

Australia and New Zealand CRC for Spatial Information Year in Summary 2015-16





BusinessCooperative Research
Centres Programme



Acknowledgements

The CRCSI wishes to acknowledge image contributions by the broader CRCSI team and the spatial information research community.

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Currency quoted in Australian dollars.



Business Cooperative Research Centres Programme



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Foreword by Dr Peter Woodgate

e strive to be at the forefront of applied research using spatial technologies for our 120 partnering organisations from the university, government and private sectors.

This Year in Summary report highlights our core activities and achievements over the last 12 months.

The influence of our research is attributable to the transformative power of the spatial technologies, harnessed for the benefit of end users. We see a number of drivers that will increase opportunities for users of spatial technologies:

The number of global and regional satellite navigation systems is set to double over the next few years. The extent and range of precise indoor positioning technologies is also blossoming. Taken together with Australia's coordinated approach to the development and delivery of a National Positioning Infrastructure strategy led by Geoscience Australia, these developments will power a new range of navigation and positioning opportunities.

- The intelligent web, known as the semantic web, will accelerate the development of geo apps and services that will operate on data from all sources. Organisations that hold large data stores (spatial and non-spatial), and/or draw on data from federated sources will find the skill mix of their workforce change as they harness the increasingly customised analytics used to produce a vast new range of information products. Analytics are set to be a huge driver over the next decade with substantial employment growth.
- The embedding of spatial thinking, and its technology and services into the supply and value chains of Australia and New Zealand, is still in its early days. Health, built environment and food are three areas that will see profound change. Whilst not a focus for us at the moment, intelligent transport is another. Virtually every supply chain has a massive transformation coming.
- On the back of the satellite revolution, and driven by far cheaper lightweight satellites that by some estimates will triple the number in service and be available to Australia and New Zealand over the next five years, the contribution of earth observation is set to substantially increase.

Our current joint venture term ends in June 2018 and we are committed to ensuring the investments made by our partners yield the highest possible return for them. We are also working with our three colleges (Industry through our private sector cluster 43pl, Government, and University) that represent our partners to develop a plan for a successor entity that will meet their long term needs for applied research in Australia and New Zealand (see: www.crcsi.com.au/future).

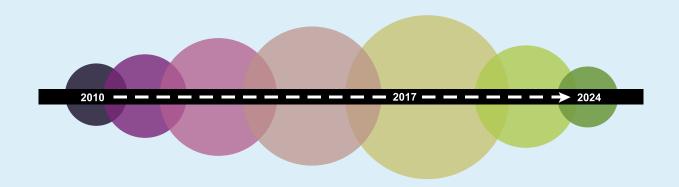
On behalf of our Board I would like to thank all our staff, researchers and partners for another excellent year of achievements. I would also like to thank the CRC Programme for its tremendous ongoing support.

Dr Peter Woodgate CEO

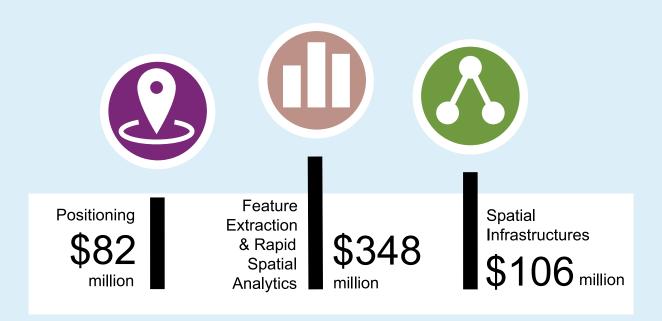


Impact from Research Investment

The CRCSI impact from 2010 towards 2024



\$733 million





\$182 million

Applications



Preventative health, early disease detection and efficient health service delivery



Sustainable urban development tools that increase planning efficiency and liveability



Best practice on-farm tools and techniques that reduce labour costs to prepare, manipulate and extract



\$15

Education



The education program is on track for 55 PhD and Masters completions

Our Purpose and Impact

he Australia and New Zealand CRC for Spatial Information (CRCSI) undertakes collaborative research that leads to the spatial enablement of both nations. To achieve this, the CRCSI pushes the frontiers of spatial science in partnership with government agencies, the private sector, university researchers, and international organisations.

The purpose of the CRCSI is to find robust solutions to three major challenges:

1. Solving the technical challenges that will permit Australia to use all global and regional navigation satellite system signals to deliver 2cm positioning accuracy to anybody, anywhere outdoors in real-time. This will support the development of Australia's National Positioning Infrastructure and is estimated to result in over \$32 billion of new value to the Australian economy (for precision agriculture, autonomous transport and infrastructure construction).

- 2. Improving the ability and efficiency of government and industry to rapidly create and value-add spatial information products from mobile devices and cloud-based infrastructure (examples include the use of drones for monitoring powerline infrastructure, real-time analysis of patterns of people movement for improved logistics planning and safety, road crack detection and maintenance and visualisation of traffic).
- 3. Identifying and exploiting the emerging capabilities of the intelligent web to enable the Foundation Spatial Data of Australian and New Zealand governments, and the critical supply chains that are underpinned, to support value-added use (city planning and the regeneration of old industrial areas, health services, and the agricultural value chain).

The solutions to these challenges will lead to the accelerated uptake of spatial science and technologies by key end users, spawning major innovation and productivity advances in the industry sectors

Some Future Impacts to 2024



\$82M through the accelerated uptake and utilisation of the National Positioning Infrastructure (NPI). It is recognised these

outputs will facilitate economic and social impacts across multiple industries including mining, transport, maritime, aviation, land management and surveying, utilities and location based services.



\$106M. The continuing use of Creative Commons licencing across government and efficiency savings due to

the adoption of semantic web technologies and supply chain frameworks.



\$241 W. Cost reductions in vegetation management by using software and improved technology solutions Australia-wide.



\$182M. The adoption of new spatial applications:

- Staff efficiency and improved health services through the use of geospatial tools
- Uptake of sustainable urban development software and systems
- Development of standards and methodologies that allow the rapid analysis of preparing, manipulating and extracting spatial information.



of agriculture, natural resources and climate change; defence; energy and utilities; the built environment; and health.

The impact from CRCSI activities since 2010 is expected to be \$733 million by 2024. For every \$1 invested by the CRCSI there will be a resulting benefit of \$2.50 to Australia and New Zealand directly attributable to the research. These benefits are calculated using the Commonwealth Government's economic impact tool which is specifically designed to provide accountability for statements of return on investment for the CRC Programme.

A Selection of Achievements during 2015-16

First-ever demonstrations in Australia of a driverless robotic tractor navigated remotely and accurately (to within 5cm of true) by a satellite. The tractor accessed the communications channel on the Japanese positioning satellite QZSS without being connected to a mobile phone network. The satellite also operated the tractor's power take off unit. This success puts Australia right at the forefront of developing the capability to control autonomous vehicles safely and reliably by satellite anywhere on the continent, irrespective of access to our existing communications network, a plus in remote areas. The research was set up under an MOU between the Australian Minister for Industry and the Japanese Minister for Internal Affairs and Communications.

- The satellite imaging based pasture monitoring system, the NRM Hub, now services 300 grazing properties (up from 40 last year) covering more than 50 million hectares, and processes 30 years of satellite imagery including the latest image in 30 seconds delivered to the pastoralist through a simple app. The Hub delivers up to 30% improvements in pasture productivity. This system is set to go commercial with the support of Meat and Livestock Australia.
- Delivered the technical components of the Datum Modernisation Roadmap in conjunction with the Intergovernmental Committee on Surveying and Mapping (ICSM). The next generation dynamic datum allows Australia's spatial information to be aligned and maintained relative to a global reference frame that reflects the complex dynamics of the Earth's crust. This research is leading the world and puts Australia and New Zealand amongst the first countries to transition to a full time-varying reference frame for all spatial information and related products and services.
- First response mapping with the Vanuatu Globe that enabled hundreds of users such as the Vanuatu Government, the World Bank, and the people of Vanuatu to upload real-time imagery of damaged areas, affected houses and inundated roads in the days following Cyclone Pam in March 2015.

- Creating sustainable suburbs within existing built environments that allow policy, local government and the community to come together with a common set of "liveability" criteria.
- In health, we have developed a clinical tool that provides 3D facial analysis of patients within 20 minutes of data capture. This tool and its analysis software is known as 3D-FAST. The use of 3D facial analysis will provide new knowledge into disorders, rare diseases and clinical genetics.

Strategic Plan 2014-18

VISION: SPATIALLY ENABLING AUSTRALIA AND NEW ZEALAND

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

SUCCESS BY 2018

By 2018 the CRCSI will be recognised worldwide for the high impact of our research. A thriving spatial information industry will acknowledge the central role of the CRCSI. We will be considered an essential partner for complex spatial information research collaborations both locally and internationally.

OUR VALUES

We will be strongly collaborative in our relationships, strive for excellence in our research, and aim to be transformational in our impact.

STRATEGIC OBJECTIVES 2014-18

Program 1: National Precise Positioning

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.

Program 2: Rapid Spatial Analytics

To conduct research that improves the ability and efficiency of government and industry to rapidly create and value add to spatial information products, manually or through automation, from devices and cloud-based infrastructure.

Program 3: Spatial Infrastructure for Australia and New Zealand

To identify and exploit the emerging capabilities of the semantic web to enable Foundation Spatial Data and spatial data supply chains to create value-added applications.

Program 4: Applications

To realise high impact use of the CRCSI's research in the following areas: Agriculture, Natural Resources and Climate Change through the creation of a biomass and carbon monitoring system for high resolution and high frequency applications on farms and through improved environmental monitoring; Defence by adapting the capabilities of the CRCSI's research portfolio; Health by helping agencies to spatially enable clinical databases; and Built Environment to develop new tools and strategies to support sustainable urban planning and built infrastructure development.

Program 5: Education

By 2018 the CRCSI will have at least 51 PhD and Masters completions through our university partners, all of whom have significant industry experience.

Program 6: Industry Development and Sustainability

- Industry development; assist our partners, in particular 43pl, develop and exploit the CRCSI intellectual property.
- Commissioned research and other funding; generate an additional \$11M of activity to June 2018 tackling complex research needs involving multiple partners from both the public and private sectors.

PERFORMANCE INDICATORS

- A solution for the impediments of multi-GNSS signal processing and economic arguments for a continent-wide, ubiquitous, sparse, precise positioning network
- Adoption by our partners of new methodologies and software tools that enhance the level of rapid automation of data fusion, feature extraction and analysis
- Wide recognition by partners of the CRCSI's role in helping establish and value add to critical supply information chains
- High impact end user applications adopted in each Application Program.



Available Intellectual Property

he CRCSI regularly releases intellectual property developed from its projects for use by partners and other interested organisations. A full list of the available intellectual property can be found at: www.crcsi.com.au/commercial/ with three selected examples highlighted here:

QA4LiDAR

QA4LiDAR simplifies, standardises and automates the quality assurance process for airborne topographic and bathymetric LiDAR data. The tool saves users time with robust data quality that is fit-for-use. As a tool that replaces timeintensive manual tasks, QA4LiDAR increases the rigour and completeness of quality assurance checks. Developed through collaborative CRCSI research, QA4LiDAR has been designed to ICSM standards and can be deployed for any aerial LiDAR data capture across Australia and the Pacific.

The independent checking mechanism can perform on supplied bathymetric or topographic LiDAR data by the LiDAR provider after acquisition and/or upon delivery to the contracting agency, in an effective and efficient manner.

Designed for use by data suppliers and local, state and federal government data custodians, QA4LiDAR allows transparency between government and private industry processes and expectations.

The tool provides a comprehensive list of checks, requiring minimal manual work, including:

- Delivery completeness and file corruption
- File naming and attribution
- Tile based classification statistics
- Survey control check
- Absolute and relative vertical accuracy
- Point density and DEM resolution
- Flight line coverage
- Data extent
- Visual review platform

To register interest and test the tool please go to: www.qa4lab.com/downloads

AusCoastVDT

Australian Coastal Vertical Datum Transformation (AusCoastVDT) Software is an easy-to-use vertical datum transformation tool, developed in collaboration with the CRCSI. The tool includes transformations between data referenced to the GRS80 ellipsoid (GDA94)/WGS84 ellipsoid (WGS84), Lowest Astronomical Tide (LAT), Mean Sea Level (MSL), the Australian Height Datum (AHD), Highest Astronomical Tide (HAT) and other tidal vertical datums of user interest (and vice versa). The tool was developed in 2013 and updated in 2016, with the supplied vertical separation grid based on the limited data available at the time. The grid will be updated as new information becomes

available. The tool also offers the option for users to supply their own vertical separation grid.

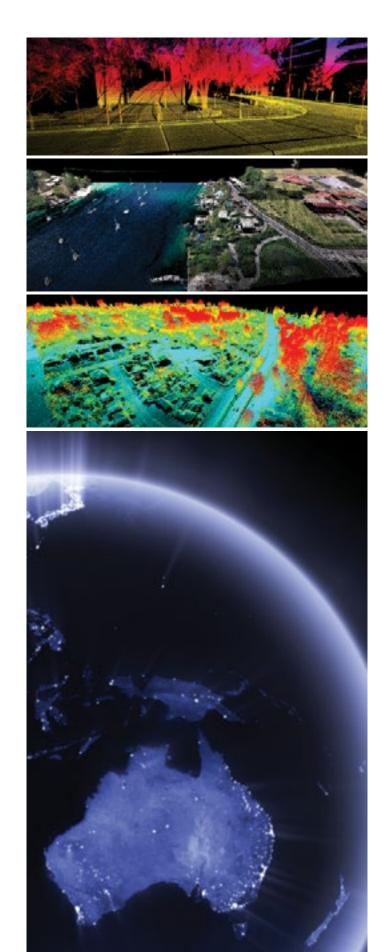
See: www.icsm.gov.au/tides for more details and to access the software.

BARISTA

Barista is available as open source. Barista is an easy-to-use photogrammetric software package, primarily for the generation of spatial information products from satellite imagery. Barista has been tailored for 3D geopositioning and feature extraction from single images. It calculates and compensates for biases in satellite position and orientation so that it is possible to use a single control point for a series of adjacent images. The core technical features are:

- High-accuracy geopositioning from high-resolution satellite imagery (HRSI) via bias-corrected RPCs (suited to IKONOS and QuickBird) which includes a rigorous physical model (eg. for SPOT5 and ALOS) and the affine projection model
- Ortho-image generation
- Pansharpening
- Monoplotting of points, lines and buildings to create 3D models from single images (requires an underlying DEM); affords building height determination.

To access this software please download at: www.baristasoftware.com.au

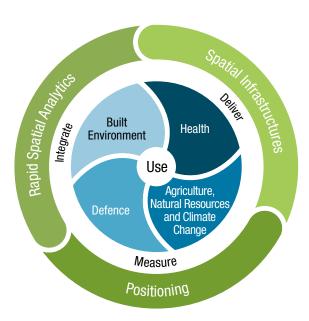


Program Overview

nd user applications are the central focus of the research conducted by the CRCSI. Four key program areas are supported by three research themes.

RESEARCH THEMES

- Positioning; the delivery of 2cm realtime accuracy, the National Positioning Infrastructure strategy and the creation of a dynamic datum.
- Rapid Spatial Analytics; to improve the government's and industry's ability to rapidly use spatial information on mobile and cloud infrastructures.



Spatial Infrastructures; to find new intelligent ways to improve the organisation, access and use of spatial data.

PROGRAM AREAS

- Agriculture, Natural Resources and Climate Change: On-farm application of spatial tools to increase profitability; high resolution, high frequency environmental monitoring in the natural environment; and development of open source spatial tools to adapt to rising sea levels.
- Defence: The adaption of current research outcomes to improve Australia's defence capabilities.
- Built Environment: To create new tools to support sustainable built infrastructure development.
- **Health:** To improve efficiency of health resource management and increase knowledge of disease cause through spatial technology.

TABLE 1: A SELECTION OF CRCSI PROJECTS

* Newly funded CRCSI projects in 2015-16 and A completed projects in 2015-16

Project Title	Lead Researcher
POSITIONING	
^New carrier phase processing strategies	Prof Peter Teunissen, Curtin University
Next Generation Australian and New Zealand Datum	Prof Chris Rizos, University of NSW
^Multi-GNSS Processing Strategies and Services	Prof Yanming Feng, QUT
^GNSS test track	Dr Allison Kealy, University of Melbourne
^Real-time Positioning with the Quasi-Zenith Satellite System	Dr Suelynn Choy, RMIT University
Development of Analysis Centre Software	Dr John Dawson, Geoscience Australia
^Evaluating the positioning capabilities of Locata terrestrial unfriendly environments – Phase 1	Prof Chris Rizos, University of NSW
Near RT Tropospheric Zenith Delay Estimation using GPS	Dr John Dawson, Geoscience Australia
Multi-GNSS PPP-RTK Network Processing	Prof Peter Teunissen, Curtin University
*Ionospheric Modelling to support ambiguity resolution for PPP-RTK	Dr Mike Terkildsen, Bureau of Meteorology
*Satellite Delivery of Augmented Positioning Data for PPP/PPP-RTK	Dr Suelynn Choy, RMIT University
*Beidou precise orbit and attitude modelling for PPP-RTK	Dr Stavros Melachroinos, Geoscience Australia
Development of AUSGeoid2020	Mr Nick Brown, Geoscience Australia
RAPID SPATIAL ANALYTICS	
Topographic Mapping Feature Extraction	Dr Chunsun Zhang, RMIT University
LiDAR QA Tool	Dr Nathan Quadros, CRCSI
Economic Value of Earth Observation from Space to Australia	Mr Chris Penning, CRCSI
^Mapping Rivers and Tree Crowns from LiDAR and Imagery	Dr Nathan Quadros, CRCSI
^Extending Development of the ComQAT Airborne LiDAR QA Tool	Dr Nathan Quadros, CRCSI
^Tools to automate Asset Capture from Earthmine Imagery	Mr Michael Borck, Curtin University
*Development of a mobile mapping QA Tool	Dr Nathan Quadros, CRCSI
State of Environment Pilot for Digital Reporting System	Dr TO Chan, Victorian Department of Environment, Land, Water & Planning
*Rapid Analytics Interactive Scenario Explorer	Dr Chris Pettit, University of NSW
	Mr Bradley Zawodny, NSW Department of Finance, Service and Innovation
*Open Spatial Analytics	A/Prof Chris Bellman, RMIT University
	Dr Lola Suarez, RMIT University

TABLE 1: A SELECTION OF CRCSI PROJECTS (continued)

* Newly funded CRCSI projects in 2015-16 and ^ completed projects in 2015-16

Project Title	Lead Researcher
SPATIAL INFRASTRUCTURES	
Semantic Web Technologies for Next Gen Spatial Infrastructures	Ms Kylie Armstrong, CRCSI
Semantic web Technologies for Supply Chain Models	Ms Kylie Armstrong, CRCSI
^Optimising the Supply Chain for Geocoded Addressing in Australia	Ms Kylie Armstrong, CRCSI
^Pilot Innovative Location Addressing in Australia	Mercury Project Solutions Pty Ltd
^Biomass Business	Prof David Lamb, University of New England
^Capturing Spatial Know-how for Agriculture – Phase 1	Mr Tim Neale, Precision Agriculture Pty Ltd
Big Data Solutions for Environmental Monitoring	Mr Chris Penning, CRCSI Dr Adam Lewis, Geoscience Australia
Tools for Real-time Biomass Estimation in Pastures	Prof David Lamb, University of New England
Natural Resource Management Spatial Hub: better management decisions in the Rangelands	Mr Phil Tickle, CRCSI
^Maintaining ground cover in mixed farming systems	Mallee Sustainable Farming Inc
Carbon accounting in diverse landscapes for carbon markets	A/Prof Brian Wilson, University of New England
*Monitoring and Forecasting Framework for SE Australian Forests	Dr Andrew Haywood, European Commission (European Forestry Institute)
	Prof Simon Jones, RMIT University
*Monitoring through many eyes the Great Barrier Reef	Prof Kerrie Mengersen, QUT
*Spatio-temporal visualisation of irrigated cotton root development	Mr Brendan Griffiths, University of New England
*NRM Hub extension	Mr Phil Tickle, CRCSI
HEALTH	
Utilisation of Epiphanee	Ms Paula Fievez, CRCSI
CliniFace	Dr Gareth Baynam, WA Department of Health
^Disaster impact and spatial links to related health outcomes	Prof Simon Kingham, University of Canterbury
Real-Time Environmental Sensors to Improve Health in the Sensing City	Dr Malcolm Campbell, University of Canterbury
BUILT ENVIRONMENT	
Barriers/Opportunities for Adoption of Spatial Tools in Planning	Dr Chris Pettit, University of NSW
^Greyfield Precinct Identification Tool	EdgResearch Pty Ltd
Greening the Greyfields – Modules 3 and 4	Prof Peter Newton, Swinburne University
^ 'Willingness to Pay' for Urban Renewal in Sydney	Dr James McIntosh and Mr Ben Hendriks, MECONE

Research Highlights

he CRCSI supported and co-funded
 12 new projects during the year with
 18 projects reaching completion. Table
 One highlights a selection of current research, with full details available on the CRCSI website.

RESEARCH

Seven research achievements for 2015-16 have been highlighted to represent the breadth of the CRCSI's work.

LEADING EDGE OF GNSS RESEARCH

The CRCSI's Positioning Program is working at the leading edge of GNSS research. New algorithms are being developed to integrate multi-frequency, multi-GNSS signals for precise (ambiguity resolved) real-time positioning through the PPP-RTK approach. This approach is unique, integrating GNSS carrier phase observations in an "un-differenced, un-combined" model that is rigorous, efficient, flexible and robust. In developing and testing PPP-RTK, notable achievements include:

- Analysis of IRNSS single-point positioning using real and simulated data
- Analysis of IRNSS carrier-phase data including an assessment of single frequency (L5) positioning when combined with GPS, QZSS and Galileo
- Analysis of new GLONASS CDMA L3 ambiguity resolved carrier phase positioning

- Characterisation of multi-GNSS receiver code and phase biases using mixed receivers
- Demonstration of the accuracy and viability of multi-GNSS positioning using low cost, single frequency receivers.

The Program has also undertaken research to support Australia and New Zealand's transition to a dynamic datum. The dynamic network adjustment software (DynaNet) has been modified to allow the continuous adjustment and analysis of geodetic data to deliver time variable coordinates. DynaNet can efficiently combine millions of measurements and hundreds of thousands of stations through a rigorous estimation process. In the height domain, researchers are working on a new national geoid model that will, for the first time, provide uncertainty estimates when transforming GNSS-derived elevations to the Australian Height Datum. A new ionospheric model is being developed in support of multi-GNSS ambiguity resolution. Evaluation of the Japanese QZSS system for national delivery of the PPP-RTK correction message for real-time use is well advanced. The Analysis Centre Software (ACS) is the core implementation strategy for the Program's research. The ACS will underpin Geoscience Australia's plans for a National Positioning Infrastructure and is set to attract international interest as a unique, next generation multi-GNSS processing capability.

The various outputs and achievements of the Program will ultimately support new national positioning capability that is fit-for-purpose and fully exploits the benefits of the multi-GNSS era. A raft of industries will benefit from the research,

including precision agriculture, autonomous vehicles, machine automation, intelligent transport systems, logistics, transport, construction, utilities and many more.

NRM SPATIAL HUB

A satellite imagery based online tool for monitoring pasture for broadacre livestock production. The Stage 1 build and demonstration phase of the Natural Resource Management Spatial Hub (NRM Spatial Hub) was completed in June 2016. The initiative was led by the CRCSI, Rangelands NRM Alliance (representing 14 regional natural resource management bodies), the Queensland Remote Sensing Centre, and supported by the National Landcare Programme, Meat and Livestock Australia, AAM Group (43pl member), and more than 20 other organisations. In its first stage, the project anticipated recruiting 40 graziers covering a million hectares, but has now achieved 300 properties across 50 million hectares. In a world first, the NRM Spatial Hub provides grazing managers with the capability to map, plan, analyse, value and monitor property infrastructure, pasture and groundcover to improve pastoral and natural resource management. In a few seconds a manager can analyse 30 years of satellite imagery to determine baseline changes in groundcover for a whole property over low bandwidth telecommunications.

Property managers have identified a number of benefits:

- 95% of users responded that the NRM Spatial Hub improves productivity, profitability and sustainability of their property
- 50% estimated the NRM Spatial Hub would save 10-30 labour days a year

- 75% responded it would increase safe carrying capacity of livestock
- 72% responded that this type of technology is important for the viability and sustainability of their business
- 50% said financial benefits over the next five years would be between \$15 000 and \$25 000.

The CRCSI has now entered Stage 2 in partner-ship with Meat and Livestock Australia, Australian Wool Innovation, and the Rangelands NRM Alliance. In Stage 2 we are supporting existing users; extending the demonstrations into higher rainfall grazing systems; continuing with technical development; and putting in place a sustainable business model by mid-2017. Development has also commenced on regional reporting tools sponsored by the NSW and Queensland governments that will be made available to all states, which will provide extension staff the ability to routinely report on the impact of government funding programs, and the condition of leasehold land and travelling stock reserves.

DIGITAL ELEVATION MODELLING

In response to the Coalition of Australian Government desire to better manage the impact of sea level rise, over the past six years the CRCSI has led the development of the National Elevation Data Framework (NEDF) program coordinating over 250 000km² of high resolution DEM mapping along built-up areas of the Australian coast. This dataset makes Australia one of the most advanced countries in the world for modelling sea level rise in populated areas.

Building on this work under an Australian aid program, the CRCSI coordinated the digital



elevation acquisition programs across a number of countries in the Pacific including Vanuatu, Papua New Guinea, Tonga and Samoa. During the past year these high resolution DEMs laid the foundation for online tools that enable communities to visualise the impact of future sea level rise scenarios.

This knowledge assisted in the recovery from the impact of Cyclone Pam in March 2015 in Vanuatu by using satellite imagery and online mapping tools to estimate the number of dwellings and the length of road subject to inundation and to show the online location of areas in need of assistance for emergency responders. As a result of this work the UN awarded the development team of NGIS Australia and the CRCSI a UN Momentum for Change Lighthouse Award during the Paris COP21 Climate Summit in December 2015, recognising the team's contribution to creating a climate resilient future through the development of new open tools and the accompanying education program. Australia's Foreign Minister, the Hon Julie Bishop MP, gave a speech during COP21 highlighting the achievements of the project team in the Pacific.

The work has led to other developments. NGIS Australia used the expertise gained through the DEM mapping of the Australian coast to launch the Coastal Risk Australia website in April 2016. The research builds on previous knowledge created by the NEDF elevation models and uses the Intergovernmental Panel on Climate Change sea level rise predictions over the next century together with the DEM data and imagery to model sea level

inundation scenarios interactively online as driven by the user. This multi-agency collaboration has led to other research and government agencies accessing the data created by the DEM to develop additional tools such as the National Climate Change Adaptation Research Facility (NCCARF) CoastAdapt information delivery website.

BUILT ENVIRONMENT LIVEABILITY

The Built Environment Program has developed a set of spatial tools, 2D planning tool (Envision) and the 3D visualisation and assessment tool (Envision Scenario Planner). These are collectively known as the 'Greening the Greyfields' tools. This year Christchurch City Council in New Zealand embedded these tools into the redevelopment of the cityscape as a result of the earthquake sequences of 2010 and 2011. These tools form one of the approaches that will support 'Plan Melbourne Refresh', the metropolitan strategic planning document designed to set Melbourne's planning framework for the next few decades.

The Greening the Greyfields toolkit is specifically designed to be applied to inner city suburbs currently undergoing renewal. In most cases, this means replacing ageing, low density, privately owned housing with strategically placed medium-and high-density, high-rise stock. The toolkit proffers the ability to plan at precinct level for sustainable buildings, walkable quarters, a sense of community, and a new place to live and work, delivering sustainable opportunities and better economic outcomes to the urban environment. These applications access online datasets including

property valuations, demolitions, zoning, transportation, demographics, water infrastructure, power infrastructure, and the location of parks, schools and activity centres. The CRCSI also holds intellectual property over 500 building typologies, assessed for energy, carbon, water and other consumables. Planning options are developed as outputs based on pre-determined criteria which include low-carbon living, green space, schools, public housing and mid-to-high rise development corridors.

There are 10 local and state agencies across Australia and New Zealand using the Greening the Greyfields toolkit including the Victorian Department of Environment, Land, Water and Planning, the New Zealand Ministry of Business and Employment, New South Wales Office of Environment and Heritage, and the cities of Maroondah, Yarra, Brimbank, Greater Dandenong, Christchurch, Stirling and Canning.

DIGITAL NATIONAL CANCER ATLAS

The existing partnership with the Cancer Council of Queensland and QUT that developed the Queensland Cancer Atlas, has now been extended to the Cancer Council of Australia, the Australian Institute of Health and Welfare and the National Health Performance Authority who have come together in a collaboration to create a Digital National Cancer Atlas. This significant development will contribute to the acceleration of the spatial enablement of Australia's public health data, a development that is planned to advance Australia's ability to move to a greater preventative health system.

FACIAL RECOGNITION OF DISEASE

The Health Program has co-created imaging technologies to capture and analyse facial data.

The CRCSI, in collaboration with Genetic Services of Western Australia Department of Health and Curtin University, has developed a clinical tool that renders 3D facial analysis of patients within 20 minutes of data capture. This tool and its analysis software are known as 3D-FAST. It is non-invasive and non-irradiating to patients. The use of 3D facial analysis will provide new knowledge into disorders, rare diseases and clinical genetics.

Thirty per cent of rare diseases patients wait up to 30 years for a diagnosis. A third see six or more doctors before receiving a diagnosis and nearly 50% receive an initial diagnosis that is incorrect.

Packaged within the 3D Facial Analysis Streamlining for Clinical Translation (3D-FAST) application, the software will quickly and accurately analyse a 3D scan of a patient's face: capturing images by photogrammetric hardware providing a summary to the clinician about the nature of facial characteristics that are likely to underlay genetic conditions.

This innovative research has led to real-time data mining for comparisons with a repository of facial imagery for powerful diagnostic and treatment monitoring. In time, it will significantly improve clinical efficiency and patient outcomes.





The CRCSI Award winners (I-r) Mr Ben Fitzpatrick, Professor David Lamb, Mr Mike Bradford and Mr Arthur Berrill, October 2015.

The next development phase of 3D-FAST includes growing a database of facial imagery that clinicians can utilise and compare captured faces and facial landmarks against normalised faces in determining disease types. Future collaborations include the Fiona Wood Burns Unit and research into Down's Syndrome and Foetal Alcohol Syndrome.

NEXT GENERATION SPATIAL INFRASTRUCTURES

The Spatial Infrastructures Program continues to make progress in researching new, intelligent ways to improve the organisation, access and use of spatial data in Australia and New Zealand through automation, methodologies to manage data, robust data tracking systems and application efficiencies.

In February 2016, the CRCSI engaged 43pl member Amristar to manage proof of concepts and develop prototype applications required by partners. The Perth based data analytics programming company is responsible for developing innovative, reusable web-based tools that can be utilised and implemented in real-world situations.

Four proof of concepts have been completed or are in development:

- Landgate (WA) road name automation: this permits users to search for road names based on location
- Land Use Victoria Automating M1 Form QA: users can submit and validate local government submissions for subdivisions, address and road changes
- University of Canterbury mobile application for trial in Zambia: this app allows farmers to crowdsource location information to better understand data tracking along the value chain of farm produce. The information gathered through the app will be stored centrally for analysis and future use
- Landgate (WA) search integration into CKAN: implement improved search and discovery methods (natural language queries) into CKAN platforms and demonstrate this working on data.gov.au

AWARDS - PARTNERS AND RESEARCHERS

CRCSI researchers and associated programs attracted a number of awards this year. The breadth of awards across the CRCSI community showcases the network of partnerships

TABLE 2: AWARDS 2015-16			
Project/Affiliation	Recipient	Organisation	Award
Capacity building of GIS and spatial data skills for Pacific Island countries	DigitalGlobe, NGIS Australia and CRCSI	DigitalGlobe, NGIS Australia and CRCSI	SSSI JK Barrie Award for Overall Excellence 2015 – Cyclone Pam Crisis Map
Capacity building of GIS and spatial data skills for Pacific Island countries	DigitalGlobe, NGIS Australia and CRCSI	DigitalGlobe, NGIS Australia and CRCSI	SIBA Award for People and Community 2015 – Cyclone Pam Crisis Map
43pl Board	Mr James Curnow	Alexander Symonds	SSSI 2015 President's Award
Capacity building of GIS and spatial data skills for Pacific Island countries	Mr Nathan Eaton and Dr Nathan Quadros	NGIS Australia and CRCSI	United Nations Momentum for Change 2015 Lighthouse Activity Award – Mapping Exposure to Sea Level Rise
Multi-GNSS PPP-RTK Network Processing	Dr Amir Khodabandeh	Curtin University	WASEA 2015 Postgraduate Student Excellence Award
Multi-GNSS PPP-RTK Network Processing	Dr Amir Khodabandeh	Curtin University	SSSI 2015 Postgraduate Student Award
Satellite Delivery of Augmented Positioning Data for PPP and PPP-RTK Services in Australia and New Zealand	Dr Suelynn Choy	RMIT University	National Measurement Institute – 2016 Outstanding Achievement in Meteorology
Rapid Spatial Analytics Science Director	Prof Matt Duckham	RMIT University	SSSI 2016 Educational Development Award
Victorian State of Environment Reporting: Pilot for Digital Reporting System	Dr Tai On Chan	Victorian Department of Environment, Land, Water & Planning	Secretary's 2015 High Five Award for Innovation: Highly commended for developing the Strategic Land Information Management Platform (that underpins the Digital Reporting System being developed)
Semantic Web Technologies for Supply Chain Management of Spatial Infrastructures	Ms Premalatha Varadharajulu	Curtin University and CRCSI	Best Student Paper Award presented to the 2nd International Conference on Geographical Information Systems Theory, Application and Management
Real-time environmental sensors to improve health in the Sensing City	Dr Malcolm Campbell	University of Canterbury	NZGS Presidents Award Winner for Emerging Researcher in Geography
Real-time environmental sensors to improve health in the Sensing City	Mr Lucas Marek	University of Canterbury	Best Map of 2015 – co-author of best map design of 2015 published in Journal of Maps
Real-time environmental sensors to improve health in the Sensing City	Prof Simon Kingham	University of Canterbury	NZ Spatial Awards Finalist "Education & Professional Development"
Greening the Greyfields	Dr Roman Trubka, Dr Stephen Glackin, Mr Phillip Delaney, Mr Tuan Ngo and Mr Jack Barton	Swinburne University and CRCSI	Planning Institute of Australia Awards 2015 – Commendation for "Cutting Edge Research and Technology"
Research into enhanced flight assist system (eFAS) for Automated Aerial Survey of Powerline Networks	Mr Ian McLeod	Ergon Energy	US-based Edison Electric Institute's (EEI's) 2015 International Edison Award. The award recognises leadership and vision in the ROAMES project
Epiphanee™	VPAC Innovations	VPAC Innovations and CRCSI	IAWARDS VICTORIA 2015 AWARD for research and development for companies at the cutting edge of technology innovation and achievements of Australian innovators

and influence of collaborative spatial research. Table Two highlights these awards.

We would also particularly like to acknowledge our Chair Professor Mary O'Kane AC and former Board director Mr Drew Clarke AO who were named in the Australia Day Honours list. Professor O'Kane was named a Companion of the Order of Australia for "eminent service to science and engineering, as a contributor to national policy development and governance, to the promotion of technology research and future energy supply, to higher education, and as a role model for young scientists." Mr Clarke received an Order of Australia for "distinguished service to public administration, to communications and energy policy initiatives and reform, and to the spatial information industry."

CRCSI AWARDS

The second awards ceremony conducted by the CRCSI highlighted four individuals for their outstanding achievements in the CRCSI.

The 2015 Research Excellence Award went to Professor David Lamb, leader of the Precision Agriculture Research Group at the University of New England (UNE). He is also the CRCSI Science Director for the Agriculture, Natural Resources and Climate Change Program.

The 2015 Student Excellence Award went to Mr Ben Fitzpatrick. Ben is a PhD candidate at QUT and is working on the Biomass Business project. His PhD is seeking to understand soil carbon across dryland agriculture at paddock level.

The 43pl Company Award went to Mr Arthur Berrill. Arthur has been involved in the CRCSI almost since inception. He was a member of the



Research and Education Advisory Committee and the Industry Advisory and Commercialisation Committee in CRCSI-1. Arthur is a member of the Research Investment Committee and contributed to the building of the Spatial Infrastructures Program.

The CRCSI Chair's Award recognises an outstanding achievement across any aspect of the CRCSI. The 2015 Award went to Mr Mike Bradford, CEO of Landgate (WA). Mike joined the Governing Board as a Director in 2008 and has served on the Industry Advisory and Commercialisation Committee, the Research Investment Committee, and was Chair of the Spatial Infrastructures Program Board. Importantly Mike galvanised the Western Australian spatial community across all three sectors (government, university and private) and helped develop a position of great strength in the national context of spatial R&D capabilities.

PUBLICATIONS

Fifty program related publications were produced in 2015-16 including 11 book chapters, 18 refereed journal papers, 16 refereed conference papers and five internal reports.

Education and Training

our postgraduate students
commenced this year with either
full or top-up scholarships, bringing
the total cohort of active students
to 26. During the year eight students
completed their studies. The CRCSI
has now recorded 39 completed postgraduates
since 2010. A list of this year's completions is
in Table Three. Current students can be found
on the CRCSI website.

ANNUAL STUDENT DAY

The CRCSI works with its students to develop their skills in deep discipline knowledge of their research along with workplace attributes such as written and oral communication skills, collaborative working, critical thinking and project management.

Each year the CRCSI hosts a student day as part of the annual conference. In November 2015, the students worked with an expert storyteller to turn complex research into crafted three-minute stories. The students found this experience challenging as it turned data and statistics into compelling



The CRCSI Scholarship Students, November 2015.

TABLE 3: COMPI	LETED PHD STUDENTS 20)15-16	
Name	Research Program	Title Of Thesis	Research Organisation
William Woodgate	Automated Feature Extraction	Derivation of Leaf Area Index and Associated Metrics from Remotely Sensed and In Situ Data Sources	RMIT
Lei Wang	Positioning	Generalised Ambiguity Resolution Approaches to Processing Multiple GNSS Signals	QUT
Ebadat Ghanbari	Rapid Spatial Analytics	Automated Registration of Multi-source, Multi-sensor Data	Melbourne
Richard Palmer	Automated Feature Extraction	Automated Generalised Methods for the Extraction and Analysis of High Level Information from Mobile Mapping Data	Curtin University
Phil Wilkes	Automated Feature Extraction	Scale Variance as Applied to Woody Attribution of Eucalypt Forests	RMIT and University of Twente
Charity Mundava	Agriculture, Natural Resources and Climate Change	Biomass Assessment Tools to Assist Grazing Management in the Kimberley Region of Western Australia	Curtin University
Niva Kiran Verma	Agriculture, Natural Resources and Climate Change	Above-ground Biomass and Carbon Determination in Farmscapes Using High Resolution Remote Sensing	UNE
Susanna Cramb	Health	Spatio-temporal Modelling of Cancer Data in Queensland Using Bayesian Methods	QUT
Daniel Hogg	Health	Modelling Spatial Variations in Natural Disaster Impact	Canterbury University

engaging stories ranging from pizza ovens to bungee ropes and the dusty plains of Africa.

The students told their stories to a panel of spatial industry experts, with the top five presenting at the plenary session of the annual conference. Understanding how storytelling skills engage and create interest in technical research outcomes is a valuable tool for the students as they move from research into employment.

GRADUATE DESTINATIONS

In 2015, the CRCSI undertook a rigorous graduate tracking study to determine where its students landed once completing their PhDs and Masters studies. The study found:

- Three are working for a 43pl member company eg. Fugro Roames, Think Spatial
- 10 are working in non-member companies eg. Geomatics Technologies, Electronic Arts
- 12 are in CRCSI partner research institutions eg. QUT, Curtin University
- Five are working for other non-partner research institutions e.g. University of Oxford, University of Otago
- Five are working in government agencies or departments eg. NICTA, CSIRO

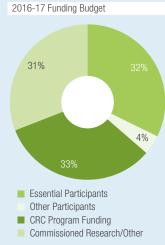
Finance Summary

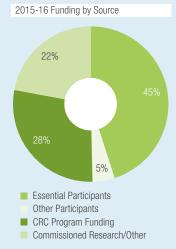
The CRCSI received \$12.6M in cash contributions and exceed the Commonwealth target by 68% this year. Essential Participant income was up by \$2.5M for additional project contributions. Cash for the year includes \$2.8M from external (third party) sources including Commissioned Research and Non Participants.

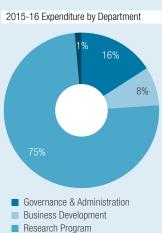
In kind staff contributions for 2015-16 were 28.9 FTE, against a Commonwealth target of 41.1 FTE. The lower in kind FTE has not impacted the CRCSI's ability to deliver the research and utilisation milestones and has been offset by the higher than expected Non-staff in kind result of \$4.8M against a Commonwealth target of \$3.9M and the additional cash.

Consistent with prior year trends, 75% of CRCSI expenditure was directed towards the research program, with the remainder allocated to business development, communication and education, governance and administration.

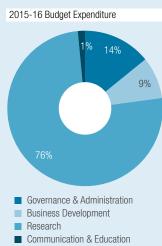
The CRCSI cash balance is \$12.7M of which 100% is committed to project agreements and current liabilities as at 30 June 2016. All funds from the CRC Programme, Essential Participants, Other Participants, Non Participants, and the Contract and Commissioned Research have been fully allocated and are on track to be fully spent by June 2018.

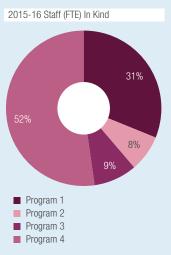






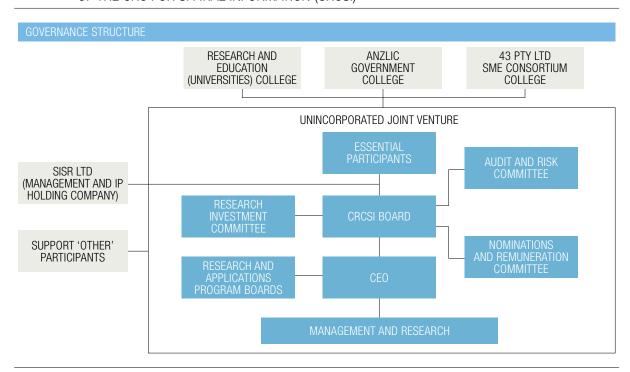
■ Communication & Education





Governance and Management

FIGURE 1: THE GOVERNANCE AND MANAGEMENT STRUCTURE OF THE CRC FOR SPATIAL INFORMATION (CRCSI)



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

There are seven Essential Participants who are a member of SISR. These are:

- 43pl (43 Version 2 Pty Ltd)
- Curtin University of Technology

- Department of Environment, Land, Water and Planning, VIC
- Land and Property Information, NSW
- Landgate, WA
- Queensland University of Technology
- University of New England

CRCSI is in partnership with 61 organisations from the government, private and research sectors, with a further 59 third party organisations that have contributed cash or in kind to the

Centre this year. The partnership base is divided into three colleges: one representing each of these three sectors; 43pl (with 38 SMEs), the Research and Education College (primarily universities), and the Government Agencies College managed by ANZLIC (the Australia New Zealand Land Information Council made up of government agencies at federal, state and territory levels).

The Colleges operate independently of each other and help represent the views of respective members especially in the formation of policy, the development of strategy, nominations of candidate directors to the Board and the admission of new participants. This structure also provides a vital mechanism for two-way feedback and communication.

The CRCSI has significant membership from New Zealand including a lead government agency, Land Information New Zealand (LINZ), the University of Canterbury, and two companies who are members of 43pl.

Partnerships

he CRCSI worked with 120 contributors across the breadth of activities this year. Of these, 50 are equity holding partners who hold beneficial ownership rights to the intellectual property based in proportion to cash contributions.

A further twelve organisations are support partners and the remaining 58, are organisations who have entered into specific project agreements or activities.

Strong key relationships continue to flourish with spatial peak bodies, ANZLIC, SIBA and SSSI.

Table Four lists the current participants, members and project partners of the CRCSI.



TABLE 4: CRCSI PARTICIPANTS 2015-16

ESS	sential Participants
43	Version 2 Pty Ltd
Cur	rtin University of Technology
Dep	partment of Environment, Land, Water & Planning, VIC
Dep NS	partment of Finance and Services, Land and Property Information, $\!$
Dep	partment of Natural Resources and Mines, QLD
Erg	on Energy Corporation Limited
Geo	oscience Australia
Lar	ndgate, WA
Que	eensland University of Technology
Roy	al Melbourne Institute of Technology University
The	e University of New England
Uni	versity of Canterbury
43	ol Members
AAI	M Pty Ltd
Ale	xander Symonds Pty Ltd
Am	ristar Solutions Pty Ltd
Bra	zier Motti
Bro	wn & Pluthero Pty Ltd
Bus	siness Aspect Pty Ltd
C F	R Kennedy & Co Pty Ltd
Car	bon Link Limited
Ecc	Logical Australia Pty Ltd
EOI	MAP GmbH & Co.KG
e-S	Spatial Ltd
ESF	RI Australia
FAF	RMpos Pty Ltd (Precision Agriculture)
Fuç	gro Spatial Solutions Pty Ltd
Gai	a Resources
GH	D Pty Ltd
Glo	bal Scanning Solutions Pty Ltd
GPS	Sat Systems Australia Pty Ltd
Insi	ight GIS
Jac	cobs Group (Australia) Pty Ltd
Lar	nd Equity International Pty Ltd
Lei	ca Geosystems Pty Ltd
Les	ster Franks Survey & Geographic Pty Ltd
Me	rcury Project Solutions Pty Ltd
	IS Australia Pty Ltd

Omnilink Pty Ltd Photomapping Services Position Partners Pty Ltd PSMA Australia Ltd Spatial Information Technology Enterprises Ltd Spatial Vision Innovations Pty Ltd Spookfish Pty Ltd Sundown Pastoral Co Pty Ltd Superair Think Spatial Twynam Agricultural Group Pty Limited VPAC Innovations Ltd Whelans (WA) Pty Ltd Support Partners Australian Geospatial Organisation Department of Health, WA Energex Limited Land Information New Zealand Murray-Darling Basin Authority Office of Environment and Heritage, NSW Open Geospatial Consortium Inc Swinburne University of Technology The University of Melbourne Western Australian Agricultural Authority Wuhan University Wuhan University
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Swinburne University of Technology The University of New South Wales University of Melbourne Western Australian Agricultural Authority
The University of New South Wales University of Melbourne Western Australian Agricultural Authority
University of Melbourne Western Australian Agricultural Authority
Western Australian Agricultural Authority
Wuhan University
Australian Wool Innovation Ltd
Bureau of Meteorology
National Health Performance Agency
North Central Catchment Management Authority
Mallee Sustainable Farming Inc
Queensland Department of Transport and Main Roads
Ministry of Business Innovation and Employment, New Zealand
Christchurch City Council, New Zealand
Canterbury District Health Board, New Zealand
University of Otago, New Zealand
Japan Aerospace Exploration Agency
Future Position X, Sweden
Ministry of Natural Resources and Environment, Samoa Research
Satellite Applications Catapult Ltd, United Kingdom

Acknowledgement of Service and Contribution

Emeritus Professor Geoff West

Professor Geoff West retired from Curtin University and the role of Science Director – Spatial Infrastructures, in February. He continues to supervise seven of the Program's PhD students in his new role of Emeritus Professor.

Geoff's computer science pedigree brought a new and exciting direction to the Spatial Infrastructures Program. His strategy to leverage the emerging Web 3.0 (semantic web) to spatial data infrastructures has allowed the current research outputs to provide step change thinking to our partners along with broadening the areas of spatially related research.

With enthusiasm, broad research knowledge and the ability to attract excellent students, Geoff has left the Program in a great position at the forefront of SDI research in Australia and internationally. We thank him for his contribution to the Spatial Infrastructures Program and to next generation spatial research.

Professor Peter Newman

We farewell and thank Professor Peter Newman for his role as Science Director – Built Environment, a role he has held since 2010. Peter was instrumental in setting the direction of the Program, focusing on addressing the unsustainable development of housing in the middle suburbs of cities, known as Greyfields.

Through Peter's guidance, along with Professor Peter Newton, the Program delivered spatial tools and engagement mechanisms to address sustainable housing strategy, policy and economics. His role involved supervising a number of CRCSI PhD scholarships students, some of whom have continued in this field.

Peter is currently the Professor of Sustainability at Curtin University.

Resources

To learn more about the CRCSI and its work, please visit www.crcsi.com.au – the website is a resource rich repository of spatial information. The website hosts over 500 published reports and documents in its library area.

To stay in touch with the CRCSI and its current activities, sign up for the regular Spatial News e-bulletin www.bit.ly/crcsiNews. Back issues can be found online.

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