of analyses to be available.
- Producing conference and journal articles to further promote the EPIPHANY system and gain international peer-reviewed approval of the approach.



Example of multiple visualisations - bi-variate choropleths and scatter plots. Each choropleth and corresponding scatter plot show the relationships between a pair of variables.

USING AUGMENTED REALITY AS AN URBAN DESIGN TOOL

SUMMARY

Augmented Reality (AR) is new technology that allows computer graphics to be seamlessly overlaid on a live view of the real world. The main objective of this project was to explore how mobile AR could be used to visualise future urban redesign of a city. This was done through the development of demonstration applications that could be tested in the city of Christchurch, a city devastated by the 2010 and 2011 earthquakes and undergoing major rebuilding.

Figure 1: Person using the CityViewAR application to see virtual buildings superimposed over the real world.

There were four main objectives in the research

- To develop a stable outdoor AR demonstration application capable of rendering hundreds of virtual buildings on a mobile phone platform
- To develop a client/server architecture that will allow users to provide feedback on the urban designs they are viewing
- To conduct a user study evaluating the ease of use of the technology and its value in the urban redesign process
- To identify areas of future research and commercialisation for the technology.

Highlights

The project was completed in the middle of 2013, and there were a number of highlights, including

- Developing the CityViewAR test application. This is a software application available for the Android and iOS platforms that uses the HIT Lab NZ's Outdoor AR platform to overlay virtual copies of demolished buildings back onto the sites where they once stood. This allows users to walk though Christchurch and see how it looked before the earthquakes. In addition, the application shows text and images explaining the history of the buildings and 360° panorama photos of how the city looked right after the earthquake. Figure 1. shows a person using the application. CityViewAR is available for download on the Android Play Market and iOS App Store and has been downloaded thousands of times.
- Building the Christchurch Central Development Unit (CCDU) 3D application. This was an application for the Android platform that allowed people to see what the city would look like in the future. The Outdoor AR library was used to provide an Augmented Reality view of the concept models for buildings placed over the real world, but in addition a new 3D graphic virtual viewing mode was added (see Figure 2.). This allowed users to see a completed virtual model of the city on their mobile device and to translate and zoom around it by using on-screen touch gestures. Unlike the CityViewAR application, users didn't need to go on-site to see what future versions of significant buildings like the stadium might look like.
- Developing a client/server architecture. The CityViewAR and CCDU 3D applications are stand alone, meaning that all the content has to be downloaded with the application and future changes are difficult. A significant amount of work was done to develop a client/server architecture to enable users to upload building content to a model database on a server and then

have this sent out as required to the mobile AR viewing applications. In this way architects and urban designers could upload new versions of significant buildings whenever they wanted and have these automatically sent to people who were interested in viewing them on their mobile devices. A big part of this work was the development of a web-based interface for uploading and positioning building content on city map views (see Figure 3.).

- User testing. The CityViewAR and CCDU 3D applications were downloaded and used by thousands of people. These applications contained forms in them that allowed us to collect user feedback and to improve each version of the application. The client/server interface was evaluated through formal user-testing which assessed users' satisfaction with the interface, and how well it allowed them to add content to the model database. In summary, over the past year we have achieved all the objectives of the project, but this work has also created a good foundation for future developments in the use of mobile AR for urban design.

Next Steps

There are a number of possible directions for future research, including

- Expanding the research and focusing on larger-scale urban design. Through the CRCSI's project, Greening the Greyfields, there is an opportunity to explore how the technology could be used to support residential design and to geo-visualise thousands of buildings.
- Improving the web-based interface. The existing interface for uploading content to the server can only support limited types of content and simple editing. For the future, development of a more intuitive interface and a wider range of different content types would be desirable.
- Testing with a wider range of users. Although CityViewAR and CCDU 3D applications have been used by many people, there is still a need for more detailed user feedback from architects and urban planners, and also for further testing of the the web interface.
- Porting to new devices. There are new wearable computers such as Google Glass that use head-mounted displays for viewing virtual content. Future research could be directed towards developing the capacity to port the software to this platform, ultimately enabling users to walk through the city and see buildings without having to hold a phone in front of their face.

Figures 2: Screenshots from the CCDU 3D application showing the Virtual Reality viewing mode of the 3D city and a concept model of the new stadium

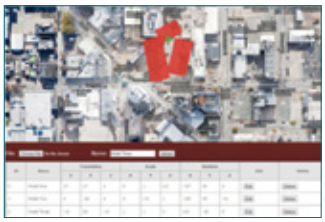


Figure 3: The map interface for the client/server application showing the footprint of a building about to the placed in the database.

CONTRACT RESEARCH OVERVIEW

The CRCSI commenced, continued and completed several client-focused projects in 2012-13. These projects were aligned with core research projects and either complemented or enhanced existing CRCSI capabilities, objectives and strategies. Brief descriptions of these projects follow.

Urban Digital Elevation Model (UDEM) Project and The National Elevation Data Framework

In 2007, the Council of Australian Governments (COAG) identified as a national priority the need for a fit-for-purpose coastal digital elevation model (DEM) to assess the potential impacts of rising sea levels. COAG also noted that a national DEM (or National Elevation Data Framework, NEDF) would deliver national benefits and considerable cost-savings. This was progressed through a national partnership between the Australia and New Zealand Land Information Council (ANZLIC), the Commonwealth Department of Climate Change and Energy Efficiency (DCCEE), Geoscience Australia (GA), and the CRCSI.

Map derived through topographic and bathymetric digital elevation data. Image courtesy of Queensland Department of Science, Information Technology, Innovation and the Arts.

Key outcomes from the investment include

- Over 60,000km^2 of high-resolution elevation data covering major urbanised coastal areas of Australia available for whole-of-government use through streamlined licensing arrangements
- Coordination of a comprehensive, national approach for the ongoing acquisition, enhancement, and distribution of elevation data to address open access (beyond whole-of-Government) issues and associated funding and licensing arrangements
- Sea-level-rise communication products that have been widely accessed by governments, community and the private sector.

The UDEM project has demonstrated world best-practise in elevation modelling, particularly at a continental scale. No other nation of comparable size has delivered coastal elevation modelling for all highly vulnerable areas in less than five years using the latest technology, with the highest possible resolution, and with a very modest budget. The project also helped create an industry that is more robust and competitive; that delivers quality-assured product to meet national standards.

The benefits of the NEDF and the UDEM will be long lasting, particularly in positioning Australia to understand and manage the risks of coastal inundation from climate change, in disaster mitigation, infrastructure and local planning and better management of insurance.

Kokoda Project

In 2008, the Governments of Papua New Guinea (PNG) and Australia committed to cooperating and working together for the protection and sustainable use of the natural and cultural resources of the 40,000km^2 that make up the Owen Stanley Ranges region, including the Kokoda Track. The Australian Department of the Environment, Water, Heritage and the Arts (DEWHA) has assisted PNG Department of Environment and Conservation (DEC), to develop spatial systems and databases to support the land-use planning requirements of the Kokoda Initiative and the development of a Sustainable Development Masterplan for the Brown River Catchment, Kokoda Track and Owen Stanley Ranges region. The CRCSI assisted in the development of key datasets through the provision of high-resolution digital elevation data for slope analysis, drainage delineation and flood modelling, using Earthdata aerial GeoSAR and Japanese satellite PALSAR radar data.

Activities in 2012-13 included the handover and training of local staff to use the tools and data developed, allowing finalisation of the project.

Surveying and geospatial workforce modelling Report

The CRCSI, through two private sector companies, ACIL Allen Consulting and Spatial Information Services, undertook modelling on the current and future demand and supply of surveying and geospatial skills in Queensland and Australia. They found that the shortages in surveying, geospatial and technical skills quantified for Queensland and projected for Australia will require a significant increase in domestic supply if dependence on net migration of skills is to be avoided. Extrapolation of Queensland modelling results indicates that the Australia-wide shortfall of graduate or licensed surveyors would be approximately 1,300 in 2025, while the Australia-wide shortfall of geospatial specialists with university degrees would be approximately 500 in 2017 and 300 in 2025.

Savannah Burning Carbon Abatement Tool (SavBAT)

The CRCSI, in conjunction with Spatial Vision and Darwin Centre for Bushfire Research, developed a Carbon Farming Initiative (CFI) Savanna Burning Abatement Tool (SavBAT). The CFI is a voluntary Australian Government scheme that allows farmers and other land managers to earn carbon credits by storing carbon or reducing greenhouse gas emissions on the land. SavBAT is an open-source, web-based application that greatly simplifies the process for undertaking carbon calculations using the Savanna Burning methodology. Users need only provide their vegetation map in a specified format and to make a number of simple selections, such as the reporting and baseline years. The system fully automates the spatial analysis and key calculations, substantially reducing the time and cost of applying this methodology. Prior to the development of SavBAT, calculating project abatements required a skilled GIS expert, the use of an associated multi-page spreadsheet and weeks of work.

Prescribed burning - west Arhneman Land, NT.

Urban Planning Geo-visualisation eResearch Tools

Traditionally, Geographical Information Systems have been used to display the outputs of health research and analysis using desktop software. With small numbers of skilled staff and minimal resources, widespread adoption of spatial information in health has been limited. CRCSI developed two separate applications: a spatial module called *HealthTracks: Mapping*, for mapping health and demographic information; and an epidemiology reporting

tool *HealthTracks: Reporting,* for creating population health profiles and summary health statistics in a report format. As part of the project these tools were made accessible to urban researchers, allowing them to see the results of various spatial and non-spatial analyses on health and related data, including their own datasets. The tools will be driven by urban researchers choosing parameters from a user-friendly interface, with results able to be displayed through the Australian Urban Research Infrastructure Network (AURIN) portal.

A Synthesis of Remote Sensing Capabilities with Specific Reference to the Business Needs of the MDBA

The Murray-Darling Basin Authority (MDBA) commissioned a review conducted by the CRCSI relating to the use of remote-sensing and its ability to contribute to the business and information needs of the MDBA. Key findings of the report include the following

- For the potential of remote sensing to be fully realised its use must be placed within the broader context of a whole-of-basin monitoring plan and adaptive management system
- There are significant opportunities for existing state and national programs to address MDBA business needs
- There are a number of existing methodologies and datasets that could be extended to produce consistent remotely-sensed products across the Basin

- Long term commercial service-level agreements may offer more cost-effective and efficient mechanisms for acquiring and processing data related to specific events within the Basin
- Rapidly emerging capabilities require an ongoing commitment to applied research and development to realise the full potential of remote sensing in relation to MDBA business and information needs.

Enhancement of Close-Range Photogrammetry Technology for Defence and National Security Applications

The CRCSI is conducting a sponsored research project for the Australian Geospatial Organisation (AGO). This project is comprised of ongoing integration of developed software tools and procedures into a data processing system that has been delivered to AGO to support day-to-day operations. Work on the project in the reporting period has produced a number of enhancements in the capabilities, levels of automation and operational flexibility of the software tools being developed. Updated versions are being regularly delivered to the AGO.

Specific areas of R&D include

- automatic calibration of digital cameras
- the ability to extract reliable 3D information from uncalibrated and/or unknown digital imaging sensors
- advances in automated network orientation and 3D object reconstruction from unstructured, multi-image configurations via new approaches to feature-based matching.

These developments both advance the state of the art in image-based 3D measurement, and make it a productive tool for defence and national security applications.

Management assistance

CRCSI has provided services to the Commonwealth in relation to management of airborne LiDAR surveys, capacity building and coastal modelling in the Pacific.

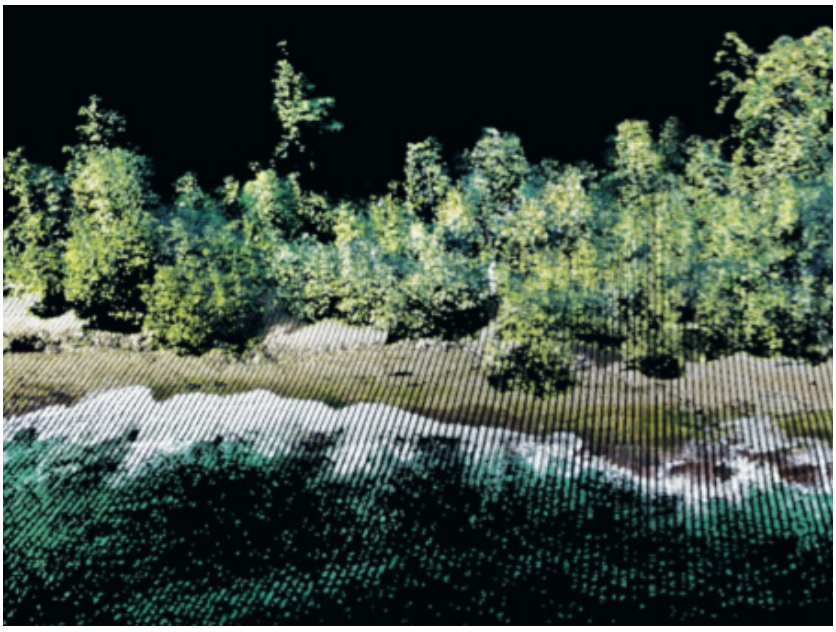
PROJECTS

Title, Lead Researcher	Partners
Surveying and Geospatial Workforce Modelling Report – Dr Peter Woodgate (CRCSI)	Department of Environment and Resource Management (QLD), National Spatial Education Leadership Group
Close Range Photogrammetry for Defence – Prof Clive Fraser (CRCSI)	Department of Defence (Commonwealth)
A Synthesis of Remote Sensing Capabilities with Specific Reference to the Business Needs of the Murray Darling Basin Authority – Mr Phil Tickle (CRCSI)	Murray-Darling Basin Authority
Urban Digital Elevation Modelling (UDEM): Phase 2 – Dr Graeme Kernich, Manager (CRCSI)	Department of Climate Change and Energy Efficiency (Commonwealth)
Flight Assist System (FAS) Demonstrator – Prof Duncan Campbell (Queensland University of Technology)	Queensland University of Technology, Ergon Energy Corporation
Kokoda Remote-Sensing Pilot Project – Prof Tony Milne (CRCSI)	Department of Environment & Conservation, Papua New Guinea
Savannah Burning Carbon Abatement Tool (SavBAT) – Prof Kim Lowell (CRCSI)	Department of Climate Change and Energy Efficiency (Commonwealth)
Management of Airborne LiDAR Surveys, Capacity-Building and Coastal-Modelling in the Pacific Region – Dr Nathan Quadros (CRCSI)	Commonwealth Government, NGIS Australia, AAM Group
Pacific-Australia Climate Change Science and Adaption Planning (PACCSAP) Regional Overview Report Review – Ms Cristina Davey (CRCSI)	Department of Climate Change and Energy Efficiency (Commonwealth)

MANAGEMENT OF AIRBORNE LIDAR SURVEYS, CAPACITY-BUILDING AND COASTAL-MODELLING IN THE PACIFIC REGION

SUMMARY

CRCSI and the Commonwealth Government have partnered in the Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP) Coastal Inundation Project. The project's goal is to develop the capacity within Tonga, Papua New Guinea, Vanuatu and Samoa to manage and use LiDAR data. The primary use of the data in these countries is to support local sea-level-rise planning and decision-making.



An airborne LiDAR point cloud captured in an area of Vanimo, PNG for the Pacific Island project with DIICCSRTE.

Phase One of the project captured high-resolution topographic and bathymetric airborne LiDAR in the Pacific Island countries. Coincident high-resolution aerial imagery was also captured with the LiDAR. During this phase of the project the CRCSI provided the technical specifications, area selections and technical assistance to the airborne capture. The project was subsequently tendered and managed by Geoscience Australia. All of the airborne LiDAR and imagery surveys used in the project were acquired and delivered by 43pl partner, AAM Group Pty Ltd. Phase One also involved assessment of the institutional technical capability within the countries to receive and use the elevation data. 43pl partner, GHD, was required to scope the capacity building requirements for the sustainable use of the LiDAR data for coastal inundation modelling and risk assessments.

Phase Two of the project involves a capacity-building and training program with each Pacific Island Government. The GIS training and capacity-building for sea-level-rise issues is being conducted by 43pl partner, NGIS Australia. The CRCSI is providing the management of the services in regards to the capacity-building and training, along with the Climate Change Office at the Department of the Environment.

The capacity building with the Tonga Government was successfully completed in May 2013. Tonga received the data and training with great enthusiasm. In fact, during the training NGIS was able to extend the use of the LiDAR data and aerial imagery into a number of current projects. The CRCSI looks forward to working with the governments in PNG, Samoa and Vanuatu in the remainder of 2013 to complete the capacity-building and training program. It is hoped that the successful review of the program will see it extended to other Pacific Island countries.

COMMUNICATIONS & STAKEHOLDER ENGAGEMENT

With over 100 key stakeholders the CRCSI emphasises effective communications. Formal channels are provided by three Colleges to encourage dialogue amongst each of the industry, academic and government sector representatives. Each participant's expectations are documented, then reviewed annually, and the cumulative understanding is fed into the strategic planning process.

CRCSI management staff operate in all major regions of activity and have regional roles to help in communications amongst the members.

Regular communiqués update members, and occasional road shows and workshops foster good networking and engagement of members in CRCSI activities.

The Annual Conference attracts 250 delegates over three days, and features research presentations, open forum sessions for members to debate and discuss critical issues, sessions for each college to discuss issues of mutual interest, presentations by selected international experts, and an interactive workshop for postgraduates.

Project participants attend quarterly project-management meetings to review progress and discuss future plans and strategic developments across the CRCSI portfolio.

The information-rich website is used to regularly report on the progress of projects, with blogs available for each project to encourage debate and enquiry. Project webcast presentations are made available regularly through the website. Discussion groups on LinkedIn and Facebook are maintained, along with blog and Twitter feeds.

The CRCSI has been instrumental in the organisation and support of national events including: the spatial@gov Conference; the Surveying and Spatial Sciences Institute (SSSI) Spatial Sciences Symposium; the Geospatial Information Technology Association (GITA) Conference; the Spatial Industries Business Association of Australia (SIBA) national events; several state-based conferences such as the Western Australia Land Information System (WALIS) Forum; as well as international events including the International Society for Digital Earth (ISDE) Symposium. These are all significant events on the calendar for Australia and most attract between 500 and 800 delegates.

Occasional media releases are prepared around significant CRCSI and project achievements, with an emphasis on the participants involved and recognition of the collaborative nature of the event.

Workshops and training courses are held when required, to transfer knowledge to end-users. These occur both in the construction of a proposed research activity, and to promote the outcomes of a given project.

The recent Australian Government CRC Program Performance Review of the CRCSI has provided impetus to increase the reach of the CRCSI external communications and this will be pursued in the coming year.

Selected quotes from feedback survey from participants at the Western Australian Roadshow held in Perth in May 2013

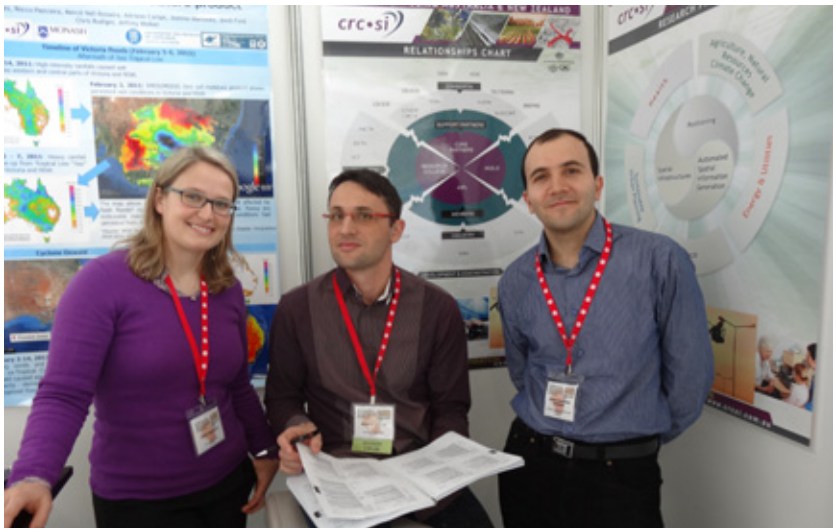
- *"Very professional in all aspects. Good content & very interesting technical presentations" – 43pl Chair*
- *"Thought provoking and interesting" – Academic*
- *"Great mix of academic and research, industry and government participation" – International academic*
- *"Greatest benefit was networking with new people from many sectors" – Academic*
- *"The Roadshow has demonstrated the interesting work being done here by a variety of people" – International academic*
- *"I liked the succinct and informative presentations, and the opportunity to network" – Government*
- *"Good to see an overview of CRCSI research areas and aims, and how spatial information is being applied" – Government*
- *"The SLIP Future development looks very interesting and relevant to our agency" – Government*
- *"The Roadshow provided exposure to the excellent research work, and the chance to get together for networking and collaboration. It was stimulating, with a lot of commonality of thought" – Other Industry*

EDUCATION

The CRCSI made good progress towards our stated aim of 'improving the skilled capability of the Australian and New Zealand workforce' by working with the key stakeholders through the National Spatial Education Leadership Group. The Group is comprised of senior representatives of all the lead bodies in the spatial industry, from government to the private sector and the university and vocational training sectors. The CRCSI led the development of the Terms of Reference for the Group. With the full endorsement of the Group the CRCSI commenced a project to assess the National Australian skilled capacity shortage, supply and demand, extrapolating up from Queensland as an initial test case. The report was prepared by ACIL Allen and Spatial Information Services and released in September 2013.

Nine postgraduate students commenced in 2012-13 with either full or top-up Scholarships, bringing the total cohort of continuing and commencing students to 41 at 30th June 2013. During the year two students completed their studies, thus we have in total 43 current or completed postgraduates, and we are on track to meet and exceed our Commonwealth target of having invested in (enrolled or graduated) at least 50 PhDs and Masters with our university partners by 30th June 2018.

Students are involved in all major projects. Each student is required to have an external supervisor from an end-user organisation. Students attend the annual CRCSI conference, which features a dedicated 'student day'.

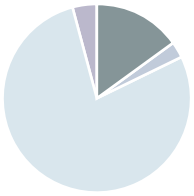


Images from the 2012 CRCSI Annual Conference held in Brisbane.

Name	Title of Thesis	Graduating University
Anna Donets	Using Single Receiver GPS Observations to Analyze the Dynamic Motion of Large Engineering Structures.	Melbourne
Jun Wang	RTK Integrity.	QUT
Michael Filmer	An Examination of the Australian Height Datum.	Curtin
Kui Zhang	Advanced InSAR Techologies.	UNSW
Eric Zhengrong Li	Aerial Image Analysis Using Spiking Neural Networks with Power Line Corridor Monitoring.	QUT
Alex Ng	PsinSAR Radar Interferometry.	UNSW
Matthew Hutchison	Developing an Agent-Based Framework for Intelligent Geocoding.	Curtin
Marco Marinelli	Assessing Error Effects in Critical Application Areas.	Curtin
Jiang Li	Intelligent Object Placement and Scaling in Virtual Decision Environments.	Melbourne
Marcos Nino-Ruiz	Application of Rural Landscape Visualisation for Decision Making and Policy Development.	Melbourne
Roman Trubka	Agglomeration Economies in Australian Cities: Productivity benefits of increasing density and accessibility by way of urban transport infrastructure planning.	Curtin
Pan Peter Wang	Real-Time Data Visualisation in Collaborative Virtual Environments for Emergency Management.	Melbourne
Tao Chen	Augmented Reality Integration and Live Communication between GIS and SIEVE.	Melbourne
Haohui Chen	Collaborative Virtual Environment for Knowledge Management - A New Paradigm for Distributed Communications.	Melbourne
Michael Schaefer	Advanced Biomass Sensing Using Active Optical Sensors.	UNE
Marcos Nino-Ruiz	Spatial Model Steering: An Exploratory Approach to Land Use Allocation Under Future Climate Change Projections.	Melbourne
Adam Roff	Hyperspectral Imagery for Vegetation Management.	UNSW
Michael Day	Hyperspectral Remote Sensing for Land Management Applications.	UNSW

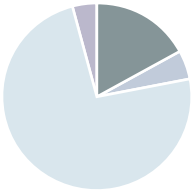
18 PhDs have completed their studies with CRCSI since 2010. Further details can be found through the CRCSI website.

FINANCE



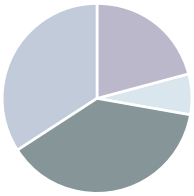
2012-13 Expenditure by Department

Governance & Administration	15%
Business Development	3%
Research Program	78%
Communications & Education	4%



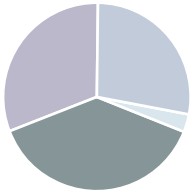
2013-14 Forecast Expenditure

Governance & Administration	17%
Business Development	5%
Research Program	74%
Communications & Education	4%



2012-13 Funding by Source

Essential Participants	21%
Other Participants	7%
CRC Program Funding	38%
Commissioned Research/Other	34%



2013-14 Funding Forecast

Essential Participants	28%
Other Participants	3%
CRC Program Funding	38%
Commissioned Research /Other	31%

2012-13 Staff (FTE) Inkind

Program 1	32%
Program 2	15%
Program 3	7%
Program 4	46%

The CRCSI was in a healthy financial state at the end of the 2012-13 year. Total cash and inkind contributions were $28.1M for the period, $0.4M favourable year on year. 78% of CRCSI Expenditure went into the Research program during the period, a trend expected to be replicated in 2013-2014.

Financial Statement ($'000s)

Funding (Cash)	2011-12 Actual	2012-13 Actual	2012-13 Budget	2013-14 Budget
Essential Participants	3,039	2,472	3,239	2,841
Other Participants	1,121	807	852	335
CRC Program	4,002	4,452	4,452	3,925
Commissioned Research/Other	3,607	3,913	3,311	3,241
Total Funds	**11,769**	**11,644**	**11,854**	**10,342**

Expenditure (Accrual)	2011-12 Actual	2012-13 Actual	2012-13 Budget	2013-14 Budget
Governance & Administration	1,565	1,638	2,104	2,196
Business Development	332	360	595	658
Research Program	7,724	8,352	10,004	9,813
Communications & Education	299	370	461	511
Total Expenditure	**9,621**	**10,720**	**13,164**	**13,178**

Inkind Statement	Staff FTE inkind			Non-staff inkind ($'000s)		
	Actual 2011-12	Actual 2012-13	Budget 2012-13	Actual 2011-12	Actual 2012-13	Budget 2012-13
Research Program 1	11.3	14.7	7.2	861	1,402	1,192
Research Program 2	6.4	7.1	12.3	1,370	1,125	1,131
Research Program 3	2.3	3.2	3.2	1,021	858	731
Research Program 4	18.2	21.1	26.7	3,773	2,632	1,802
Total	**38.2**	**46.1**	**49.4**	**7,025**	**6,017**	**4,856**

Contributions	2011-12 Actual	2012-13 Actual	2012-13 Budget	2013-14 Budget
Cash	11,769	11,644	11,854	10,342
Staff Inkind	8,848	10,404	12,066	11,750
Non-Staff inkind	7,025	6,017	5,146	4,229
Total Contributions	**27,642**	**28,065**	**29,066**	**26,321**

CRCSI PARTNERS

Essential Partners	Support Partners
43 Version 2 Pty Ltd	Department of Defence (Commonwealth)
Curtin University	Department of Health, WA
Department of Environment and Resource Management (QLD)	Department of Environment Climate Change & Water, NSW
Department of Environment and Primary Industries, VIC	Delft University of Technology
Ergon Energy Corporation Limited	Energex Limited
Geoscience Australia	GEOIDE (Inc), Canada
Land and Property Information (LPI) of the Department of Finance and Services, NSW	Land Information New Zealand
Landgate, WA	Murray-Darling Basin Authority
Queensland University of Technology	Open Geospatial Consortium Inc
University of New England	Royal Melbourne Institute of Technology University
University of Canterbury	Swinburne University of Technology
	Telethon Institute for Child Health Research, WA
	University of New South Wales
	University of Melbourne
	Western Australian Agricultural Authority
	Wuhan University

43PL COMPANIES

AAM Group	Nearmap
Alexander Symonds	NGIS Australia
Amristar Solutions	Omnilink
Brazier Motti	Fugro Satellite Positioning
Brown & Pluthero	Photomapping Services
C R Kennedy & Co	Precision Agriculture
Critchlow	PSMA Australia
CTF Solutions	RPS Mapping
CTG Consulting	Scanalyse
Eco Logical Australia	Septentrio
e-Spatial	Sinclair Knight Merz
ESRI Australia	Spatial Information Technology Enterprises
Fitzroy Basin Association	Spatial Vision Innovations
Fugro Spatial Solutions	Sundown Pastoral Company
GeoSmart Maps	Superair
Geoimage	ThinkSpatial
Geometry	Trimble Navigation Australia
GPSat Systems Australia	True 3D
iintegrate Systems	Twynam Investments
Insight GIS	Vekta
Land Equity International	VPAC
Lester Franks Survey & Geographic	we-do-IT
Mercury Project Solutions	Whelans (WA)
Milne Agricultural Group	

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