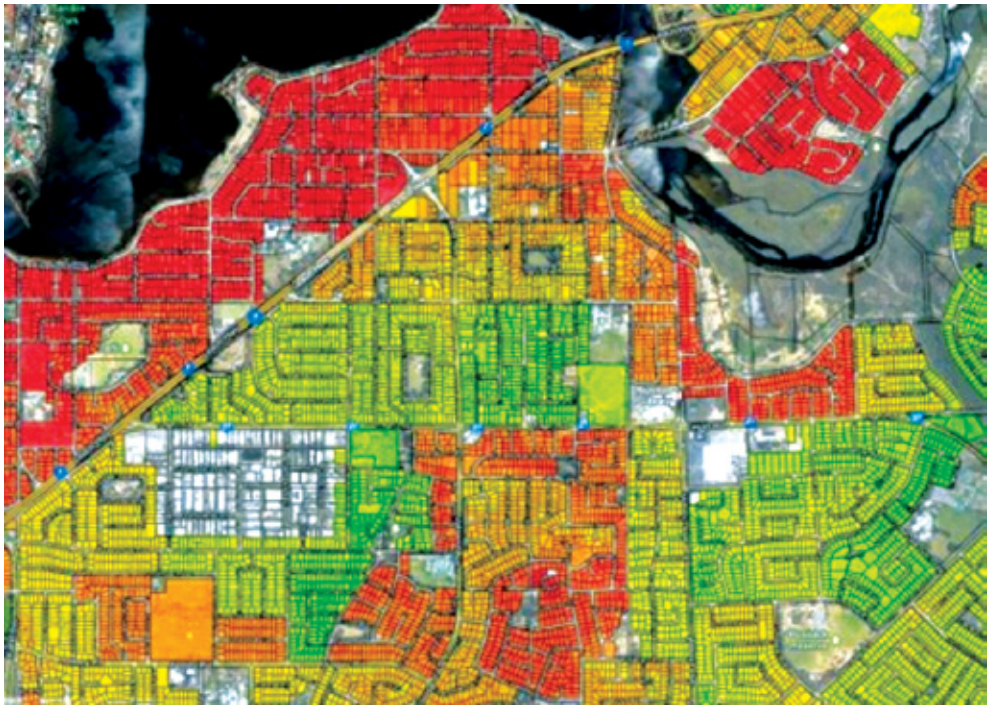
crc•si

ACHIEVEMENTS REPORT 2011-12

COOPERATIVE RESEARCH CENTRE FOR SPATIAL INFORMATION

CRCSI ACHIEVEMENTS REPORT 2011-12



The front cover image is an analysis output from the ENVISION demonstrator toolset developed through the 'Greening the Greyfields' project. The map shows the output from a strategic evaluation of precinct-scale redevelopment suitability in the City of Canning, Western Australia. For more information see the related featured project summary on page 26.

An Australian Government Initiative

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

CONTENTS

AT A GLANCE

- CRCSI stands for Cooperative Research Centre for Spatial Information.
- 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 Navigation Satellite Systems), remote sensing from satellites, aircraft and ground based vehicles, and geographic information systems analyses.
- CRCSI has three major challenges;
  1. Solving the technical challenges that will permit Australia and New Zealand to use all of the world's global and regional navigation satellite systems so that we can support the delivery of 2 cm positioning accuracy to anybody, anywhere outdoors in real time. This will support the development of Australia's new National Positioning Infrastructure Plan.
  2. To develop our research capability to enable Australia to be one of the world's leading centres for automated production of spatial from data recorded using terrestrial, airborne and satellite platforms, and from existing data sources.
  3. To identify and solve the research issues that will enable the operators of the Australia and New Zealand Spatial Marketplace to construct the infrastructure and operate the marketplace to enable our 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 and natural resources as influenced by climate change
  - defence and security
  - energy and utilities
  - health
  - urban planning and development.
- CRCSI is committing projected resources (cash and in-kind) of $160M (and growing) over the period 2010-2018.
- Our 94 partners include federal and state government agencies (18), universities (13), companies (60) and overseas research organisations (3).
- The CRCSI has a vital partnership with 51 SME companies through the establishment of a unit trust called 43pl.
- 75 per cent of our total expenditure was directed to the Research program in 2011-12. The remainder goes on business development, the education program and administration.
- Our values emphasise collaboration in our relationships, creation of excellence in our research, and to be transformational in our impact.
- We currently have 88 effective full time researchers and staff including 27 PhD candidates.

EXECUTIVE SUMMARY

Peter Woodgate,
Chief Executive Officer, CRCSI.

This year the CRCSI ramped up all research programs as we continued to make good progress towards our vision - to spatially enable Australia and New Zealand - ultimately across all market and community sectors.

The vital relationship with our 94 partners epitomises the overall objective of Australia's Cooperative Research Centre Program. Our partners are government agencies, universities and research organisations. Fifty-one small to medium enterprise (SME) companies enjoy the benefits of being research partners through our unit trust 43pl. CRCSI is further engaged with industry through our close relationship with the Spatial Industries Business Association – the peak private sector Spatial Body in Australia.

We are making good progress with all of our goals. Our first key objective is to improve Australia's and New Zealand's precise positioning capability by supporting the development of the National Positioning Infrastructure (NPI). The NPI will deliver 2cm positioning accuracy to anyone, anywhere outdoors. Our second key objective is the adoption by our partners of new methodologies and software tools for the analysis of imagery and laser ranging data from satellite, airborne and ground based remote sensing systems that enhance the level of automation of spatial information product generation through enhanced feature extraction, leading to productivity gains industry-wide. Our third key objective, supporting the development of the Australia and New Zealand Spatial Marketplace, will enable government agencies to lift the licensing, governance and technical restrictions on providing the vast stores of government-held spatial data to the open market, and encourage other users to trade and value-add their data as well.

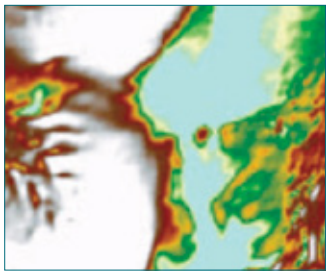
This report summarises CRCSI activities at the close of its second year of operation, following its successful rebid in 2009. Seven of our eight research programs are close to full operating capacity and our major achievements are summarised on the following page. The CRCSI has provided important research advisory services to major government and academic bodies including; the Department of Climate Change and Energy Efficiency, the Murray-Darling Basin Authority, the Department of Broadband, Communications and the Digital Economy, and the Queensland Department of Natural Resources and Mines. The CRCSI has also participated in the preparation of Australia's National Positioning Infrastructure Plan and the new GNSS Strategic Plan, amongst others.

CRCSI's research has produced over 110 separate publications this year. Highlighting our commitment to the innovators of tomorrow, another nine postgraduate students began this year, and we had 38 current or completed postgraduates – precisely double our 2011-12 target. As a result the CRCSI is on track to exceed the overall target of at least 50 PhDs and Masters awarded by 2018.

A number of the CRCSI's researchers have won awards for their CRCSI research, including Professor Clive Fraser and Dr Mehdi Ravanbakhsh (both of the University of Melbourne), and Professor Rod Walker, Dr Jason Ford, Dr Luis Mejia and Dr Felipe Gonzalez (all of the Queensland University of Technology). The CRCSI's annual three day conference, held in Brisbane in May 2012, attracted 250 delegates. Workshops enabled feedback between stakeholders, and project leaders held crucial face-to-face meetings. The CRCSI also welcomed several long-stay international colleagues this year; Professor Manfred Ehlers (Germany); Associate Professor Takeo Tadono (Japan); and Dr Sandra Verhagen (Netherlands).

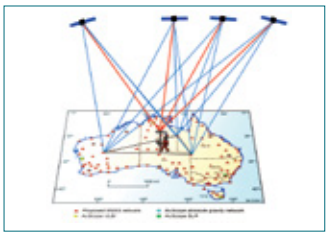
Strong international connections underlie the CRCSI's globally relevant projects. We have valued partners at the Chinese Academy of Science and Wuhan University, at Technical University Delft in the Netherlands, and from the Global Spatial Network and its partners in Canada, the EU, Mexico, South Korea, Sweden, and the United States of America.

HIGHLIGHTS 2011-12



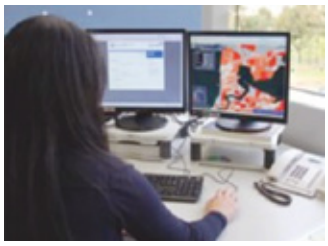
Vital climate change data improves Australia's management of rising sea levels

CRCSI researchers have significantly improved Australia's ability to manage the effects of climate change such as coastal sea-level rise. Working with the Department of Climate Change and Energy Efficiency, the CRCSI team has delivered coastal elevation models and sea-level rise maps for the Urban Digital Elevation Management Project. Development of a national web portal has prompted over 300,000 map downloads. Page 28



World-first results in integrating GPS and Galileo signals for improved positioning

A range of Global Navigation Satellite Systems (GNSS) users will experience direct benefits as a result of research by Curtin University-based CRCSI researchers. The team have achieved a world first by integrating GPS and Galileo signals. This research will lead to improvements in real-time, high accuracy GNSS positioning. Page 12

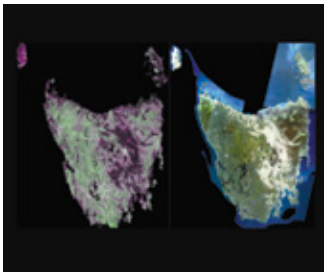


Revolution in access to crucial population health data

CRCSI researchers at Curtin University, with WA government partners and 43pl members, have extended our web application HealthTracks. HealthTracks' population data was previously accessible to only a few researchers. Now, over 150 government users have accessed HealthTracks data over 10,000 times, for improvements in analysis and treatment of community health. Page 21

Accuracy gains for international Global Navigation Satellite Systems (GNSS) positioning products

IGS provides high-accuracy clock and orbit products for real-time and post-processed GNSS positioning. Curtin University-based CRCSI researchers identified technical problems affecting the accuracy of IGS regional orbit products, and are now working with IGS to improve their products for more accurate positioning. Page 11



Australian research provides world-leading emissions and deforestation management advice

A joint CRCSI and CSIRO team has completed research into management of emissions from deforestation/forest degradation in developing countries. CRCSI researchers produced a Forest Carbon Tracking Guide for Australia's International Forest Carbon Initiative, a key contributor to global action on climate change. User manuals for world-wide use are forthcoming. Page 28

CRCSI developed Flight Assist System reaches 1000 hour milestone and is deployed into second aircraft

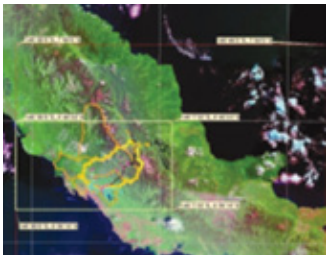
Continued research by Queensland University of Technology has resulted in the development of advanced techniques for real-time control of aircraft for the capture of power line infrastructure. This includes new turn strategies, dynamic 'in-wind' flight and altitude control to reduce pilot workload and a reduction in mission distances of approximately 15%. Page 24

Improved predictions of cancer incidence

Queensland University of Technology-based CRCSI researchers have improved analysis of population variations in the treatment of cancer. This will streamline the fight against cancer for health providers. The models can assess the best location for treatment centres, and the current state of cancer incidence and current access to treatment in any given area. Page 25

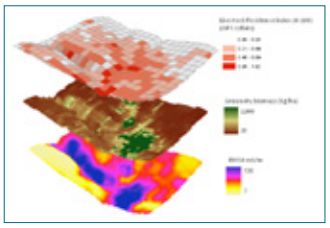
Sustainable use of Kokoda Track through Australia - Papua New Guinea regional research partnership

CRCSI researchers delivered three datasets to complete a cross-government project for the sustainable use of the Owen Stanley Ranges region, including the Kokoda Track. The elevation data, satellite imaging of forests, and multiple maps provided by the researchers mean the joint Australian and PNG taskforce can better help protect the area into the future. Page 31



Savings and efficiency gains for farmers by remote crop/pasture measuring

University of New England-based CRCSI researchers have created the potential for substantial savings for Australian and New Zealand farmers in their management of grazed pastures. Partners have assessed the use of cheap, lightweight and airborne sensors to remotely quantify and map green crop biomass. Page 20



Technology breakthrough in refinement of geospatial satellite image reference system

CRCSI researchers have saved government millions of dollars in processing costs in the generation of the new Geographic Reference Image, which forms a mosaic image framework against which satellite imagery of varying resolutions can be georeferenced, giving a more accurate and comprehensive time series analysis in remote sensing applications in environmental monitoring and natural resource management. The team created a new processing method, reducing ground control needs by 95% and by treating the roughly 10,000 satellite images as just 100 or so multi-image strips. Page 15

Major Digital Rights Management project generates huge international interest and saves millions

Web developments by CRCSI researchers to embed shared information with licensing data has been implemented in three government departments. Since project completion in 2010, 59 other countries have made 12,000 downloads of information about the project. Published independent estimates suggest overall costs associated with free online access to ABS publications and data online and unrestricted standard licencing of around $4.6 million per annum and measurable annualised benefits of perhaps $25 million (ie more than five times the costs). Page 19

STRATEGIC PLAN - GOVERNANCE & MANAGEMENT

Strategic Plan

The Vision

The CRCSI will spatially enable Australia and New Zealand and will be widely recognised for its high impact, collaborative research that leads to accelerated industry growth, improved social well-being and a more sustainable environment. We will be strongly collaborative in our relationships, strive for excellence in our research, and transformational in our impact.

Strategic collaboration will be sought where it enhances the effectiveness of the CRCSI. In addition to our Australian and New Zealand partners, the CRCSI will be an active partner in the Global Spatial Network, the alliance of spatial CRCSI-like entities from around the world. The CRCSI will continue to grow its relationship with CEODE and Wuhan University (China), GEOIDE and Tecterra (Canada) and with other selected organisations.

Strategic Objectives

National 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) accuracies.

Automated Generation of Spatial Information Products Program

To develop the research capability to enable the CRC and its partners to become Australia's leading centres 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 key research issues that will enable the operators of the Australia and New Zealand Spatial Marketplace to construct the infrastructure, operate the marketplace and to enable CRCSI partners to create value-added applications with new technologies.

Applications Program

To realise 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 Planning, to build new tools, paradigms and theories including agglomeration economics and greyfield regeneration to support 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 education providers. By 2018 the CRCSI will have graduated 50 PhDs through 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 intellectual property; 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

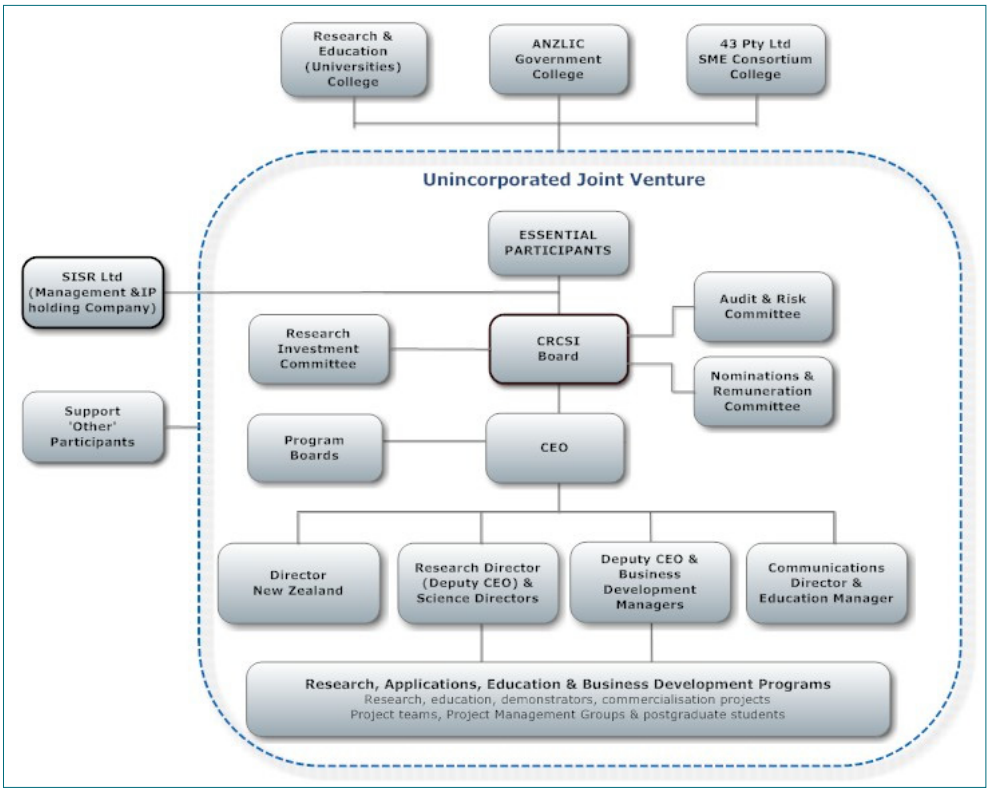
Commissioned research is expected to generate an additional $10M of activity in the CRCSI (from January 2010), tackling complex research needs involving multiple partners from both the public and the private sectors. Initially most of this research will focus around the existing core expertise. In time 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 manages the UJV's operations.

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

There are 78 formal participants in the CRCSI from the government, private and research sectors with a further 16 organisations committed through letters of agreement. They have been formed into three Colleges, one representing each of these three sectors; 43pl (with 51 SMEs), the Research and Education College (primarily universities), and the Government Agencies College managed by the Australia New Zealand Land Information Council (ANZLIC), made up of government agencies



Governance Structure of CRCSI.

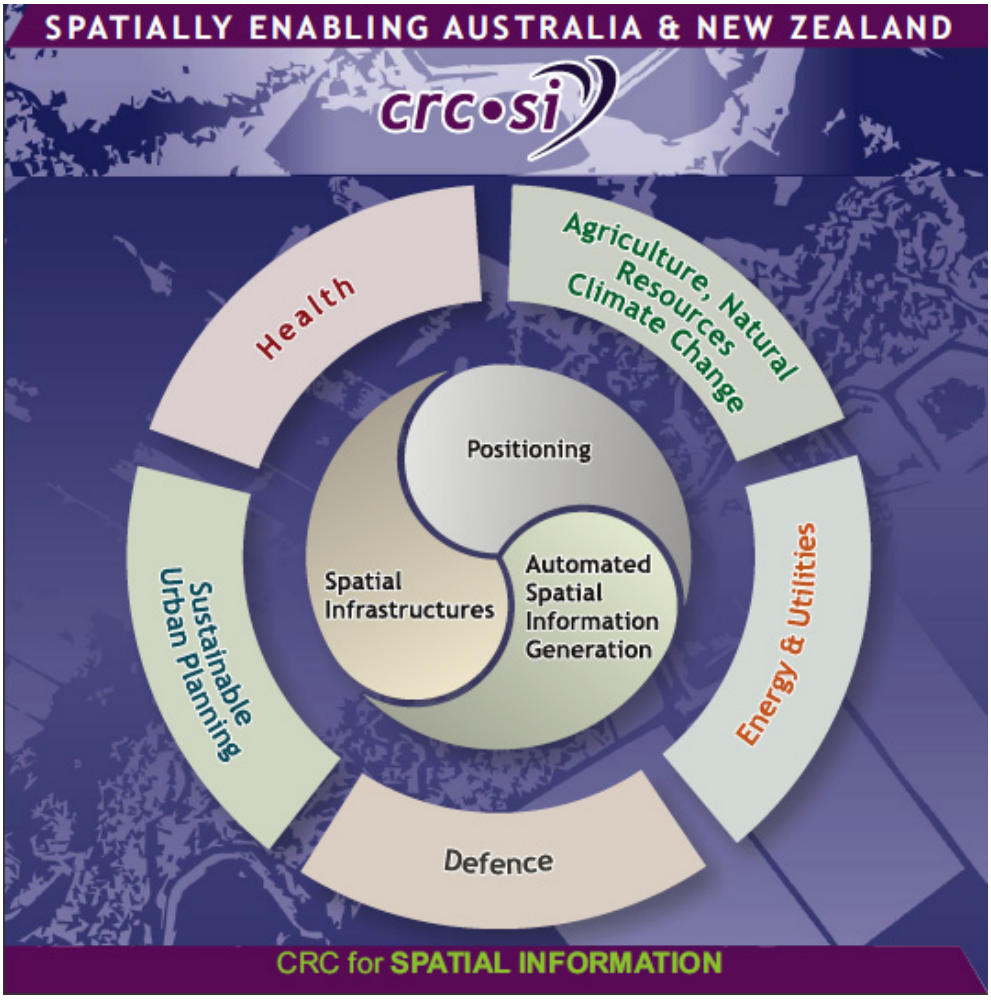
at Federal, State and Territory levels. The Colleges help represent the views of their respective members, especially in the formation of policy, the development of strategy, nominations of candidate directors to the Board and the admittance of new participants. They also provide a vital mechanism for 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.

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.



POSITIONING PROGRAM

The Positioning Program is structured to deliver the Analysis Centre Software, which is designed to process multi GNSS data streams from a continuously operating reference station network. A second core milestone relates to the design and implementation of a new dynamic datum for Australia and New Zealand, which is the subject of a new Dynamic Datum project. This project has secured a very high level of end-user engagement and the program is proceeding well and is on track to deliver on milestones.

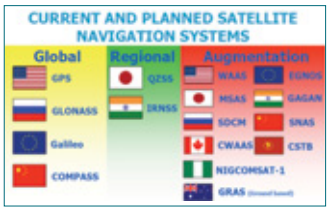
The program has established a high profile both nationally and internationally with researchers actively participating in major conferences and scientific working groups as well as providing invited and keynote presentations. Visiting researchers from China and Europe have been hosted by the program and have made notable contributions to the research activities. The program produced 14 refereed journal papers and 13 refereed conference papers in 2011-12. 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.

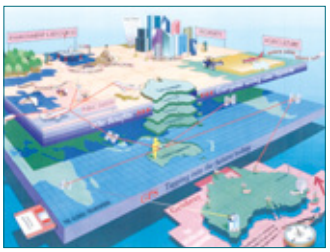
RESEARCH PROGRAM HIGHLIGHTS

Professor Peter Teunissen, Science Director.

Projects

Title, Lead Researcher	Partners
New carrier phase processing strategies achieving precise and reliable multi-satellite, multi-frequency GNSS/RNSS positioning in Australia. Professor Peter Teunissen (Curtin University)	Delft University of Technology, University of NSW, RMIT University, Queensland University of Technology, Geoscience Australia, Curtin University, Septentrio, AAM Group, Landgate, GP Sat Systems, Fugro Satellite Positioning.
Regionally enhanced orbits and clocks to support multi-GNSS real-time positioning. Professor Yanming Feng (Queensland University of Technology)	Wuhan University, Queensland University of Technology, AAM Group, Landgate, GP Sat Systems, Leica Geosystems, Department of Natural Resources and Mines (QLD), Sinclair Knight Merz, Ergon Energy Corporation, Vekta, Department of Sustainability and Environment (VIC), Fugro Satellite Positioning.
GNSS measurement and quality control: Initiating the development of a test track for positioning-system validation and certification and regionally enhanced orbits and clocks to support multi-GNSS real-time positioning. Dr Allison Kealy (University of Melbourne)	University of Melbourne, Department of Sustainability and Environment (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 Sustainability and Environment (VIC), Land and Property Information (NSW), Fitzroy Basin Authority, CTF Projects.





Top: The USA, Russia, Europe, China, Japan and India, amongst others, are all investing in global and/or regional navigation satellite systems. Australia and New Zealand need to carry out a coordinated program of research to design, build and operate positioning infrastructure that will optimise the benefits to be gleaned from these systems.
Bottom: Image depicting the National Positioning Infrastructure for spatially enabling Australia.

FEATURED PROJECT

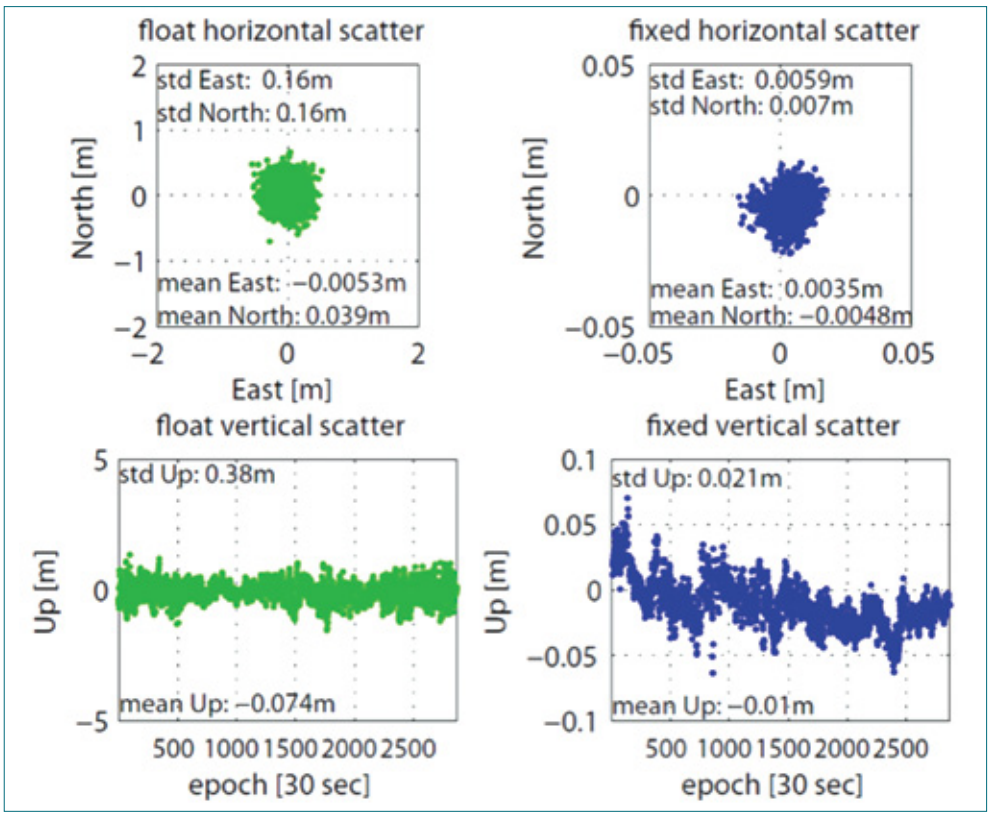
New carrier-phase processing strategies for next generation GNSS positioning

Summary

In the present decade of new Global and Regional Navigation Satellite Systems (GNSS/RNSS), this project addresses two important aspects of multi-GNSS multi-frequency data processing—an optimal ambiguity resolution strategy for carrier-phase data and devising new processing models. This project is an important step towards the objective of CRCSI's positioning program goal of "instantaneous GNSS/RNSS positioning, anywhere, anytime, with the highest possible accuracy and the highest possible integrity." Ambiguity resolution (AR) is the key to high-precision GNSS positioning. In the emerging new multi-constellation multi-frequency GNSS signal of the future, the complexity and variability of AR can be enormous. In order to estimate ambiguities rigorously, and validate the solution statistically, a new theory of integer inference needs to be generalized. New precise positioning models like multi-GNSS PPP-RTK will also be developed as part of this project. These models will benefit from the availability of multi-frequency multi-GNSS signals and from the use of CORS networks for estimation of corrections essential for PPP with AR. This challenge has particular significance to Australia where inter-station distances of CORS are large and non-uniform.

Highlights

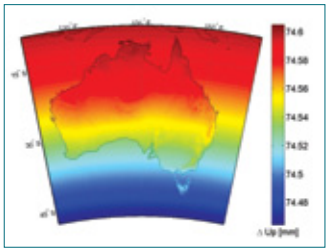
- The Curtin PPP-RTK approach has the flexibility to be used for single, dual or multi-frequency GNSS data. This means that low cost single-frequency GNSS receivers can be used for precise positioning. Single-frequency PPP-RTK users, however, require regional ionospheric corrections in order to keep the convergence time low and enable AR. In addition, satellite clocks and phase-



Right: Comparison of single frequency PPP and single frequency PPP with ambiguity resolution (PPP-RTK).

bias corrections are also estimated from a regional network. Experimental results with regional corrections from GPS Network Perth demonstrate that single-frequency PPP-RTK is feasible with a convergence time of 5 minutes.

- Precise Point Positioning (PPP) provides user position in the reference frame of the precise orbits. In order to enable positioning in regional frames of reference, either precise orbits must be provided in the regional frame of reference or final positioning results must be transformed into the regional frame of reference. With the real-time availability of precise orbits in regional frames known as Regional Broadcast Corrections (RBC), the former approach is promising. But Curtin University discovered a flaw in the provision of RBC due to which the current RBC cannot give correct PPP positions in the RRF without changing existing user-software. A new user-friendly RBC approach was proposed for which users do not need to change their PPP software, which provides correct horizontal PPP positions in the required regional frame of reference. For users requiring precise height information, a simple constant height-correction was proposed which was valid for the whole Australian continent.
- LAMBDA (Least-squares AMBiguity Decorrelation Adjustment), which was introduced by Professor Teunissen in 1993, is the most widely-used AR method used in high-precision GNSS positioning today. LAMBDA version 3.0 was released this year (gnss.curtin.edu.au) with many enhancements upon LAMBDA version 1.0 (released 1996) and LAMBDA version 2.1 (released 2001). It now incorporates a new search strategy based on alternative searching, which continuously shrinks the search ellipse. In addition to standard Integer Least Squares (ILS), the so-called bootstrapping and rounding estimators are also supported now. LAMBDA version 3.0 can also output bootstrapping success rates and it supports Ratio Test and Partial AR (PAR).
- To facilitate the research for this project, Curtin University maintains a considerable number of multi-GNSS multi-frequency receivers and a multi-GNSS signal simulator. Curtin University has also been developing multi-GNSS analysis and processing software from the ground up, as well as by developing existing in-house software. In addition to this in-house-developed software, the GNSS Research Centre has also purchased a number of scientific and commercial software packages for this project. Finally, the data collected using these receivers is a valuable asset to understand the multi-GNSS problem and to research and develop solutions. The GNSS hardware, software and data at Curtin University are together called GNSS Infrastructure which is in itself an important contribution to the research deliverables of the project.



Above: Variation of vertical positions in Australia when using modified approach of PPP with Regional.

Below: Capabilities of multi-GNSS receivers installed at GNSS Research Centre, Curtin University.

Next Steps

The project team will continue its multi-GNSS research on new carrier-phase processing strategies. More particularly there will be:

- further development of the multi-GNSS, multi-frequency ambiguity resolution and ambiguity-validation theory and algorithms (the validation procedures, particularly, will be developed further for the future multi-GNSS mixing scenarios).
- further developments of the PPP-RTK platform, in which emphasis will be given to the inclusion of the Compass/BeiDou GNSS System.
- further development of Curtin's S-system theory to achieve greater flexibility in PPP-RTK platform applications.

AUTOMATED SPATIAL INFORMATION GENERATION PROGRAM

Professor Clive Fraser, Science Director.

This research program comprises three projects focusing on the development of automated procedures for the detection, identification and measurement of natural and man-made features from terrestrial, airborne and satellite-borne remote-sensing technologies. 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 key tool for this program is the CRCSI-developed Barista software, which provides an operational platform for implementing and testing research outputs, and allows end-users to engage directly and in a timely fashion with the research activity. Research excellence in this program is evidenced by the international profile of the research team and the substantial international engagement that occurs through conferences, scientific exchanges (the program hosted a visting scientist from JAXA, the Japanese Space Agency, for 12 months) and participation on international review panels. In addition, the program has produced nine refereed journal papers and twelve 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 who is a leading international researcher and Australia's most senior researcher in this area of science.

Projects

Title, Lead Researcher	Partners
Multimodal data acquisition and feature from multi-sensor terrestrial mobile mapping systems. Professor Geoff West (Curtin University)	Whelans, Curtin University, AAM Group, Landgate (WA), Lester Franks, Vekta, Fugro, Department of Sustainability and Environment (VIC), Land and Property Information (NSW), Geomatic Technologies, Department of Transport (VIC).
Feature extraction from multi-source airborne and space-borne imaging and ranging data. Dr Chunsun Zhang (University of Melbourne)	University of Melbourne, Landgate (WA), Department of Natural Resources and Mines (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 space-borne imaging and ranging data. Dr Andrew Haywood Professor Simon Jones (RMIT University)	Department of Sustainability and Environment (VIC), RMIT University, Department of Natural Resources and Mines (QLD), Department of Trade & Investment, Regional Infrastructure and Services (NSW), Department of Sustainability and Environment (VIC).

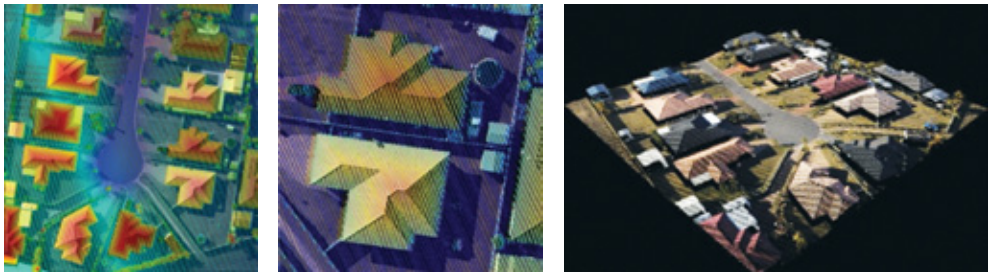
FEATURED PROJECT

Feature Extraction from Multi-source Airborne and Space-borne Imaging and Ranging Data

This project concentrates on automated 3D reconstruction of man-made objects and vegetation parameters through new software systems for integrated processing of imagery and ranging data, improved feature extraction, and robust object-reconstruction. The project aims to produce software tools that both enhance automated transformation of earth-observation data into usable spatial information, and derive identity and location characteristics, and geometric and semantic attributes of built and natural objects such as buildings, roads, forests and vegetation.

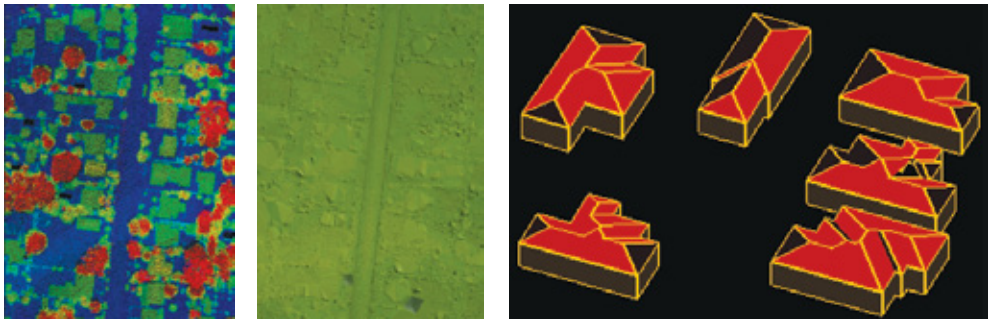
Highlights

- The development of a new algorithm for efficient registration of LiDAR point clouds with optical imagery. The accurate alignment of point clouds with imagery will enable efficient and robust feature extraction, which is necessary for automated object-reconstruction. The new method is appropriate for aerial and satellite imagery and upon completion of the research it will have high potential for uptake by industry.



Left: Overlay of registered point clouds and image.
Middle: Close view.
Right: LiDAR point clouds colorised by corresponding pixels of the RGB imagery.

- New techniques for processing LiDAR point clouds have been developed to efficiently differentiate points into planar, linear or volumetric segments. Roof structures have been reconstructed and a filtering algorithm investigated that extracts digital terrain models (DTMs) from LiDAR point clouds. The result is improved quality of DTMs.

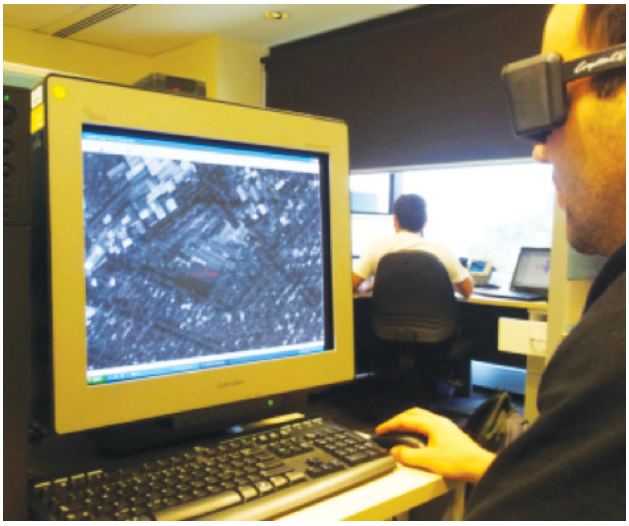


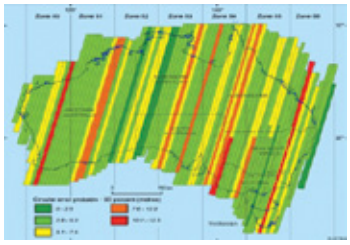
Left: LiDAR point cloud.
Middle: Extracted digital terrain model.
Right: Reconstructed 3D building models.

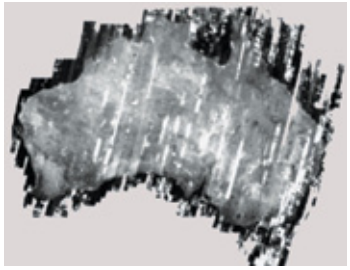
- New algorithms for matching of multiple images have been developed to support dense 3D object point-generation from imagery. Low-level features, such as edges, feature points and grid points are extracted and matched by the developed algorithms. A software module for 3D visualisation and measurement of stereo satellite imagery, which is nearly ready for industry adoption, has also been implemented.

- The rigorous sensor model incorporated into the Barista software system for high-precision orientation and georeferencing of multi-image strip and block configurations of high-resolution satellite imagery, developed within CRCSI, was adapted to support the production of the Australian Geographic Reference Image (AGRI) by Geoscience Australia (GA). AGRI is an orthoimage mosaic that provides a spatially-correct reference image at a 2.5 metre resolution covering the whole of Australia. Adoption of the outputs by GA facilitated the automated production of AGRI, which would not have been feasible without the long-strip adjustment technique developed within the project. This led to a 98% reduction in the cost of ground control and an increase in productivity of 570%. The long-strip adjustment technique was also validated for Quickbird satellite imagery in two test data sets.
- Improved performance of the automated extraction and mapping of buildings from a combination of aerial imagery and LiDAR has been achieved. The developed algorithms provide high object-based completeness, correctness and quality to a level of 90% or more of buildings forming suburban and semi-rural scenes. The approach is fully automatic and has been tested on seven datasets covering different terrain and vegetation types. The approach is especially efficient at separating buildings from trees, even when the buildings are mostly occluded and shadowed by trees.

Left: Implementation of stereo-viewing capability into Barista.
Top right: Image strips forming AGRI, colour coded with accuracy values.
Bottom right: The generated reference image mosaic.







Next Steps

- Improvement and refinement of the multi-source imagery and point cloud registration techniques for more efficient processing of different type of imagery over large areas.
- Continued development of algorithms for LiDAR point cloud processing for terrain modeling and object reconstruction.
- Continued development of algorithms for matching of multiple images. Integration of multiple-image and 3D data (LiDAR and image DSM) to generate geometrically precise 3D images with rich semantic information.
- Further development of algorithms to process ‘3D images’ for feature extraction of man-made object features, such as roads, and automated building reconstruction.

SPATIAL INFRASTRUCTURES PROGRAM

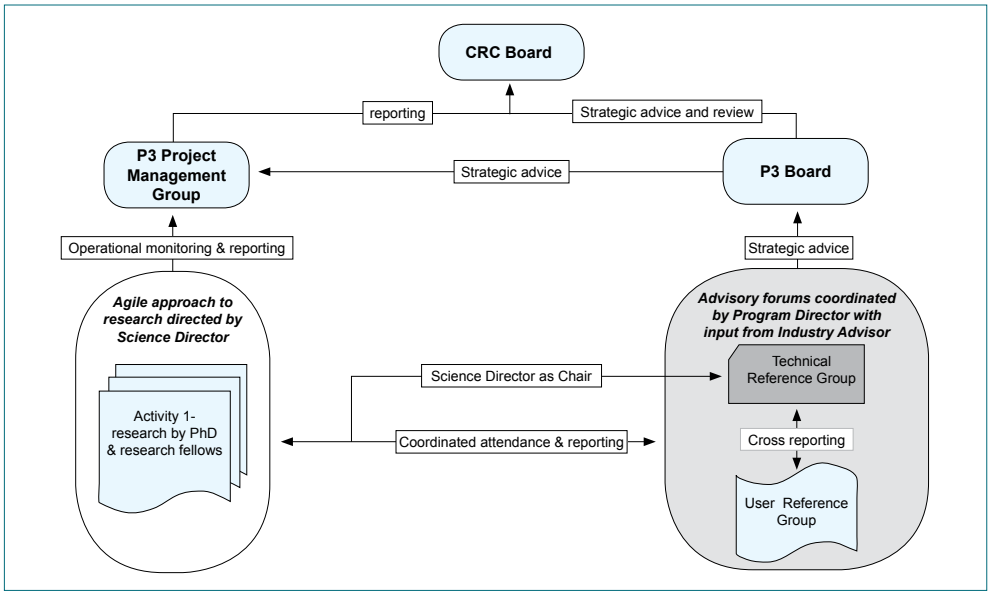
The Spatial Infrastructures Program has developed, through extensive consultation with end-users, a well developed and thoroughly reviewed research strategy. This progress has been made possible through the leadership of Professor Geoff West, who was appointed in late 2011 as the Program Science Director, and Dr Tai On Chan, Program Director and a Senior Manager on secondment from the Victorian Department of Sustainability and Environment. Research work will commence in early 2013. In the meantime, an alignment study of spatial data infrastructure activities at the government level across Australia and New Zealand has identified technology capabilities and gaps, and allowed "best of breed" criteria for a future spatial marketplace to be defined. The spatial marketplace concept continues to gain acceptance across the spatial industry and, in demonstrator form, will provide a mechanism for utilisation of research outputs by users.

Professor Geoff West, Science Director.

Research activities in Program 3 were delayed due to the need for comprehensive consultation, the complexity of the user requirements, the diversity of user views and the need for stakeholders to make good progress on the creation of a demonstrator for the marketplace. Already, however, the program has produced one book chapter and three papers in refereed conference proceedings. The Program Board is chaired by Mr Mike Bradford, CEO of Landgate, WA, and an acknowledged leader in this field.

Projects

Title, Lead Researcher	Partners
Unlocking the LANDSAT archive for future challenges. Glenn Frankish (Lockheed Martin) Dr Tai On Chan (Department of Sustainability and Environment (VIC))	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 (WA).



Governance Model for the Spatial Infrastructures Program.

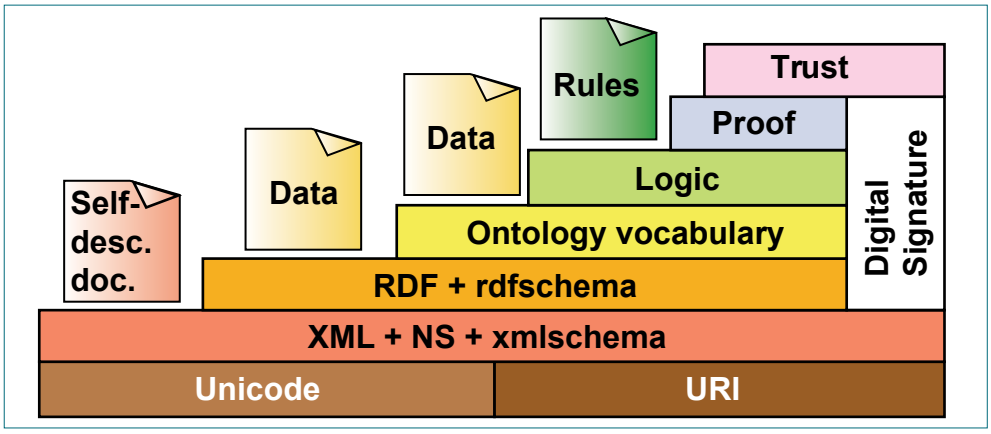
SPATIAL INFRASTRUCTURES - KEY CHALLENGES & STRATEGY

The Program 3 Research Strategy sets out to significantly improve the organisation, access and use of spatial data in Australia and New Zealand (ANZ) by supporting the design and development of Next Generation Spatial Infrastructures. This will build on the vision and the demonstrator of the Australia and New Zealand Spatial Marketplace and will occur through: improving the user experience by making many of the operations more seamless, improving access to spatial resources (data, apps and services), and enabling a stronger role for the private sector in innovating the next generation of spatial products and services in partnership with the public sector.

Program 3 activities will involve research into the Semantic Web, Artificial Intelligence and Supply Chains. Such technologies will be implemented on top of existing infrastructures to significantly improve: search and discovery of data and processes, the generation of supply chains for derived products, the ease of publishing data and processes, the integration of datasets, and query-based processing. This requires research into the various technologies around the Semantic Web technology stack, mainly at the higher levels from ontologies to sophisticated rule-based intelligence that accesses and uses the lower levels of the Semantic Web stack.

The integrated nature of the research challenges leads to the proposal for a single overarching research project that addresses seven research activities: search and discovery, data integration, web service orchestration, crowd sourced information, big data queries, licensing and copyright and review of other spatial infrastructure models. These activities will be undertaken as staggered sub-projects implemented over time using an agile approach involving regular meetings to take into consideration the uncertainties of a rapidly changing development landscape.

Semantic Web technology Stack: T Berners-Lee.



The research activities will address user requirements expressed as user stories for applications. Each user story covers one or more research activities. User stories currently of relevance and under consideration cover: Data Integration at the National and Jurisdictional Levels, The Spatial Marketplace, SLIP future, Property models, user queries across large 3D/4D datasets, Health, Sustainable Urban Development, Biomass Business and Disaster and Emergency Management.

To ensure the utilisation of the research outputs, the research activities must be supported by the right technical research architectures and user stories. Therefore a formal consultative process involving a Technical Reference Group and a User Reference Group is being implemented as an integral part of program governance. The Science Director and Program Director will chair the two groups respectively to ensure timely advice is provided to the Program Board to ensure the continual relevance of the research.

CRCSI AND CREATIVE COMMONS

Digital Rights Management for Spatial Data

From 2007 to 2010 the CRCSI undertook a major project related to Digital Rights Management, which conducted a systematic and detailed investigation into the transfer and exchange of public sector information. After extensive analysis of the legal, technical and economic aspects of Digital Rights Management the CRCSI team delivered the following key outcomes:

1) An institutional model and policy framework based on sound legal, economic and technical reasoning and principles relevant to the emerging technical, economic and political environments.
2) The development and demonstration of a web-based government portal that automates the embedding of public sector information with appropriate Creative Commons licensing and metadata provisions.

Since its completion in 2010, this seminal work has paved the way for change and policy reform beyond the initial project partners and into the national and international arena. The principles developed as part of the project have been adopted as the National Standard for Australia and New Zealand by the peak government body ANZLIC – the Spatial Council.

CRCSI's Digital Rights Management project has left a substantial ongoing legacy.

CRCSI'S DIGITAL RIGHTS MANAGEMENT PROJECT HAS LEFT A SUBSTANTIAL ONGOING LEGACY

Usage and impact highlights at project completion

- Successful deployment of the web portal in three government departments engaged with spatial data: the Australian Bureau of Statistics, the QLD Department of Environment and Resource Management and Landgate (WA).
- Principles developed in the project were adopted by the Bureau of Meteorology, Geoscience Australia and the Victorian Government.
- Findings of the project were used to create Government policy on open access to public sector information, and key reports, reviews and recommendations relied on the CRCSI project information.

Legacy outcomes and highlights in the two years since project completion

- Case studies and data published, citing major economic returns generated by the project, including ABS' adoption of the project principles. Published independent estimates suggest overall costs associated with free online access to ABS publications and data online and unrestricted standard licencing of around $4.6 million per annum and measurable annualised benefits of perhaps $25 million (ie more than five times the costs).
- Policy changes at Federal and State levels of Government to directly incorporate the principles developed in the CRCSI project.
- Principles of Open Access and use of Creative Commons commonplace(Revised Attorney General IP Policy, many States and agencies use CC BY license as default).
- Use of the project findings and principles across many sectors including education research, the environment, and health.
- Similar outcomes were noted in New Zealand through the use of NZGOAL and data.govt.nz.
- Findings and principles from the CRCSI project material were referenced at the United Nations' Economic Commission to Africa.
- There have been nearly 15,000 full downloads of CRCSI project-related material from the Queensland University of Technology website – significantly, 80% of these downloads were to 59 countries outside of Australia, attesting to the project's international impact.

COMPRISES FIVE SEPARATE APPLICATION AREAS WHICH BUILD ON THE CAPABILITIES OF THE CORE RESEARCH PROGRAMS AND APPLY RESEARCH IN CHOSEN SECTORS

Top to bottom: Professor Kim Lowell, Professor James Semmens, Professor Peter Newman, Science Directors.

Right: Plane carrying a raptor sensor mounted underneath its belly – Biomass Business Project.

RESEARCH APPLICATIONS PROGRAM

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.

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 six refereed journal papers and three papers in refereed conference proceedings have been produced by the research teams in 2011-12. 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).

Defence Program

This is a different type of program to the others within CRCSI. Defence agency partners have kept a watching brief over the Centre's programs. An increased level of involvement is likely in the future, with one Defence funded project (related to close-range photogrammetry) having commenced in early 2012 and the potential for more to follow.

Energy Program

The Energy Program comprises a single project focused on the spatial information priorities of electricity distribution companies, in particular Ergon Energy. The research develops an enhanced Flight Assist System (eFAS) to deliver substantial efficiency gains in the aerial acquisition of spatial

information covering power line assets. eFAS has already demonstrated cost savings of approximately 15% compared to existing systems, through intelligent aircraft control when turning between flight legs.

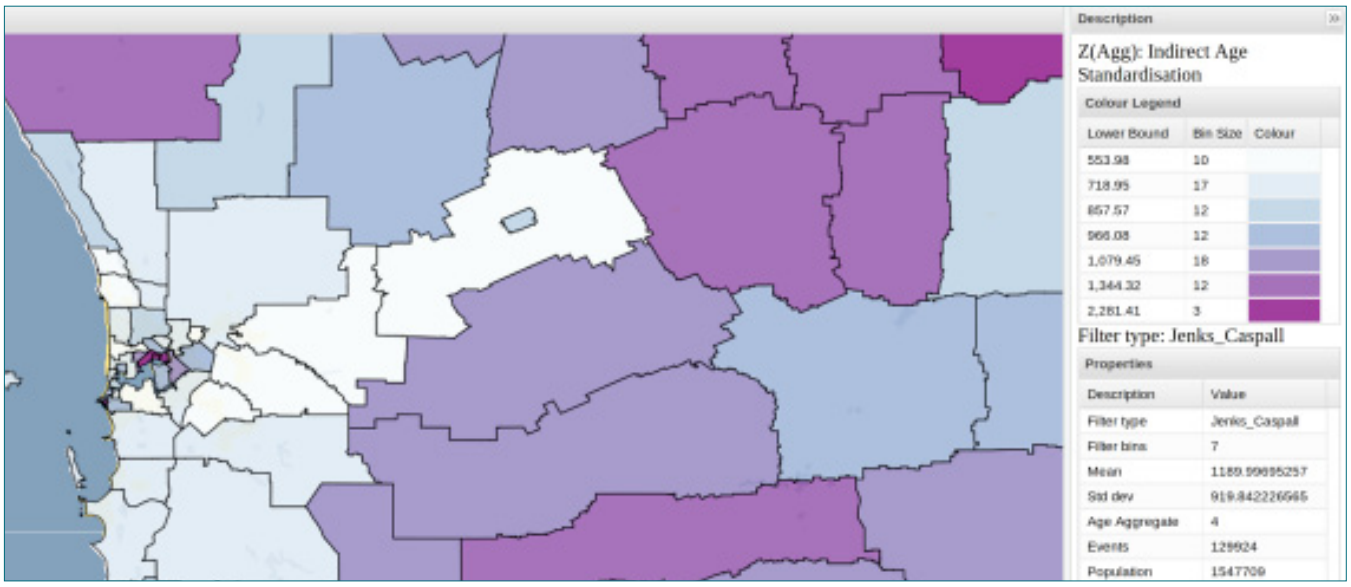
This program has produced one refereed journal paper and two refereed conference papers in 2011-12. The Program Director is Mr James Bangay, the Director of Strategy at Ergon Energy.

Health Program

This program aims to bring the benefits of spatial enablement to the analysis, interpretation and application of public health data, ultimately leading to better public health outcomes through the provision of improved and more appropriately targeted health services and facilities.

There are three projects in the program investigating: the geovisualisation of health data; strategies for anonymising health records in a geospatial context; and the application of spatial statistics to enhance the analysis and interpretation of health records and improve government understanding of disease risk and contributing factors.

The Science Director is Professor James Semmens, Director of the Centre for Population Health Research at Curtin University, with Ms. Narelle Mullan, seconded from the WA Department of Health, as Program Manager. The Program Board is chaired by Dr Tarun Weeramanthri, WA's Chief Health Officer and Executive Director of Public Health and Clinical Services.



An example of Thematic Map Styling for Visual Analytics. The map shows analytical processing embedded in the workflow to reveal age-standardised rate for miscellaneous injuries.

Sustainable Urban Planning Program

This program 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, who is 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 team has produced two book chapters and four refereed conference publications.

Projects

Title, Lead Researcher	Partners
Agriculture, Natural Resource Management & Climate Change	
Biomass Business. Professor David Lamb (University of New England)	Milne Agricultural Group, Department of Environment, Climate Change & Water (NSW), University of New England, Sundown Pastoral, Curtin University, AgLab, Twynam Investments, Eco Logical Australia,Landgate (WA), Superair, Queensland University of Technology.
Towards operational monitoring of key climate parameters from synthetic aperture radar. Professor 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.
Health	
Geovisualisation of health information. Professor Geoff West (Curtin University) Narelle Mullan (CRCSI)	Spatial Vision, Telethon Institute for Child Health Research (WA), Department of Health (WA), Landgate (WA), Curtin University, ESRI Australia, Sinclair Knight Merz.
Spatial-temporal modelling of cancer incidence, survival and mortality. Professor Kerrie Mengersen (Queensland University)	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) Associate Professor James Boyd (Curtin University)	Curtin University, Department of Health (WA), Landgate (WA), Critchlow.
Urban Planning Geovisualisation eResearch Tools. Professor Geoff West (Curtin University)	AURIN.
Sustainable Urban Planning	
Greening the Greyfields: A Spatial Information Platform for 21st Century Sustainable Urban Planning. Professor Peter Newman (Curtin University)	Curtin University, Department of Planning (WA), Landgate (WA), Swinburne University, City of Canning (WA), Department of Planning & Community Development (VIC), Manningham City Council (VIC).
Using Augmented Reality as an urban design tool. Dr Mark Billinghurst (University of Canterbury)	University of Canterbury, ZNO.

FEATURED PROJECT

Towards operational monitoring of key climate parameters from synthetic aperture radar

The use of Australia's natural resources in an environmentally sustainable manner is critical for the well-being of future generations. Better monitoring of key landscape components is fundamental to improved productivity and environmental health.

This project (co-funded by the Australian Research Council) targets the development of more accurate information about soil moisture and forest structure. Localised soil moisture information is important for agricultural management, as well as being important for weather forecasting at a coarser scale. Better descriptions of forest structure are necessary to better document how Australia is meeting its international climate change obligations. At a more local scale, forest structure is also related to biodiversity, economic productivity, and wildlife habitat.

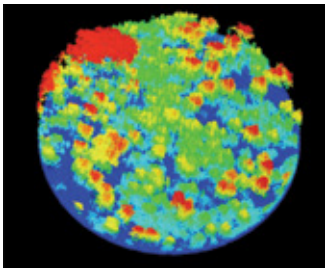
This project explores how a unique airplane-mounted radar/active sensor - the Polarimetric L-band Imaging Scatterometer or PLIS - can improve information about soil moisture and forest structure compared to a variety of satellite-mounted optical/passive sensors. The project is part of a larger long-term project that includes NASA and the Jet Propulsion Laboratory as well as other Australian partners such as Monash University and Airborne Research Australia.

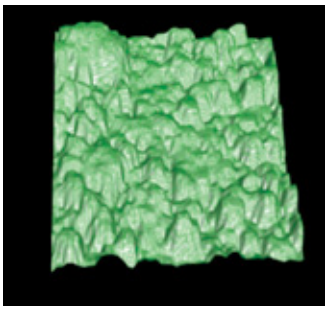
The project team has worked with image providers and commercial software vendors to overcome difficulties in calibration for airborne radar data. Operational users of airborne radar will now not only better understand potential difficulties in using airborne radar, but will also have solutions. Operational users also want to know if the added difficulty of working with airborne radar compared to satellite-based radar is justified. The project team is in the process of making comparisons between airborne PLIS data and satellite-based ALOS PALSAR (obtained from the Japanese space agency JAXA) to guide potential users.

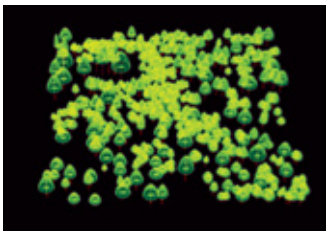
The use of airborne radar for soil moisture and forest structure also requires examination of existing models and methodologies. Exploring different models has also shed light on which factors impact the ability of airborne radar to estimate soil moisture and forest structure. Because radar is an active sensor, it was determined that surface roughness at various scales - individual soil mounds to clumps of plants to entire fields or forests - has a greater impact on airborne radar.

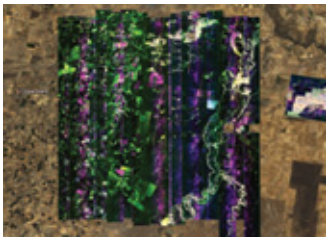
The project team is spending its time developing models that can improve the accuracy of soil moisture measurements and forest structure characterisation extracted from the PLIS airborne radar data. This is being achieved by evaluating the potential contributions of measurements taken on the ground or extracted from LiDAR. The models being used as a basis for this work are those that have shown promise for extracting soil moisture and forest structure from satellite-based radar data.

The potential benefits of project outputs are substantial. Currently soil moisture and forest structure can only be accurately characterised at isolated points on which intensive ground-based measurements are collected. This project has the potential to produce accurate "wall-to-wall" information in an efficient manner.







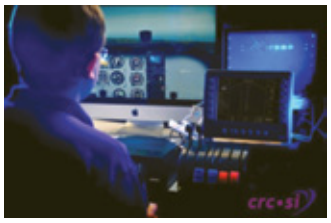


Top four: Forest Metrics extraction from LiDAR data.
Bottom: PLIS calibrated/geocoded data over the Yanco study area and the Gillenbah State forest.

FEATURED PROJECT

"The CRCSI-developed FAS system has been absolutely instrumental in enabling the cost effective and safe capture of our network infrastructure…."

Matt Coleman
ROAMES Capability Development Manager



Top to bottom:
Lead Researcher, R Fechnie.
Specifically modified aircraft fitted with sensors that include photographic and LiDAR laser ranging equipment.
FAS installed in ROAMES aircraft.
FAS in lab testing.

Enhanced flight assist system for automated aerial survey of powerline networks

Summary

The flight path planning and aerial inspection of large powerline networks at low altitude with fixed-wing aircraft is a complex and potentially hazardous task. This motivates the project aims of improvements to safety and efficiency of powerline inspection by automation of the aircraft's planning and control. Since 2009, the CRCSI has researched and developed flight-test-proven automated aerial powerline inspection technologies and the project extends the 2D aircraft flight-path planning, data capture and flight assist concepts developed under previous projects to an active 3D capability. The benefits are:

- reduced pilot workload regarding the horizontal and vertical control of the aircraft and maintenance of safe horizontal and vertical separation from terrain/obstacles and positioning the aircraft at the correct altitude and speed
- consistent data capture and point cloud density
- reduced flight mission times and improved operational efficiencies.

Highlights

The potential benefits of advanced 3D planning and flight control for the powerline network inspection activity include reduced pilot workload positioning the aircraft at the correct altitude, speed and orientation for effective data capture.

In 2012, this project developed 3D strategic flight planning and related aircraft control software for increased operational tempo and safety of fixed-wing inspection aircraft. The planning software is able to optimise inspection paths with consideration of the flight behaviour of the inspection aircraft, terrain variations (hills etc.), and other flight considerations (no fly zones etc.). The feasibility of the developed technology was successfully demonstrated through flight testing. The tests also provided further insight into performance characteristics of the inspection system. Overall, the improved aircraft planning capability demonstrated a total 15-35% reduction in survey flight time.

Concurrently, the project began investigating the benefit of active control of the inspection aircraft (ie. controlling the inspection aircraft on the basis of real-time sensed information). The key benefit of active control is the ability to adjust inspection behaviour to the exact location of the infrastructure currently being inspected (rather than rely on provided GPS location information which may not be 100% accurate). For this purpose, prototype technology was developed that is able to control the inspection aircraft on the basis of powerline infrastructure information detected from visual information in real-time.

Next Steps

The next steps for this project include:

- further evolution of inspection planning technology, towards development of real-time replanning capabilities
- improvements to reliability and frame-rate of sensor-based aircraft guidance technology and flight demonstration
- investigation of advanced autopilot hardware to enable the next levels of automation.

FEATURED PROJECT

Spatial-temporal modelling of cancer incidence, survival and mortality

Summary

This project aims to develop and apply frontier statistical methodology for understanding spatial and temporal patterns in cancer outcomes and related health service provision. In light of the significant economic and quality-of-life burdens that cancer creates, the outputs of this project seek to provide more robust predictions of cancer outcome risk to policy makers, and to inform on the planning and management of health services. This project has four goals:

- development of algorithms for improved estimation and prediction. Models will address a number of issues currently faced in the analysis and presentation of spatial patterns of cancer, including small-area estimation, risk-factor exploration and the use of case information at disparate spatial scales
- model development to link cancer outcomes with health service location and utilisation: Acknowledging the role public health initiatives such as screening play in improving cancer outcomes, methodology capable of defining this relationship over space and time will be developed
- development of methods for informing health service planning and management teams. By linking service use with cancer outcomes, tools for assessing the impacts of resource allocation will be explored
- consideration of other disease types, such as Asthma and Type II Diabetes.

Highlights

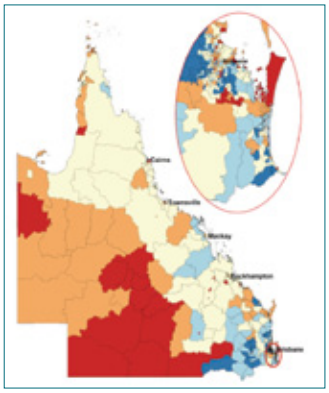
- Work on modelling cancer-incidence data has led to the development of a spatio-temporal model that combines information at the individual case level (eg. age, gender) with covariates available at the areal level (eg. socioeconomic status, geographic remoteness), resulting in more accurate estimates of risk. This marks a novel departure from traditional disease-mapping methods that only use information at a single spatial scale. In addition to improved estimates, these models can be used to identify the level (individual or region) and the geographic location(s) at which to target management options for improved health outcomes.
- Models for describing spatial trends in service use have been developed, focusing on participation in mammography, delivered through the BreastScreen Queensland program. This work is viewed as the foundation for upcoming work on determining the optimal allocation of resources based on available data.
- Collaboration between the Queensland University of Technology and the University of Sydney has resulted in the commencement of work on modelling spatial patterns in Type II Diabetes incidence and hospitalisations data.

Next Steps

- Further model development to predict impacts of resource allocation on utilisation and cancer outcomes.
- Integration of methodology into web-based mapping technology.
- Continuation of extension of methods to other outcomes, including improved modelling of space-time interactions for sparse data.
- Development of novel methods of visualisation and communication of spatial-health model outputs.
- Engagement with other national agencies and international research groups.

Above: Mammography map – Model predictions of catchment areas for participation in mammography services in Brisbane.

Below: Example of model output visualisation for cancer outcomes in Queensland.



FEATURED PROJECT

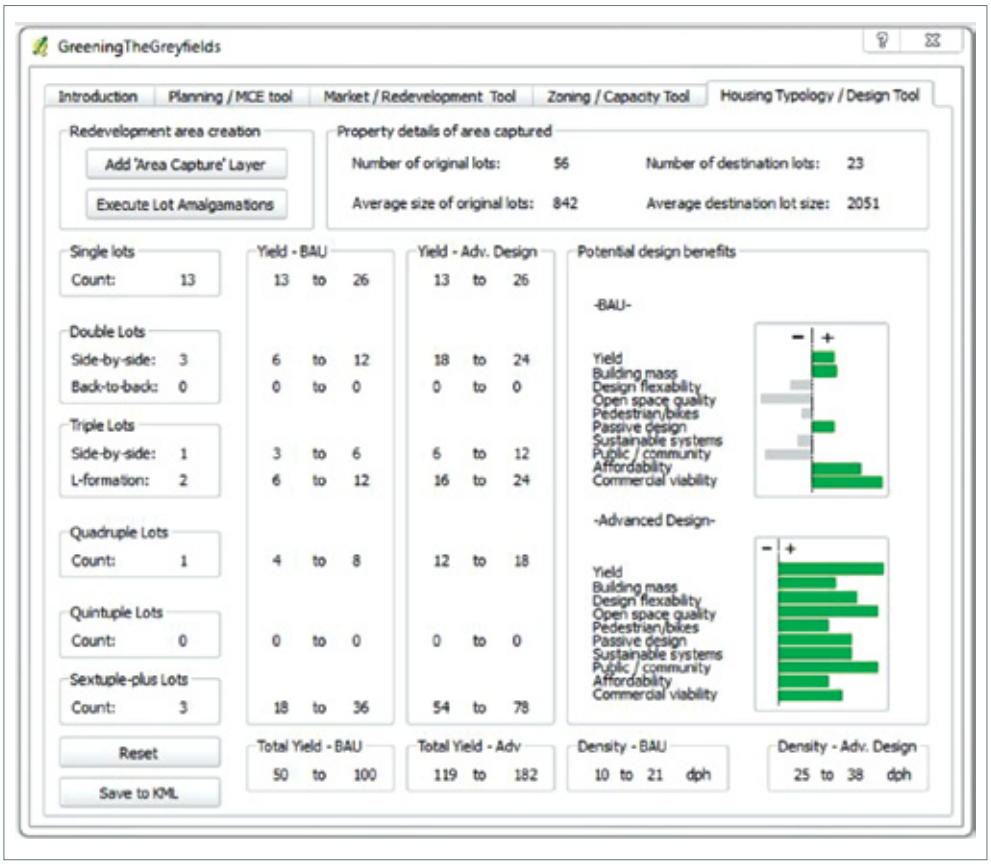
Greening the Greyfields – A Spatial Information Platform for 21st Century Sustainable Urban Planning

Summary

Cities need to constantly be renewed if they are to remain competitive and resilient to the challenges of a changing world. As Australian cities are slated to grow substantially in the next 30 years there is a need to determine how best to direct this growth. The research team is developing spatial decision support tools and strategies to assist planners and policy makers devise sustainable redevelopment solutions with a focus on Australia's ageing middle suburbs. One product has been the ENVISION system that allows users to explore the redevelopment potential of a case-study local government area and begin envisioning future redevelopment options. The aim of ENVISION is to facilitate discussion between various local government departments, and eventually developers and the greater community, to facilitate a shift away from current fragmented redevelopment patterns to more coordinated precinct-scale alternatives. Eventually the project will also offer users sketch-planning, visualisation and assessment tools that build on the ENVISION system for more comprehensive visioning and benchmarking of potential future growth options.

Highlights

The Greening the Greyfields project is divided into four modules that address the questions of "Why?", "Where?", "What?", and "How?" in relation to housing redevelopment. Module 1 investigated the labour-productivity impacts of employment density and accessibility. This research is integral to



Above and right: ENVISION's Housing Typology / Design tool demonstrates how lot amalgamation can lead to higher dwelling yields and better redevelopment outcomes.

understanding the Wider Economic Impacts (WEIs) of investments in transport infrastructure and strategic decisions impacting the location and concentration of future development.

Module 2 developed ENVISION, a shared urban spatial information platform that utilises a wide range of planning-related datasets for exploring the redevelopment potential of local government areas on a lot-by-lot basis. The system draws on datasets related to property valuations, demolitions, zoning, transportation, demographics, water infrastructure, power infrastructure and the location of parks, schools and activity centres, to create indicators that can be combined and mapped in a single user-friendly GIS environment.

It is the simplicity of the system that has been its major success, as it allows for a wide array of information pertinent to land redevelopment to be queried instantaneously by those who have limited experience handling and processing large volumes of data, and who do not have timely access to these varied datasets. The system facilitates a style of decision-making that is based on quantifiable metrics and is in line with currently evolving federal and state planning policies that are pushing for inter-departmental collaboration and community engagement in strategic planning.

ENVISION has been used as an engagement device to drive discussion at the Department of Planning in Western Australia and the Department of Planning and Community Development in Victoria. There has also been uptake of the software in the municipalities of Manningham (Victoria), where it is used by the GIS and planning offices, and in Canning (Western Australia), where it was used in the creation of a local housing study to inform their local housing strategy.

Numerous stakeholder engagement workshops have provided feedback on the system and resulted in a definitive version of the ENVISION being produced. This final version will be implemented by the Australian Urban Research Infrastructure Network (AURIN) as an eResearch tool, where it will be able to access datasets through a federated data architecture for users to access the most up-to-date information.

Left: Residential (green) and commercial (light blue) land are depicted along with redevelopable properties (dark blue) using ENVISION's Market / Redevelopment Tool.

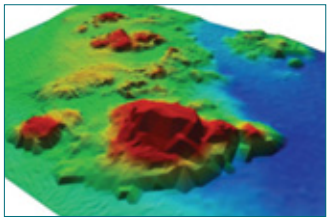
Right: Multi-Criteria Evaluation in ENVISION allows users to determine the most strategically appropriate areas for higher density redevelopment.

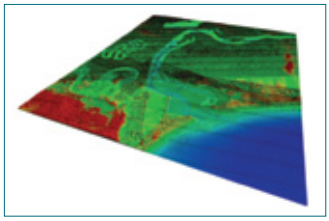
Next Steps

The next steps for this project involve:

- developing a visualisation and assessment toolset as an extension to the ENVISION system. Users will be able to identify their redevelopment precincts and then redesign their precinct in a 3D virtual world with feedback mechanisms in place, benchmarking the design against "business as usual" and other design alternatives
- trialling the entire suite of spatial planning tools during community engagements. The community engagement research will examine how bottom-up planning processes can complement conventional top-down approaches in creating liveable and sustainable communities, and can increase public acceptance and ownership of future redevelopment plans.

CONTRACT RESEARCH OVERVIEW





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

The CRCSI continued, commenced and completed several client-focused projects in 2011-12. These projects were aligned with core research projects and either complemented or enhanced existing research capability, CRCSI objectives and strategy. Brief descriptions follow.

Urban Digital Elevation Model 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 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. Key outcomes from the investment include:

- Over 60,000 km^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
- Improved discoverability and access to elevation data via a national portal (nedf.ga.gov.au) supplying over 300,000 downloads.
- Consistent national guidelines for the collection and processing of high-resolution elevation data implemented as industry standards
- Sea-level rise communication products that have been widely accessed by governments, community and the private sector
- Substantial research to improve the quality and accuracy of DEMs.

Carbon Monitoring to Support the International Forest Carbon Initiative (IFCI)

An initiative of the Department of Climate Change and Energy Efficiency (DCCEE), the IFCI forms a key part of Australia's leadership in reducing emissions from deforestation and forest degradation in developing countries (REDD). A critical component of the IFCI is the development of a global carbon monitoring system (GCMS) that has the capability to use advanced satellite imagery from radar and optical sensors to measure rates of deforestation and forest degradation by monitoring, reporting and verifying (MRV) emissions of greenhouse gases. The GCMS will form a global network of compatible national forest monitoring and reporting systems that meet national reporting requirements, and can potentially be linked, to support domestic and international carbon-trading initiatives. The CRCSI Carbon Monitoring project:

- Evaluated the feasibility of using optical and radar imagery interchangeably in the same carbon-monitoring system
- Demonstrated results of different accuracy assessment procedures for single-data Forest/Non-forest maps and multi-temporal maps showing deforestation and regeneration
- Authored a Forest Carbon Tracking guide on accuracy assessment of remote-sensing products
- Provided training in image processing for carbon accounting

- Contributed research for ongoing use of emerging remote-sensing-derived biophysical parameters for improved forest characterization (forest type, structure, biomass, function), and identification of forest disturbance and degradation events.

Priorities for Investment in Remote Sensing Satellite Technology for Australia

Australia has a strong dependency and reliance on foreign Earth Observation (EO) satellites. This gives rise to questions regarding investment priorities for the nation in EO satellite infrastructure and technologies. This paper provides background to Australia's present complete dependence upon overseas owned and operated EO satellites, and then briefly summarizes relevant strategic objectives. (www.crcsi.com.au/getattachment/b2035ae1-4cb8-42b1-9c8e-2a0768b0b877/.aspx).

Spatial Information for Disaster Response in Australia Report

This report was commissioned by the Australian Space Policy Unit (SPU), Geoscience Australia (GA), the University of New South Wales, the then Department of Environment and Natural Resources (QLD), and the former Land and Property Management Authority (NSW). Its purpose was to review the lessons learnt during the Queensland floods of 2011 and Victorian bushfires of 2009 to enable the spatial information community to better support Australia's ability to manage natural disasters.

(www.crcsi.com.au/getattachment/61ef1eba-1b53-43f8-9aa1-e63ccb7d17d4/.aspx).

Australian Strategic Plan for GNSS

The CRCSI conceived and managed the development of the Strategic Plan to make recommendations to prepare Australia to face the challenges of, and to capitalise on, the opportunities that will flow from imminent, far-reaching changes in the Global Navigation Satellite System (GNSS) domain. The plan was subsequently used to assist the Federal Government to develop both a new Satellite Utilisation Policy and the National Positioning Infrastructure Plan. (www.spatialbusiness.org/site/DefaultSite/filesystem/documents/Miscellaneous/Australian%20Strategic%20Plan%20for%20GNSS.pdf).

Assistance in Development of the National Positioning Infrastructure Plan

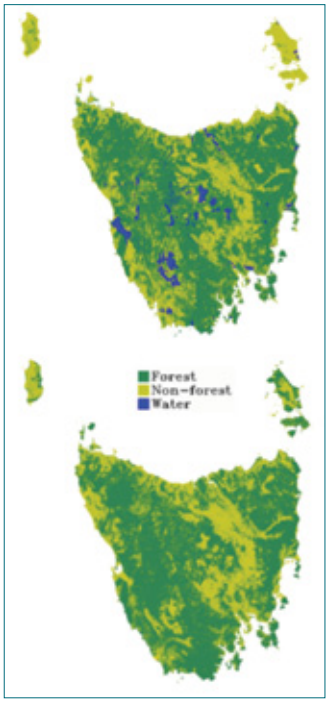
The Government has developed the National Positioning Infrastructure Plan. The CRCSI assisted Geoscience Australia with the development of this Plan. The Plan will: facilitate coordinated access to critical space-based positioning infrastructure; enable a nationwide positioning capability through informed public and private investment and international cooperation; and enhance the nation's capacity to develop and deliver integrated, reliable and sustainable Position Navigation and Timing applications and services.

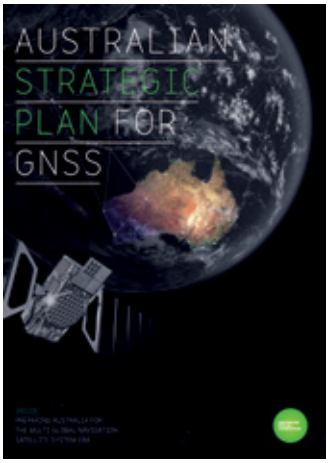
Management assistance

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

Verification update for the National Carbon Accounting System

This project provided an updated verification of forest extent and change for Australia's National Inventory System. The national inventory forms the foundation for Australia's efforts to address climate change and provides information fundamental to the development of domestic mitigation policies and programs, while also tracking Australia's progress towards meeting international obligations.





Top: 2009 forest/non-forest maps derived from radar (above) and Thematic Mapper (below) images.
Middle: Australian Strategic Plan for GNSS.
Bottom: Tongatapu topography and aerial map - part of management assistance given to the Commonwealth.

Projects

Title, Lead Researcher	Partners
An Australian Plan for Global Satellite Navigation Systems. Dr Phil Collier (CRCSI)	Land and Property Information (NSW).
Development of the National Positioning Infrastucture Plan. Dr John Dawson (Geoscience Australia)	Geoscience Australia.
Urban Digital Elevation Modelling (UDEM), Phase 2. Dr Graeme Kernich (CRCSI)	Commonwealth Department of Climate Change and Energy Efficiency.
Flight Assist System (FAS) Demonstrator – Association. Professor Duncan Campbell (Queensland University of Technology)	Queensland University of Technology, Ergon Energy.
Kokoda Remote Sensing Pilot Project. Professor Tony Milne (CRCSI)	Department of Environment & Conservation, Papua New Guinea.
International Forest Carbon Initiative. Professor Kim Lowell (CRCSI)	Commonwealth Department of Climate Change and Energy Efficiency.
Verification of NCAS Forest Extent Maps. Professor Kim Lowell (CRCSI)	Commonwealth Department of Climate Change and Energy Efficiency.
Management of Airborne LiDAR Surveys, Capacity-Building and Coastal-Modelling in the Pacific Region. Dr Nathan Quadros (CRCSI)	Commonwealth Department of Climate Change and Energy Efficiency.

FEATURED PROJECT

Kokoda Remote Sensing Pilot Project

Kokoda Project

In 2008, Australia and Papua and New Guinea committed to cooperate and work together for the protection and sustainable use of the natural and cultural resources of the 40,000 square kilometres that make up the Owen Stanley Ranges region, and which include the Kokoda Track.

The Australian Department of the Environment, Water, Heritage and the Arts (DEWHA) is assisting PNG to undertake a number of land-use and protection projects. This is a whole-of-government initiative and the PNG Department of Environment and Conservation (DEC), with DEWHA's assistance, is currently developing spatial systems and databases to support the land-use planning requirements of the Kokoda Initiative, and the creation of a Sustainable Development Masterplan for the Brown River Catchment, Kokoda Track and Owen Stanley Ranges region.

The Australian Kokoda Taskforce and PNG National Taskforce identified three critical datasets as requirements for the land use planning work for the Kokoda Initiative:

- High-Resolution Digital Elevation Model (DEM) for use in deriving key terrain attributes such as slope, aspect, drainage and susceptibility to erosion
- Current land-use maps for delineating the Kokoda Track and Broader Heritage Values and Interim Protection Zone
- Forest-cover change and biomass assessment.

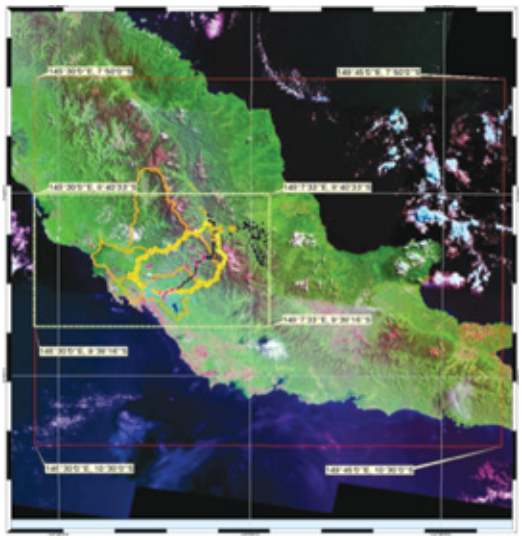
CRCSI assisted in the development of these key datasets through the provision of high-spatial-resolution, digital elevation data for slope analysis, drainage delineation and flood modelling using Satellite Synthetic Aparture Radar (SAR) (Earthdata aerial GeoSAR and Japanese satellite PALSAR) data. These datasets were required to assess the suitability of the Owen-Stanley Ranges and adjacent high-relief hills and foothills for logging, susceptibility of the cleared landscape to erosion, line of site visualisation and to assess the suitability of these areas for different land uses.

Land-cover mapping was also carried out using the combined GeoSAR data set, which included P-band and X-band radar imagery, and in which land cover types, such as forest, plantations and crops, mangroves, clearings and disturbed areas could be readily distinguished.

Above: Gateway marking the beginning of the Kokoda Track.

Bottom left: Map of the Kokoda Track region developed utilising DEM techniques for deriving key terrain attributes.

Bottom right: Mark Williams (4th from left) a CRCSI Researcher, enjoys a drink with colleagues from the PNG National Taskforce.



*"The CRCSI Conference is not only a great opportunity to dip into R&D across the CRCSI, and to network - it is also where I get to see where my cash contributions are being applied and to understand better how I can take advantage of all the various benefits the CRCSI provides." - **43pl company***

*"I got a lot out of the conference and the opportunity to network was fantastic" - **43pl company***

*"Excellent array of presentations - a great chance to catch up on what is going on across the CRC.Chance to catch up with all participants (and new ones). The layout and networking sessions were well designed to foster interactions. The webcasts (when available) will be an added bonus for me to catch up on presentations I missed - well done!" - **Project Leader***

*"I thoroughly enjoyed it and gained a lot as it was a part of my learning curve" - **Government end-user***

*"I thought it was a very interesting and well organized conference - Congratulations. Some of the fresh contacts I made seem to be bearing fruit already" - **International guest speaker***

*"Congratulations on a brilliant conference well organised and superbly run. Well done indeed" - **Research Investment Committee member***

COMMUNICATION & 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 sectors. 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 was held in Brisbane this year and attracted 250 delegates over three days with 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.

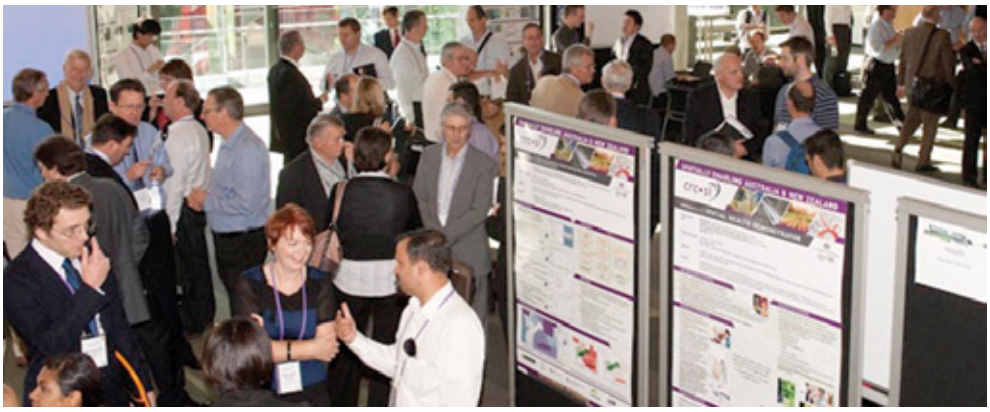
Project participants attend quarterly project management meetings to review progress and discuss future plans and strategic developments across the CRCSI portfolio. These are mostly conducted by teleconference.

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 e.g. the Western Australia Land Information System (WALIS) Forum; as well as international events such as the International Society for Digital Earth (ISDE) Symposium. These are all significant events on the calendar for Australia and most of these 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 construct of a proposed research activity and to promote the outcomes of a given project.



EDUCATION

The CRCSI made good progress towards the Commonwealth Agreement target of 'improving the skilled capability of the Australian and New Zealand workforce' working with the key stakeholders through the National Spatial Education Leadership Group. The Group comprises senior representatives of all of the lead bodies in the spatial industry from government, the private sector and the university and vocational training sectors. The CRCSI led the development of the Terms of Reference for the Group and funded a project to assess the skilled capacity shortage, using Queensland as an initial test case to develop a method for scaling-up nationwide and prepare a recommended suite of measures to improve the national skills shortage.

Thirteen postgraduate students commenced in 2011-12 with either full or top-up scholarships, bringing the total cohort of continuing and commencing students to twenty-seven. CRCSI have forty current or completed post-graduates and is well on track to meet and exceed the overall target of having (enrolled or graduated) at least fifty PhDs and Masters by 2018.

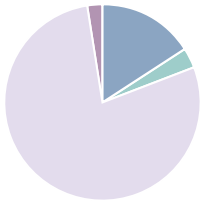
Students are involved in all major projects. Each student is required to have an external end-user supervisor. CRCSI conferences have a specific session for students. Highlights from the 2012 event included networking, cultural learning, meeting other PhD students, and improved interactivity and collaboration.

Table: 16 PhDs have completed their studies with CRCSI since 2010. Further details can be found through the CRCSI website.

CRCSI Student Completions

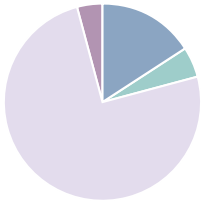
Name	Title of Thesis	Graduating University
Anna Donets	Using Single Receiver GPS Observations to Analyze the Dynamic Motion of Large Engineering Structures.	Melbourne
Jun Wang	RTK Integrity.	QUT
Michael Filmer	An Examination of the Australian Height Datum.	Curtin
Kui Zhang	Advanced InSAR Techologies.	UNSW
Eric Zhengrong Li	Aerial Image Analysis Using Spiking Neural Networks with Application to Power Line Corridor Monitoring.	QUT
Alex Ng	PsinSAR Radar Interferometry.	UNSW
Adam Roff	Hyperspectral Imagery for Vegetation Management.	UNSW
Michael Day	Hyperspectral Remote Sensing for Land Management Applications.	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

FINANCE



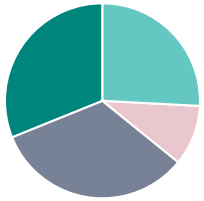
2011-12 Expenditure by Department

- Governance & Administration 16%
- Business Development 3%
- Research Program 78%
- Communications & Education 3%



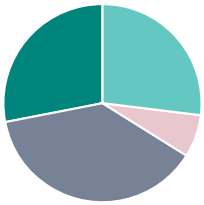
2012-13 Forecast Expenditure

- Governance & Administration 16%
- Business Development 5%
- Research 75%
- Communications & Education 4%



2011-12 Funding by Source

- Essential Participants 26%
- Other Participants 10%
- CRC Program Funding 33%
- Commissioned Research/Other 31%



2012-13 Funding Forecast

- Essential Participants 27%
- Other Participants 7%
- CRC Program Funding 38%
- Commissioned Research /Other 28%

2011-12 FTE inkind

- Positioning Program 30%
- Feature Extraction Program 17%
- Spatial Infrastructures Program 6%
- Applications Program 47%

The CRCSI was in a healthy financial state at the end of the 2011-12 year. Total cash and inkind contributions were $27.6M for the period, favourable year on year by $2.7M. 75% of CRCSI expenditure went into the Research Program during the period, a trend expected to be replicated in 2012-13.

Funding (Cash) ($000s)	2010-11 Actual	2011-12 Actual	2011-12 Budget	2012-13 Budget
Essential Participants	4,093	3,039	3,786	3,239
Other Participants	238	1,121	522	852
CRC Program	3674	4,002	4,002	4,452
Commissioned Research/Other	5422	3,607	3,254	3,311
Total Funds	**13,427**	**11,769**	**11,564**	**11,854**

Expenditure (Accrual) ($000s)	2010-11 Actual	2011-12 Actual	2011-12 Budget	2012-13 Budget
Essential Participants	1,662	1,565	2,091	2,104
Other Participants	333	332	438	595
CRC Program	3,861	7,724	10,182	10,004
Commissioned Research/Other	0	299	423	461
Total Expenditure	**5,856**	**9,621**	**13,134**	**13,164**

Inkind Statement	Staff FTE inkind			Non-staff inkind ($'000s)		
	Actual 2010-11	Actual 2011-12	Budget 2011-12	Actual 2010-11	Actual 2011-12	Budget 2011-12
Positioning Program	6.0	11.3	3.9	206	861	1,375
Feature Extraction Program	4.6	6.4	12.5	789	1,370	1,227
Spatial Infrastructures Program	2.9	2.3	3.2	1,282	1,021	948
Applications Program	18.1	18.2	28.0	1,704	3,773	1,956
Total	**31.6**	**38.2**	**47.6**	**3,981**	**7,025**	**5,506**

Contributions ($000s)	2010-11 Actual	2011-12 Actual	2011-12 Budget	2012-13 Budget
CASH	13,427	11,769	11,564	11,854
FTE inkind	7,526	8,848	11,284	12,066
Non-Staff inkind	3,981	7,025	5,506	5,146
Total Contributions	**24,934**	**27,642**	**28,354**	**29,066**

CRCSI PARTNERS

Essential Partners

43 Version 2 Pty Ltd

Curtin University of Technology

Department of Natural Resources and Mines, QLD

Ergon Energy Corporation Limited

Geoscience Australia

Land and Property Information (LPI) of the Department of Finance and Services, NSW

Landgate, WA

Queensland University of Technology

The University of New England

University of Canterbury

University of Melbourne

Department of Sustainability and Environment, VIC

Support Partners

Defence Imagery and Geospatial Organisation

Department of Health, WA

GEOIDE (Inc), Canada

Land Information New Zealand

Department of Environment Climate Change & Water, NSW

Delft University of Technology

Energex Limited

Murray-Darling Basin Authority

Royal Melbourne Institute of Technology University

Spatial Information Systems Limited

Swinburne University of Technology

Telethon Institute for Child Health Research, WA

The University of New South Wales

Western Australian Agricultural Authority

Wuhan University

43PL COMPANIES

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

Head Office

PO BOX 672
Carlton South,
VIC 3053
Australia

t +61 3 8344 9200
e crcsi@crcsi.com.au
w www.crcsi.com.au

Regional Contacts

WA
Michael Ridout
t +61 8 6143 6830
e mridout@crcsi.com.au

QLD
George Curran
t +61 4 3104 1336
e gcurran@crcsi.com.au

ACT/NSW
Philip Tickle
t +61 2 6249 9769
e ptickle@crcsi.com.au

NEW ZEALAND
Mary Sue Severn
t +64 4 460 0188
e msevern@linz.govt.nz

An Australian Government Initiative