



Australia and New Zealand CRC for Spatial Information Annual Report 2015-16



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Statement Of Purpose

The Cooperative Research Centre for Spatial Information (CRCSI) is an unincorporated joint venture set up under the Cooperative Research Centres Programme of the Australian Commonwealth Government through the Department of Industry and Science. The purpose of the CRCSI is to build critical mass in research ventures between end users and researchers tackling clearly articulated, major challenges for end users using the fundamental spatial technologies of global navigation satellite systems, spatial data infrastructures, data fusion and rapid spatial analytics. The CRCSI offers collaborative research and education in the spatial disciplines. In doing so the CRCSI seeks to accelerate the take-up of spatial science by key end users, spawning major innovation and productivity advances in the key industry sectors of defence, built environment, health and agriculture, natural resources and climate change.

This report has been prepared in accordance with the 2015-16 Cooperative Research Centres Programme Annual Report Guidelines and is submitted to comply with the requirements of Section 4 of the Guide.

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1. Executive Summary

1.1 Achievements

Research

The CRCSI has chosen to profile a selection the research achievements for 2015-16. The application of this work has resulted or will result in significant commercial and societal impacts.

1) Positioning Program

Our Positioning Program has now achieved six world firsts in developing a suite of algorithms that will over the next couple of years enable Australia to combine signals from all six Global and Regional Navigation Systems to produce a positioning capability for anyone anywhere outdoors at 2cm accuracy. The Indian Regional Navigation Satellite System (IRNSS) is a new GNSS satellite constellation. Current IRNSS satellites provide signal coverage across the west coast of Australia which has allowed CRCSI researchers to test, through the open access signals, its capabilities to deliver precise positioning. The Russian GLONASS constellation was recently updated with a new feature, the CDMA signal (a channel access method). For the first time the GLONASS CDMA constellation was tested and analysed on its own and integrated with other systems (GPS). Geoscience Australia, through the National Positioning Infrastructure strategy, are now poised to operationalise these solutions over the next few years, by making them available to the market in partnership with the private sector and the existing networks operated by the states. This system will make a fundamental contribution to precision agriculture, autonomous and intelligent road transport, robotic infrastructure like ports, aerial navigation and many other applications. CRCSI research solutions are the heart of this national building capability.

2) Agriculture, Natural Resource and Climate Change Program

NRM Hub

A satellite imagery based online tool for monitoring pasture for broad-acre livestock production, the Stage 1 build and demonstration phase of the Natural Resource Management Spatial Hub (NRM Hub) was completed in June 2016. The initiative was led by the Rangelands NRM Alliance (representing 14 regional natural resource management bodies), the CRCSI, and the Queensland Remote Sensing Centre, and supported by the National Landcare Programme, Meat and Livestock Australia, our 43PL partner AAM Group, and more than other 20 organisations. In its first stage, the project anticipated recruiting 40 graziers covering a million hectares, but has now achieved over 300 properties covering more than 50 million hectares. In a world-first, the Hub provides grazing managers the capability to map, plan, analyse, value and monitor their properties infrastructure, pasture and ground cover 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.

Users have identified a number of benefits:

- 95% of users responding that the NRM Spatial Hub improves productivity, profitability and sustainability of their property
- 50% estimating the NRM Spatial Hub would save 10-30 labour days a year
- 75% responding it would increase safe carrying capacity of livestock
- 72% responding that this type of technology is important for the viability and sustainability of their business

- Half the respondents felt that benefits in financial and valuation tasks alone over the next five years would be between \$15 000 and \$25 000.

The CRCSI has now entered Stage 2 in partnership 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 system; continuing with technical development; and putting in place the sustainable business model to be launched in 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 with the ability to routinely report on the impact of government funding programs, and the condition of leasehold land and travelling stock reserves. The Hub is now on its way to a commercial spinout.

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 the over 200,000km² of high resolution DEM mapping along the 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 and under an Australian aid program the CRCSI coordinated the digital elevation acquisition programs across a number of countries in the Pacific including Vanuatu, Papua and New Guinea, Tonga and Samoa. During the past year these high resolution DEMs have laid the foundation for online tools that enable communities to visualise the impact of future sea level rise scenarios. They were used to assist 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 their location online for emergency responders. As a result of this work the UN awarded the development team of NGIS Australia Pty Ltd and the CRCSI a UN Momentum for Change Lighthouse Award during the Paris COP21 Climate Summit last December, recognising the team's contribution to creating a climate resilient future through the development of these new open tools and the accompanying education program. The Foreign Minister, the Hon Julie Bishop, gave a speech during COP21 highlighting the achievements of the project team in the Pacific.

The work has led to other developments. NGIS Australia Pty Ltd, a member of the CRCSI's industry cluster company known as 43pl, used the expertise gained through the DEM mapping of the Australian coast, to launch the *Coastal Risk Australia* website in April. 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 NCCARF (National Climate Change Adaptation Research Facility) CoastAdapt information delivery website.

3) Built Environment Program

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 (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 provides the ability to plan at precinct level for sustainable buildings, walkable precincts, 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. CRC SI also holds intellectual property over five hundred 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 Environment, Land, Water and Planning, 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.

4) Health Program

National Cancer Atlas

The existing partnership with the Cancer Council of Queensland and Queensland University of Technology 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 created imaging technologies to capture and analyse facial data. The CRC SI, in collaboration with Genetic Services of Western Australian Department of Health and Curtin University has 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 CliniFace. 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. Thirty per cent see six or more doctors before receiving a diagnosis and nearly fifty per cent receive an initial diagnosis that is incorrect.

Packaged within the 3D-FAST application (3D Facial Analysis Streamlining for Clinical Translation), the CliniFace software will quickly and accurately analyse a 3D scan of a patient's face: capturing images by photogrammetric hardware to provide a summary to the clinician of 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.

Table 1: Awards received by the CRCSI community in 2015-16

Project	Name	Organisation	Award
Voluntary work	DigitalGlobe, NGIS Australia and CRCSI	DigitalGlobe, NGIS Australia and CRCSI	SSSI JK Barrie Award for Overall Excellence 2015 – Cyclone Pam Crisis Map
Voluntary work	DigitalGlobe, NGIS Australia and CRCSI	DigitalGlobe, NGIS Australia and CRCSI	SIBA Award for People and Community 2015 – Cyclone Pam Crisis Map
43pl	James Curnow	43PL – Alexander Symonds	SSSI 2015 President's Award
9.31	Nathan Eaton and Nathan Quadros	NGIS Australia and CRCSI	United Nations Momentum for Change 2015 Lighthouse Activity Award – Mapping Exposure to Sea Level Rise
1.19	Amir Khodabandeh	Curtin University	WASEA 2015 Postgraduate Student Excellence Award
1.19	Amir Khodabandeh	Curtin University	SSSI 2015 Postgraduate Student Award
1.22	Suelynn Choy	RMIT	National Measurement Institute – 2016 Outstanding Achievement in Meteorology
Program 2	Matt Duckham	RMIT	SSSI 2016 Educational Development Award
2.21	Tai On Chan	DELWP	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)
3.02	Premalatha Varadharajulu	Curtin University CRCSI Student	Best Student Paper Award presented to the 2nd International Conference on Geographical Information Systems Theory, Application and Management
4.49	Malcolm Campbell	University of Canterbury	NZGS Presidents Award winner for Emerging Researcher in Geography
4.49	Lucas Marek	University of Canterbury	Best Map of 2015 – co-author of best map design of 2015 published in Journal of Maps
4.49	Simon Kingham	University of Canterbury	NZ Spatial Awards Finalist "Education & Professional Development"
4.55	Roman Trubka, Stephen Glackin, Phillip Delaney, Tuan Ngo and Jack Barton	CRCSI Envision – Greening the Greyfields	Planning Institute of Australia Awards 2015 – Commendation for "Cutting Edge Research and Technology"
4.31	Ian McLeod, CEO, Ergon Energy	Ergon Energy	US-based Edison Electric Institute's (EEI's) 2015 International Edison Award. The award recognises leadership and vision in the ROAMES project
Epiphane™	VPAC Innovations	43pl and CRCSI	IAWARDS VICTORIA 2015 AWARD for research and development for companies at the cutting edge of technology innovation and achievements of Australian innovators

The next development phase of CliniFace 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.

5) Spatial Infrastructure Program

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 prototype applications required by partners of the Spatial Infrastructures program. 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 allows users to search for road names based on location.
- Land Use Victoria Automating M1 Form QA; this allows users to submit and validate local government submissions for subdivisions, address and roads changes.
- University of Canterbury mobile application for trial in Zambia; this app allows farmers to crowdsource location information to the better understand data tracking the value chain of farm produce. This information 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

CRCSI researchers and associated programs attracted a number of awards in the reporting period. Table 1 highlights these awards.

Commercialisation/Utilisation

Notable successes include the expanded utilisation of the Flight Assist System (FAS) through the growth of Fugro Roames across Australia and internationally; increased evidence of government data access policy changes related to earlier CRCSI Creative Commons work; enhanced use of elevation products released through the CRCSI partners; use of the CRCSI coastalrisk.com.au website; expanded use of the CRCSI software by government agencies, researchers and industry (Barista, Vertical Datum Transformation Tool, LiDAR Quality Assurance Tool, VicRivers tools); continued use of the HealthTracks™ tool inside the WA Department of Health; policy acceptance and use of the Greyfields scenario planning tools inside government; rapid uptake of the NRM (Natural Resource Management) Hub tool in the grazing industry; the acceptance of recommendations from CRCSI work in the move to a dynamic datum for Australia; and the use of the CRCSI research in shaping policy and resourcing decisions in Queensland Health.

The CRCSI to date has met 74 of its 119 utilisation milestones, or 64% of the total. There are seven milestones which are behind schedule. Four delayed milestones relate to the CRCSI Health Program where there has been delayed deployment of both the Geovisualisation HealthTracks software in state government departments and a lack of uptake in the related Epiphane™ software. A re-focused adoption

strategy to specific analytical units within health agencies and to analysts in non-health agencies (i.e. other government applications) is expected to yield the desired impact.

Under the Spatial Infrastructures Program there are two laggard milestones as a result of delays in research progress and in the Positioning Program, there has been deferred software testing due to slower than anticipated research results. These milestones will be met in 2016-17.

Education and Training

Four postgraduate students commenced in 2015-16 with either full or top-up scholarships, bringing the total cohort of active students to 26 at 30 June 2016. During the year eight students completed their studies resulting in 39 completed post-graduates since 2010. A full list of CRCSI PhD and Masters students commenced, completed and withdrawn for 2010-16 is included in Appendix 2 .

Annual Student Day

The CRCSI works with its students to develop their skills in deep discipline knowledge of their research (PhD and masters) 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 CRCSI 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 engaging stories ranging from pizza ovens to bungee ropes and dusty plains for 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 will engage and create interest in technical research outcomes is a valuable tool for the students as they move from research into employment in the spatial industry.

Graduate destinations

In 2015, the CRCSI undertook a rigorous graduate tracking study to determine where CRCSI students landed once completing PhDs and masters through the CRCSI education program. The study determined the following results:

- Three are working for a 43pl member company e.g. Fugro Roames, Think Spatial
- 10 are working in non-member companies e.g. Geomatics Technologies, Electronic Arts
- 12 are in CRCSI partner research institutions e.g. Queensland University of Technology (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 e.g. National ICT Australia Ltd (NICTA), CSIRO
- One is between jobs
- Two ex-student locations are unknown.

Communication

The CRCSI student newsletter continues with four editions being published during this reporting period. The students consider the newsletter as a major source for linking the activities of the student cohort.

The CRCSI began a student leadership program in 2016, with a student leader nominated for each of three regions: Western Australia, Eastern Australia

and New Zealand. The student leaders meet with the CRCSI Education Manager every month to discuss issues, events and opportunities in each region. The feedback from the first six months of this program has been extremely positive.

In mid-2016, the CRCSI conducted a communication audit with the student cohort. Ninety-five per cent of the students responded that they have a broad understanding of the work of the CRCSI across its three core programs and four end-user applications. These students also reported that they felt part of an inclusive cooperative research centre. This sense of understanding and belonging is 12% higher than the 2015 results.

The Annual Conference, the Student Day and the student newsletters were recorded as the most valued communication channels between the students and the CRCSI. Eighty-five per cent of students felt the mentoring program is 'useful to very useful' in understanding the CRCSI. Eighty per cent believed mentoring helped with wellbeing, and 90% said mentoring increased networking opportunities.

SME Engagement

SME engagement is a strength of the CRCSI, through its consortium called 43 Pty Ltd (43pl) a unit trust and Essential Participant of the CRCSI. 43pl allows SMEs in the spatial information sector to purchase units through which they can participate in the CRCSI with appropriate flexibility. This permits each member SME to access CRCSI intellectual property and participate in all CRCSI activities at a reduced cost of involvement. 43pl (the company) assumes indemnity for each member SME, the administrative costs and Company Secretary function for the company are provided by the CRCSI. 43pl has its own elected Board with directors from across Australia and New Zealand. As at 30 June 2016, 43pl had 38 member companies. In addition, a further 22 third party companies have engaged with CRCSI through projects

or other activities. When including Essential and Other Participant companies Ergon and Energex, CRCSI collaborated with 62 private sector organisations in 2015-16, the majority SMEs.

In addition, the CRCSI has an MOU with the Spatial Industries Business Association of Australia (SIBA) that ensures close cooperation between the two organisations. SIBA is the peak private sector spatial industry body in Australia with about 300 members. It is working closely with the CRCSI in studies designed to systematically improve the innovation capacity of the industry. Collaborative studies are also underway in relation to quantifying the capacity and skill level needs of the spatial industry to the designing of education programs to help overcome skills shortages.

1.2 Risks and Impediments

Risks and impediments and strategies adopted to address the risks

The CRCSI maintains a comprehensive risk register which is reviewed annually by the Audit and Risk Committee and the Board and which was updated in May 2016. The register monitors 48 identified risks. A progress report on strategies to mitigate any risks which maintain a high residual impact rating is reported to the Board at every Board meeting. The high impact risks monitored by the Board are listed in Table 2.

1.3 End-User Environment

The key sectors for the CRCSI, the spatial industry and its partners – Government, Agriculture, Natural Resources and Climate Change, Asset Management, Defence, Utilities, Construction investment – have experienced improved economic and business conditions over the past 12 months. While two of our end-user Essential Participant organisations are undergoing large restructures (Ergon Energy and NSW Department of Financial Services – Land & Property Information (LPI),

the remaining end-user partners have maintained a strong project activity base. We have previously reported that across the board, reductions in staff numbers over the life of the CRC SI has decreased the ability of these agencies to both meet in kind obligations and implement developed solutions. This reduced commitment of in kind resources has also been evident in our private sector partners. The flow-on effects to the CRC SI has included more focused recruiting of partners to projects through cash contributions, rather than in kind, as well as re-orienting delivery pathways from direct deployment in government agencies to the provision of outputs to service providers, who then enable utilisation within government. The CRC SI does not expect this situation to change over the remaining two years of the CRC SI.

Notwithstanding the current economic environment, the CRC SI partners and third parties contributed additional amounts over and above Commonwealth Agreement funding in 2015-16, reflecting the relevance of the CRC SI activities.

Risks in relation to end users and the strategies adopted to mitigate risks

The CRC SI prepares and monitors individual partner engagement plans with its Essential and Other Participants. These set out the requirements for each company, government agency and university. They are reviewed annually. The collective knowledge from these plans makes an important contribution to the annual review of the CRC SI's Strategic Plan. A record is kept of the nature of the engagement for every partner in every aspect of the CRC SI's activities from projects and utilisation activities, to Boards and Committees.

Table 2: Risk and Mitigation Strategies

Risk	Mitigation Strategies
Intellectual property not protected/commercialised	Regular review of IP register. IP register used to develop the Business Development Strategy which seeks to actively manage the use of IP. The register is available for circulation to participants under confidentiality agreements and a summary has been made available through the CRC SI website www.crcsi.com.au/commercial
Ensuring that partner investment is justified by 2018 and beyond and acknowledged as a sound investment	Continuous improvement monitoring of research programs and plan to ensure high impact utilisation of outputs. Measures include: Strategic Plan and annual Business Plans in place and quarterly milestone monitoring through projects.
Ensuring CRC SI creates wealth for its participants	Stakeholder Engagement Plans updated and monitored. Regular communication through formal mechanisms; Colleges, Program Boards, Project Management Groups, Annual Conference reporting and monitoring of impact tool.
Failure to deliver outcomes from one or more research programs	The Investment Committee and Program Boards provide regular due diligence and review. Quarterly reports from each project leader to be reviewed by the Management and Board. Although there have been milestone achievement delays in a few programs, no major points of failure evident. Mid-term reviews of every project are yielding improvements in quality.
Quality and quantity of in kind commitment from participants is insufficient	In kind is monitored and reviewed quarterly for every project and organisation. Note that in kind is at the threshold required for useful input in projects but that industry commitment should now progressively increase as the emphasis on utilisation increases.
Failure to meet the key Commonwealth targets; including milestones and financial targets.	Quarterly monitoring of research programs and projects to ensure both milestones are being achieved and mitigation strategies such as additional projects implemented. Utilisation projects being increasingly pursued with partners. Annual Business Plans in place.

Opportunities for the CRCSI and strategies adopted to exploit these opportunities

The Program Boards meet regularly to review the strategic development within each research and application program and the Project Management Groups meet quarterly to review progress with respect to each project. These bodies are dominated by end users. These are two primary mechanisms for ensuring opportunities are identified early and mechanisms for adoption are pursued.

How the CRCSI's strategic direction aligns with the end-user environment

The CRCSI participants are organised into Colleges: government, research and education, and industry. This ensures the timely flow of views, knowledge and information, and aids the accountability of management to participants from all sectors and particularly to the respective end users.

There were no major changes in the end-user environment that significantly affected the CRCSI's strategic direction. We are expecting that the recent evidence of gradual upturn in business, government and the spatial industry in 2015-16 will continue for 2016-17.

1.4 Impacts

Any substantial changes to the expected outputs, usages or impacts of the CRCSI

The CRCSI conducted a first pass update of its outputs, usages and impacts in 2015-16 and made modifications to the Evaluation Impact Performance Tool following reviews by our project and program leaders, and by our users who have updated previous estimates and in many cases provided historical data for impacts which have now occurred. It is anticipated that the expected benefits will total \$733M, at a benefit cost of 2.51, which is increased from the initial ratio of 1.63. In 2014-15, the total cumulative benefits (\$178M) exceeded the total cumulative costs (\$173M) for the first time, and the respective numbers for 2015-16

were benefits to date of \$230M and costs to date of \$216M. Changes in outputs which have led to the increased impacts were:

1. Positioning Program: Future benefits are anticipated as a result of the National Positioning Infrastructure and are estimated at \$82M. This was initially estimated at \$74M. The primary reason for the increase is that we have substantiated the likely impact on all major industries in Australia, where previously only three industry sectors were quantified. A comprehensive economic analysis conducted by ACIL Allen on behalf of the Commonwealth Government was released in 2014 and it formed the basis for this revised analysis. Benefits will flow through the accelerated uptake and utilisation of the National Positioning Infrastructure and avoided cost to the nation through the establishment of optimally deployed and networked positioning infrastructure. It is now recognised that 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.

2. Information Generation Program: We estimate that there has been a total of \$153M of benefits delivered to date via three impacts:

(1) \$79M largely through the implementation of the National Elevation Data Framework data distribution portal, publicly downloadable sea level rise maps, a government oriented sea level rise visualisation tool, CRCSI commercial receipts, and implementation of the SAVBAT tool;

(2) \$66M through the introduction of software and improved technology solutions at Ergon Energy resulting in a reduction of annual costs of the vegetation management program; and

(3) \$8M through labour savings from deploying more effective software solutions to more

efficiently process data into information in government and industry. Over the life of the CRC SI and until 2025, it is expected that the Program will deliver \$348M of benefits relating to:

(1) \$241M benefits resulting from reduction of costs of the vegetation management program through the introduction of software and improved technology solutions Australia wide;

(2) \$93M from the Urban Digital Elevation Modelling in High Priority Regions (Urban Digital Elevation Model-UDEM) project, commercial receipts and the use of the Savanna Burning Abatement Tool (SavBAT) tool; and

(3) \$14M of benefits resulting from savings in labour used from deploying more effective software solutions into organisations to more efficiently process data into information. This cost-saving and efficiency gain will translate into either more productive capacity or a reduced labour requirement. The ability to process data into spatial information more quickly through automated processes will alleviate the largely manual processes that exist to date in identifying, extracting and compiling information from a multitude of spatial data sources. The expected benefits from the program have increased from the initial forecast of \$51M to \$348M.

3. Data Infrastructures Program: An estimated \$45M of benefits have been delivered to date through the influence/adoption of policy through Creative Commons frameworks. An estimated \$106M of expected benefits will arise from the Program (up from originally forecast \$42M) through more developed, expanded and nationally cohesive infrastructure as a result of adoption of new policies and online infrastructure technologies in government and industry, associated cost reductions and implementation of the creative commons framework, and industry growth impacts from access, rights and governance usage.

4. Applications Program: Although the general thrust of the activities has not changed, outputs have been better tuned to partner needs and re-phased to better match timelines that can be achieved in conjunction with partners. We estimate the Program has delivered benefits of \$34M to date through:

(1) \$23M in savings from increased staff efficiency and improved health services via new geospatial visualisation tools for staff who collate and analyse disease, risk factor and program information for preventative health and avoided monetary costs for early disease detection;

(2) \$5M cost savings through the use of the sustainable urban development tool to avoid costs of capital infrastructure, greenhouse gas emissions, physical activity costs, private occupier costs and improved healthcare and productivity and efficiency improvement; and

(3) \$6M from the introduction of tool sets by skilled government agencies and research organisations for spatial analysis purposes which avoid labour costs that would otherwise be required to prepare, manipulate and extract spatial information. This also includes usage by corporate agriculture operations, technology-literate farm managers, agronomists and agricultural service providers, who will directly increase farm profitability through improved efficiencies in water use, fertiliser application and on-ground monitoring.

The Program plans to deliver \$155M of expected benefits, up from \$138M originally estimated.

Any changes in the expected non-monetary impacts and a brief overview of the changes

The CRC SI has reviewed its non-monetary impacts in light of the changes to the research output and utilisation milestones and does not expect any changes to result as a consequence. The non-monetary impacts for each program are still valid.

Table 3: Summary of monetary impacts and expected benefits within programs due to amendment of output and utilisation milestones as at June 2016

Impact	Milestone Changes	Probability of usage to enable impact			Probability of impact occurring			NPV (\$M)		
		2010	2016	% change	2010	2016	% change	2010	2016	\$ change
Impact Reference	none / rephased / moderate / significant / new									
1.1 Avoided cost of network infrastructure	rephased	30%	30%	0%	60%	60%	0%	\$0.10	\$0.07	-\$0.03
1.2 Accelerated uptake of National Positioning Infrastructure	rephased	30%	30%	0%	30%	30%	0%	\$73.89	\$81.96	\$8.07
1.3 Postgraduate completions	new	0%	90%	90%	0%	100%	100%	\$0.00	\$15.30	\$15.30
2.1 Avoided costs of labour (resource management)	moderate	50%	75%	25%	60%	75%	15%	\$25.00	\$14.00	-\$11.00
2.2 Avoided costs of (Energy) / business process improvement	rephased	21%	90%	69%	70%	90%	20%	\$25.82	\$240.70	\$214.87
2.3 National Elevation Data Portal, data and tool; and commercialisation receipts	significant	90%	90%	0%	25%	90%	65%	\$0.68	\$92.88	\$92.20
3.1 Cost reduction – policy adoption and online technologies	rephased	49%	25%	-24%	20%	20%	0%	\$39.28	\$11.17	-\$28.11
3.2 Spatial industry growth	none	40%	20%	-20%	15%	15%	0%	\$2.86	\$1.26	-\$1.60
3.3 ABS Implementation of Creative Commons license	new	0%	100%	100%	0%	75%	75%	\$0.00	\$93.53	\$93.53
4.1 Impact of tools on farm probability	significant	38%	30%	-8%	50%	50%	0%	\$101.24	\$85.73	-\$15.51
4.2 Impact of tools on health	moderate	8%	15%	7%	40%	60%	20%	\$9.86	\$44.02	\$34.16
4.3 Impact of tools on urban planning	moderate	8%	20%	12%	60%	60%	0%	\$28.76	\$52.13	\$23.37

Where the expected monetary impacts have changed, provide the current predictions for the expected benefits associated with all programs and the expected costs associated with all programs

A number of changes to monetary impacts have been documented above. The overall expected program costs have increased from \$186M (2010) to \$292M (2016). The expected benefits have also increased from \$305M (2010) to \$733M (2016) resulting in a change in the CRCSI cost benefit ratio to 2.51, as compared to the 2010 value of 1.63. The changes on a program basis for Benefit: Cost ratio are:

Expected Benefit: Cost Ratio of Program 1

The cost benefit ratio has increased slightly from 2.52 (2010) to 2.71 (2016).

Expected Benefit: Cost Ratio of Program 2

The cost benefit ratio has increased from 0.95 (2010) to 3.10 (2016). This is due to an increase in all Program impacts, including the identification of new benefits from impact 2.3 National Elevation Data Framework and commercialisation receipts (\$92M), accelerated uptake of impact 2.2 Energy activity (\$212M) and avoided labour costs for impact 2.1 – NRM management (\$13M).

Expected Benefit: Cost Ratio of Program 3

The cost benefit ratio has decreased from 2.15 (2010) to 1.91 (2016). This reflects the net change between the \$30M (from \$42M to \$12M) decrease in expected benefits of the original two impacts and the identification of new benefits that have resulted from implementation of impact 3.3 (+\$93M).

Expected Benefit: Cost Ratio of Program 4

The cost benefit ratio has increased from 1.65 (2010) to 2.07 (2016). This reflects the change to impact Program 4.1 Tools for farm profitability (-\$15M) and impact of Program 4.2 Health visualisation (+\$34M) and Program 4.3 Urban planning (+\$23M).

The changes are summarised in Table 3. The CRC Programme tool methodology has been used as the framework for generating the impacts noted within this section of the report.

Actions the CRCSI will take to address any issues and maximise impact

The CRCSI is now six and a half years into an eight and a half year research program with the research beginning to yield significant impacts.

2. Research

2.1 Performance Against Activities

Progress against the key challenges/outcomes

The CRCSI undertakes end-user driven research focused on the goal of “spatially enabling Australia and New Zealand”. This goal is being realised through two strategic objectives, around which the research program has been designed and is being executed.

Objective 1: To undertake the research needed to enable the creation of a national network of Global Navigation Satellite System (GNSS) reference stations to support real-time positioning to an accuracy of $\pm 2\text{cm}$

The CRCSI is conducting the research needed to facilitate the creation of a coordinated National Positioning Infrastructure (NPI) which will take advantage of Australia’s unique geographic location, giving its access to signals from all of the existing and emerging global and regional navigation satellite systems. The NPI will enable real-time, 3D positioning of people, vehicles, built infrastructure and natural assets based on the new method of PPP-RTK (precise point positioning-real-time kinematic). Realising the full potential of the NPI through PPP-RTK requires research to optimise the processing of multi-frequency, multi-GNSS signals in a robust, rigorous and efficient way. The CRCSI’s approach to PPP-RTK is unique and promises benefits for end users in both the professional and consumer markets.

Key deliverables from research addressing Objective 1 include:

- New integer inference theory to allow the estimation and validation of a full or partial set of carrier phase ambiguities in a multi-GNSS, multi-frequency environment.

- An indigenous capability for computing and delivering real-time multi-GNSS orbit and clock products.
- PPP-RTK network parameter estimates and quality descriptors including; satellite and receiver clock errors, multi-frequency satellite and receiver code biases, multi-frequency satellite and receiver phase biases, slant ionospheric delays and zenith tropospheric delays.
- Algorithms for the implementation of PPP-RTK by end users.
- A methodology optimised for satellite delivery of the PPP-RTK augmentation message across Australia and New Zealand.
- A new approach to dynamic datum definition that will underpin operational implementation of the NPI and revolutionise the way spatial information is collected and managed into the future.

Objective 2: To undertake the research needed to enable the features and power of the semantic web to be optimally exploited in managing, maintaining and delivering spatial information

The National Innovation Systems Review sets out the benefits of improved access to raw spatial information and derived spatial information products currently held by government, but largely inaccessible to the broader community. The semantic web, coupled with developments in artificial intelligence and supply chain theory, emerge as components to the solution of this problem.

The ability to structure data and then to undertake natural language queries, federate disparate data sets with different provenance and utilise the emerging power of crowd sourcing, opens up a range of possibilities to secure the benefits

of broadly accessible and fit-for-purpose spatial information. Adopting a supply chain approach will enable the automation of many processes that are currently manual and therefore costly and time consuming to execute. The use of higher levels of the semantic web including; knowledge representation (ontologies) and rules (business, geometric, policy) will create efficiencies for data providers and custodians, and confidence to users in terms of reliability and fit-for-purpose data.

Key activities for research addressing Objective 2 include:

- **Search and discovery.** The outcome will be new spatial search tools that accept natural language queries to find relevant datasets from metadata, documents and other sources.
- **Data federation.** The outcome will be new methods to allow users to access data from any source and present it in a form which is consistent across all jurisdictions. This approach means jurisdictions do not have to change data formats or infrastructures.
- **Web services orchestration.** The outcome will be new methods to allow users to request spatial information that may not exist but which can be generated. Processes will be automatically “orchestrated” to deliver what the user needs.

- **Crowd sourced and authoritative data integration.** The outcome will be models and processes to enable data to be crowd sourced in various ways to add to, delete and modify authoritative data.
- **Querying big data.** The outcome will be methods to allow users to run natural language spatial queries on very large, remotely hosted datasets such as the Landsat archive. Such datasets cannot be downloaded and processes have to run where the data is stored.
- **Spatial data supply chains for business processes.** The outcome will be ontologies and rules that capture business processes to enable automation of decisions. Examples include; the conflation of datasets, and approvals of new subdivisions. The ontologies and rules will be captured from documents, policies and information from expert interviews.

Summary of Research Activities by Program and the associated risks

A total of 12 new CRC SI funded projects were approved during 2015-16 and 18 projects were successfully completed. Table 4 shows the portfolio of active or completed projects with co-funding by the CRC SI.

Table 4: CRC SI Projects: 2015-16

*Key: *newly funded projects. ^projects completed during 2015-16*

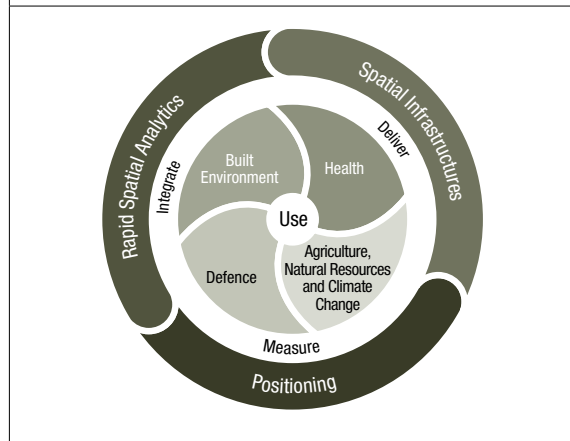
Project Number	Title	Start	Finish	Partners
1.01^	New carrier phase processing strategies	1/7/2011	30/6/2015 Delayed	12
1.02	Next Generation Australian and New Zealand Datum	1/7/2012	1/1/2016	7
1.03^	Multi-GNSS Processing Strategies and Services	3/10/2011	30/9/2015	11
1.04^	GNSS test track	1/3/2012	28/2/2015	4
1.11^	Real-time Positioning with the Quasi-Zenith Satellite System	1/7/2012	30/6/2014	5
1.14	Development of Analysis Centre Software	1/7/2013	30/6/2018	1

Project Number	Title	Start	Finish	Partners
1.15	Program 1 Science Director & GNSS Research Professor	1/3/2014	30/6/2018	2
1.17^	Evaluating the positioning capabilities of Locata terrestrial unfriendly environments – Phase 1	1/4/2014	30/9/2014	1
1.18	Near RT Tropospheric Zenith Delay Estimation using GPS	1/7/2014	30/6/2016	2
1.19	Multi-GNSS PPP-RTK Network Processing	1/11/2014	31/3/2018	10
1.21*	Ionospheric Modelling to support ambiguity resolution for PPP-RTK	1/7/2015	30/9/2017	5
1.22*	Satellite Delivery of Augmented Positioning Data for PPP/PPP-RTK	1/9/2015	31/3/2018	5
1.23*	Beidou precise orbit and attitude modelling for PPP-RTK	1/1/2016	31/3/2018	1
1.24	Development of AUSGeoid2020	1/4/2016	30/6/2017	5
1.26*	SBAS Testbed	25/6/2016	30/6/2018	1
2.02	Topographic Mapping Feature Extraction	1/9/2010	31/12/2014	14
2.09	LiDAR QA Tool	1/7/2012	30/6/2015	5
2.12	Economic Value of Earth Observation from Space to Australia	01/6/2014	30/6/2017	1
2.14^	Mapping Rivers and Tree Crowns from LiDAR & Imagery	29/5/2014	30/6/2016	1
2.15^	Extending Development of the ComQAT Airborne LiDAR QA Tool	1/7/2014	1/11/2014	1
2.16^	Tools to automate Asset Capture from Earthmine Imagery	1/1/2015	30/6/2015	1
2.17*	Development of a mobile mapping QA Tool	1/10/2015	30/3/2017	1
2.19	QUT Spatial Science (Bronwyn Harch)	1/4/2015	31/4/2015	1
2.21	State of Environment Pilot for Digital Reporting System	4/1/2016	30/6/2018	2
2.22*	Rapid Analytics Interactive Scenario Explorer	1/4/2016	30/9/2017	5
2.23*	Open Spatial Analytics	1/4/2016	30/9/2016	2
2.25*	AusCover Case Study	1/5/2016	31/8/2016	1
3.01	Semantic Web Technologies for Next Gen Spatial Infrastructures	1/1/2013	31/12/2015	6
3.02	Semantic web Technologies for Supply Chain Models	1/4/2014	31/3/2018	10
3.03	Semantic web Technologies Developer	4/4/2016	3/4/2017	1
3.09	Spatial Information Professor Appointment	1/7/2013	30/6/2018	1
3.10^	Optimising the Supply Chain for Geocoded Addressing in Australia	28/3/2014	31/5/2014	2
3.13^	Pilot Innovative Location Addressing in Australia	15/4/2015	12/6/2015	2
3.14	Assessing EM-COP Crowd-sourcing for Vicmap Maintenance	22/6/2015	31/12/2015	2
4.10	Project 4.10 Science Director (David Lamb)	19/2/2015	30/6/2018	1
4.12^	Biomass Business	1/7/2010	30/6/2014	11
4.13^	Capturing Spatial Know-how for Agriculture – Phase 1	1/1/2015	30/6/2015	2
4.17	Big Data Solutions for Environmental Monitoring	1/10/2013	31/8/2016	5
4.18	Tools for Real-time Biomass Estimation in Pastures	30/8/2013	29/8/2017	5
4.19	Natural Resource Management Spatial Hub: better management decisions in the Rangelands	1/7/2014	30/3/2016	20
4.101*	Estimating live weight gain for Australia's cattle industry	17/9/2015	30/9/2016	3

Project Number	Title	Start	Finish	Partners
4.102^	Maintaining ground cover in mixed farming systems	1/3/2015	28/2/2016	1
4.103	Carbon accounting in diverse landscapes for carbon markets	1/7/2015	30/6/2018	1
4.104*	Monitoring & Forecasting Framework for SE Australian Forests	1/10/2015	31/3/2018	2
4.105*	Monitoring through many eyes the Great Barrier Reef	1/10/2015	30/9/2015	2
4.106*	Spatio-temporal visualisation of irrigated cotton root development	1/10/2015	30/6/2016	1
4.109	NRM Hub extension – MLA AWI	26/5/2016	26/5/2017	4
4.402^	Place as a Vital Sign of Health	1/4/2014	30/3/2015	1
4.403	Utilisation of Epiphany	1/4/2014	31/3/2015	1
4.406	CliniFace	1/4/2015	31/7/2016	1
4.45^	Disaster impact & spatial links to related health outcomes	1/9/2012	31/8/2015	3
4.46^	Health Program Research Fellow	1/2/2013	31/1/2016	1
4.49	RT Environmental Sensors to Improve Health in the Sensing City	1/10/2014	31/3/2018	3
4.53	Barriers/Opportunities for Adoption of Spatial Tools in Planning	1/1/2013	30/6/2017	4
4.54^	Greyfield Precinct Identification Tool	1/9/2014	28/2/2015	1
4.55	Greening the Greyfields' – Modules 3 and 4	1/4/2013	30/6/2016	4
4.57^	'Willingness to Pay' for Urban Renewal in Sydney	23/2/2015	21/12/2015	1

As illustrated in Diagram 1, the CRC SI's research program has three core research areas – Positioning, Rapid Spatial Analytics and Spatial Infrastructure. There are also four key application areas – Built Environment, Health, Agriculture, Natural Resources and Climate Change and Defence.

Diagram 1. The use of our research is central to the three research themes and the four research program areas.



The following sections summarise the primary activities and achievements of the CRC SI's research programs.

Program 1 (Positioning)

This Program comprises 11 active projects. The core deliverable for the Program is the Analysis Centre Software (ACS) which will facilitate the integration of research outputs (new algorithms, processes and software modules) into a single system to enable adoption by partners and broader industry and community impact. The ACS will support the implementation of a new real-time positioning paradigm known as PPP-RTK (Precise Point Positioning– Real-Time Kinematic) which aims to deliver ± 2 cm positioning anywhere (outdoors) with reduced dependence on costly ground infrastructure.

In the last year, several world-first results have been achieved in the Positioning Program. For example, an analysis of the quality and impact of

the new GLONASS L3 CDMA signals has been undertaken, demonstrating that it is possible to perform conventional ambiguity resolution with these signals, which was previously not possible with GLONASS FDMA signals. 3D positioning performance and the noise characteristics of the L3 code and carrier signals have also been assessed, with the L3 code observations shown to be more precise than GPS. Analyses were also undertaken of the new Indian Regional Navigation Satellite System (IRNSS/NavIC) for L5 precise positioning, stand-alone as well as in combination with GPS, Quasi-Zenith Satellite System (QZSS) and Galileo, the GNSS being developed by the European Space Agency on behalf of the European Union. It will be interoperable with GPS and other such systems.

Finally, the first version of the PPP-RTK network platform was delivered by researchers from Curtin University to Geoscience Australia. This fundamental research output will play a pivotal role in the ongoing development of the ACS.

This year has also seen the start of a new project led by the Bureau of Meteorology. The project is aimed at developing an accurate, time-dependent, 3D ionospheric model to support real-time ambiguity resolution for PPP-RTK. The disturbing influence of the ionosphere is the most significant barrier to practical realisation of PPP-RTK. The project aims to deliver the algorithms and prototype source code needed to compute and deliver an ionospheric model to support the operational implementation of PPP-RTK through the ACS.

Project 1.22 extends the collaboration between the CRC SI and JAXA to deliver a real-time PPP-RTK solution in Australia using the QZSS LEX (L-band Experimental) signal. Local ionospheric corrections have been computed in real-time using the Victorian GPSnet stations with the aim of reducing solution convergence times and enhancing positioning accuracies. In partnership with 43pl company Position Partners, the performance

of the PPP-RTK solution delivered through the QZSS LEX signal will be demonstrated in real-time dynamic applications such as machine control in landfill mining. The performance target is centimetre-level positioning accuracies within two minutes of solution convergence.

Significant progress is being made on the development of the ACS. Funded by partners, the project is currently resourced with four staff including a part-time Project Manager and a full-time Technical Leader and two software developers. Work on GNSS data editing and quality control in real-time, and the development of software to model conservative and non-conservative forces acting on the GPS constellation is near completion. An Expert Technical Committee (ETC), chaired by Professor Thomas Herring from the Massachusetts Institute of Technology (MIT), provides guidance in relation to substantive technical issues and provides an external review of progress. The ETC members are drawn from both international and Australian organisations. The ETC has met in Canberra three times, with the last meeting being held in conjunction with the International GNSS Service Workshop in February 2016.

Both Australia and New Zealand have made considerable progress in addressing issues associated with geodetic datum modernisation, and in particular in relation to a so-called “dynamic datum”. The CRC SI has supported this activity through Project 1.02 ‘Next generation Australian and New Zealand datum’ which addresses technical (and other) challenges to do with the continental-scale network adjustment of terrestrial measurements and GNSS coordinate observations, the development of deformation models in areas subject to crustal distortion, the development of eGeodesy tools to support the adoption and maintenance of a modernised datum, and an analysis of the legislative and administrative impediments to a new national datum. This work has influenced government policy and

has resulted in a recommendation through the Intergovernmental Committee on Surveying and Mapping (ICSM) regarding datum modernisation for Australia and New Zealand. The new Australian datum (GDA2020) will be released on 1 January 2017.

Full realisation of the objectives of Program 1 are partially dependent on the launch of new global and regional navigation satellites. This dependency is being monitored and the associated risks are being mitigated through growing international collaborations with China, Europe and Japan. Over the last year, Program 1 researchers have succeeded in tracking all available GNSS/ Radio Navigation Satellite Services (RNSS) signals, including those of IRNSS/NavIC and the new GLONASS CDMA K-satellites.

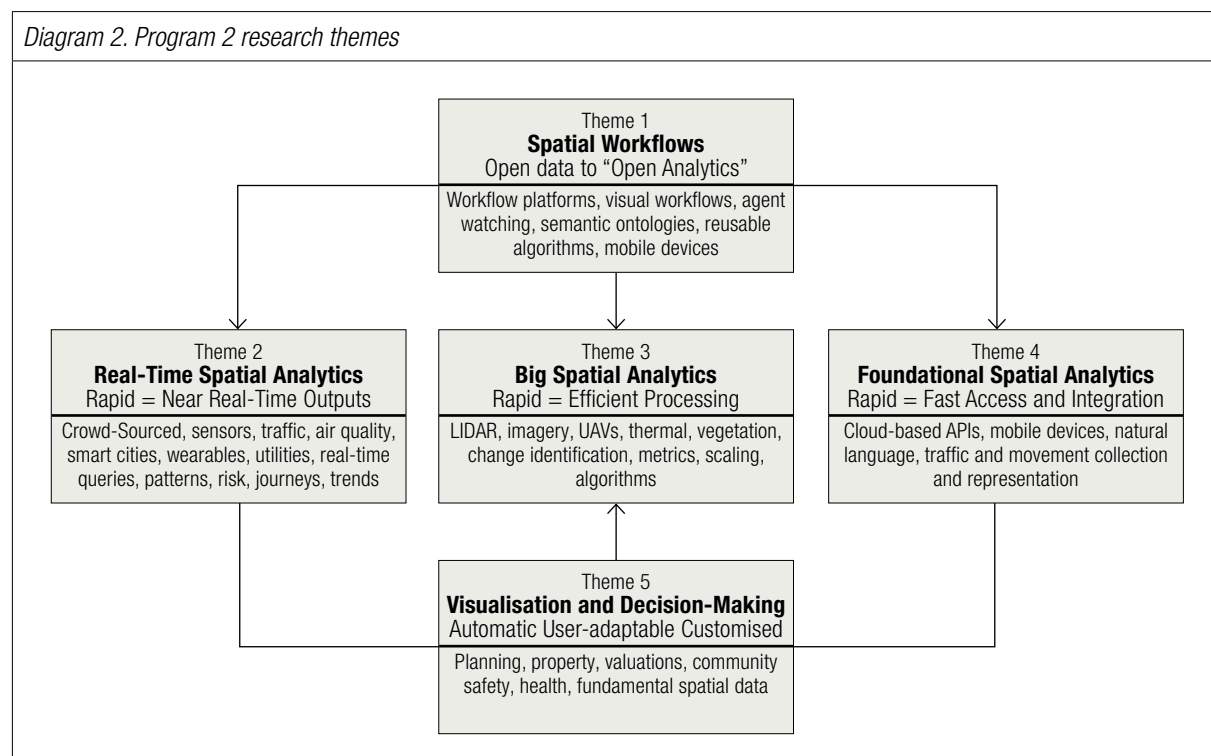
From a science perspective, the profile of the Program continues to grow with researchers actively participating in major conferences and scientific working groups as well as providing

invited and keynote presentations at a number of international forums.

The Program produced 18 published papers which included 10 refereed journal articles and 8 refereed conference papers, as well as one book chapter and two internal reports. The CRC SI also applied for patents on two positioning inventions, being a method of analysing multiple signals transmitted by global navigation satellite systems and a method to unbiasedly identify GNSS parameter functions. The Science Director for the Program is Professor Peter Teunissen, one of the world's most highly regarded researchers in this area. The Chair of the Program Board is Dr Chris Pigram, CEO of Geoscience Australia.

Program 2 (Rapid Spatial Analytics)

This new Program kicked off with a workshop in July 2015. Participants from partner organisations across government, academia and the private sector identified five key research themes as shown in Diagram 2.



Since the workshop, the Program has generated considerable interest across the CRC SI community, with increasing recognition of the relevance and importance of growing a rapid spatial analytics research capability to service the needs of industry.

While government agencies and the private sector are identifying research problems falling into the Rapid Spatial Analytics (RSA) domain, the academic sector is responding by forming teams with the needed capabilities to address partner needs. New collaborations within and between university partners are being formed as a result, and a pleasing level of research expertise is building around the RSA theme. Additionally, there is a growing level of interest in the Program from outside the existing CRC SI partner base and strong linkages are emerging between the RSA Program and other programs within the CRC SI, especially the Spatial Infrastructures Program and the broader Applications Program. It is clear that the decision to re-engineer Program 2 with a rapid spatial analytics focus has been timely and well received by stakeholders. While still in its early stages, the new Program 2 is resonating strongly and offers an area of activity and expertise of growing importance to the CRC SI.

In the first half of 2016 three new projects have been funded under RSA:

- **Project 2.21** *'Victorian State of the Environment, Digital Reporting System'*
- **Project 2.22** *'Rapid Analytics Interactive Scenario Explorer (RAISE)'*
- **Project 2.2.3** *'Open Spatial Analytics'*

Additional projects to more fully address partner needs and interests are being planned. One of special interest has a focus on real-time people tracking and the analytics and applications that flow from such a capability. A case study with strong partner engagement based on Melbourne's Southern Cross Station is in the final stages of planning.

Activity in the original Program 2 area (Automated Spatial Information Generation) is likewise continuing, but with increasing alignment to the RSA theme. Current projects in this category include:

- **Project 2.12** *'Economic Value of Earth Observations from Space'*
- **Project 2.17** *'Automated Mobile LiDAR Quality Assurance – QA4MOBILE'*
- **Project 2.14** *'Victorian Rivers Feature Extraction'*
- **Project 2.24** *'Aerial Robotics for Close Proximity Infrastructure Inspection'*

The CRC SI appointed a new Science Director to the RSA Program in late 2015, Professor Matt Duckham, Deputy Head of Geospatial Sciences at RMIT University. A new Program Board was also formed with Mr Simon Gilkes, Valuer-General of NSW, appointed as Chair. Mr Gilkes is supported on the Board by Ms Kate Williams (GHD, a 43pl member company), Mr John Blackburn (AAM, a 43pl member company) and Mr Brian Sloan (Department of Prime Minister and Cabinet).

The Program is in its formative stage, so outputs are modest compared to the more established programs within the CRC SI. This year the Program produced six book chapters and three refereed journal articles.

Program 3 (Spatial infrastructures)

This Program comprises three active projects with direct links into two other major projects in **Program 4.1** (Agriculture, Natural Resources, and Climate Change). In addition, the Program has successfully completed **Project 3.12** *'A Review of Innovative Locations and Addressing in Australia'* this year.

The Spatial Infrastructures team, comprising several part-time researchers, 10 PhD students and a full-time software developer from 43pl company, Amristar, has commenced the creation of proof of

concept software tools derived from the research outputs for evaluation, assessment and ultimately adoption by partners. This strategy enhances the Program's links to end users and significantly increases the prospects of securing real-world utilisation and impact from the research. Agencies such as Landgate WA and DELWP are amongst the first to be engaged in the proof of concept trials, with the aim of working closely with Land Information New Zealand (LINZ) in coming months.

This year has seen the Program bring projects together to provide partners with a more holistic view of the benefits of the research, being demonstrated through changing the spatial infrastructure supply chain from a "supplier-push" to a "customer-pull" approach. Emerging trends within the industry, including Open Data and the expanding user base, mean many partners have supply chain challenges, including determining what activities they, as suppliers, need to do to deliver the right knowledge to the end user, at the right time. Research also now considers uncertainty from the user's perspective and the need for believability of information for it to be valued as new knowledge. A new supply chain architecture and methodology that comprises semantic web technologies opens the way for the spatial sector to move beyond data curation to a knowledge-based industry that offers enhanced value for end users.

Joint Project 4.17 *'Big data solutions for environmental monitoring'* sees Program 3 and Program 4.1 joining forces to explore methods for automating and optimising data management, querying, analysis and visualisation of very large, satellite imagery archives that are continental in scale and span several decades in time. The aim is to allow these vast data stacks to be meaningfully queried, depicted and analysed by non-expert end users with only limited spatial awareness, but who have access to the needed data manipulation tools.

Project 4.18 *'Biomass business II – Tools for real-time biomass estimation in pastures'* likewise draws on Program 3 for crowd sourcing expertise and techniques to quality assure and validate crowd sourced information gathered by producers and synthesised via a web service.

The Program 3 Board is active in revisiting and revising research priorities in the dynamic and somewhat crowded space of spatial infrastructures. The impact of corporate entities such as Google, Apple and Microsoft is being regularly monitored and the niche filled by the CRC SI is routinely re-examined to ensure the research is not duplicative of that being performed elsewhere. To this end, the user community is vital and the use of an agile project management methodology is being employed to good effect for all research activities.

The Program has produced seven published papers which were all refereed conference papers. The Science Director for the Program is Professor Geoff West, who continues in an Emeritus role, having retired from Curtin University in early 2016. Dr David McMeekin is supporting Geoff as Associate Science Director. The Chair of the Program Board is Ms Claire Foo, Chief Information Officer at DELWP.

Program 4.1 (Agriculture, Natural Resources and Climate Change)

Over the past 12 months, Program 4.1 has paid particular attention to strengthening the nexus between production agriculture and environmental management through the development and application of spatial tools and technologies. Additionally, there has been a concentration on delivering existing project commitments, developing new proposals aimed at capitalising on previous investments and building new capabilities, and the preparation of a strategy to take the Program to 2018 and beyond.

This year saw the commencement of four new projects with a direct 'line of sight' to end-user operability, facilitated by solid end-user partner engagement. These were:

Project 4.101 *'A Big Data Approach to Estimating Live Weight Gain for Australia's Cattle Industry'* – investigating the extent to which stock and paddock records, remotely sensed variables, climate data and integrated or modelled outputs of these sensing platforms can be used to forecast animal-equivalent grazing days over the first month of the dry season. It is proposed to merge available data sets and apply statistical and machine-learning algorithms to investigate the predictive capabilities of the developed models and forecasts.

Project 4.103 *'Improved high-resolution carbon accounting in diverse landscapes for participation in carbon markets'* – allowing carbon storage potential of the landscape to be more accurately estimated using a range of data from ground-based, airborne and satellite-borne sensors and advanced modelling techniques.

Project 4.104 *'A Monitoring and Forecasting Framework for the Sustainable Management of SE Australian Forests at the Large Area Scale'* – creating a framework that allows the integration of Landsat (land and satellite) time-series data in conjunction with Victoria's forest monitoring and forecasting framework to assess forest disturbance for State of the Forest reporting.

Project 4.105 *'Monitoring through many eyes: spatially enabling people to protect the Great Barrier Reef'* – creating an immersive and interactive visual environment to better monitor the health of the Great Barrier Reef. A "citizen science" approach is being used to source underwater images from professional and recreational divers. Experts in reef health will use the digital "immersive" environment to elicit information to support future reef management.

Projects currently into their second or third year include:

- **Project 4.17** *'Big data solutions for environmental monitoring'*
- **Project 4.18** *'Biomass business II – Tools for real-time biomass estimation in pastures'*
- **Project 4.19** *'NRM Spatial Hub'*

Recently completed projects include:

- **Project 4.102** *'Maintaining ground cover in mixed farming systems'*
- **Project 4.13** *'Intelligence Bottler – Capturing spatial know-how for agriculture'*

The Science Director for the Program is Professor David Lamb, Leader of the Precision Agriculture Research Group at University of New England (UNE) and the Program Manager is Mr Phil Tickle. The Chair of the Program Board is Dr Matthew Adams, Manager, Satellite Remote Sensing Services, Landgate WA.

Program 4.2 (Defence)

The Defence Program currently has one research project underway. **Project 4.21** – *'Potential of 3D Point Clouds for Geospatial Intelligence Operations'*, is being conducted for the Australian Geospatial Intelligence Organisation (AGO). The overall objective of the project is to investigate new approaches to the processing and analysis of dense 3D point cloud data in the specific context of AGO requirements. Newly emerging technologies and data processing techniques for point cloud generation, primarily from optical imaging sensors, but also from radar and laser ranging, are being investigated. The integration of data from imaging and ranging sensors on space-borne, airborne and terrestrial platforms, through new data fusion tools, forms a key activity for the research, since this is a prerequisite for comprehensive implementation of "Activity-Based Intelligence" (ABI), as specified by AGO.

The relatively new concept of ABI envisages a more whole-of-data analysis methodology whereby sensor data from various sources is simultaneously accessed so as to afford a move away from individually exploited pieces of data to an integrated, multi-temporal, activity-based analysis. Through highly automated processes ABI seeks to address the question of what previously normal condition has undergone change to the extent that it can now be considered abnormal and thus warrant closer, specialised attention from an analyst.

ABI can be considered a transformational approach to data processing and analysis that relies on modern methods of intelligence, analysis and processing. Nowhere is this more apparent than within the geospatial information domain. Here, recent trends have focused on the provision of dense point cloud data as an underpinning to both image-based and topographic/object based feature analysis. Project 4.21 investigates the technology of very high-resolution point clouds from the standpoint of their potential for integration into AGO operations, centring upon the rapid-response detection, extraction and modelling of features of interest, be they man-made or natural, and the detection and temporal monitoring of changed conditions within a scene. An important topic within the project is object reconstruction and modelling from full motion video (FMV), with increased emphasis being placed on multi-temporal aspects and the 3D modelling of change.

Present and future research in both phases of the project will continue to encompass two parallel streams of activity: an investigative phase and a software development and evaluation phase.

The former aims to examine state-of-the-art approaches to the various stages of the 3D point cloud processing pipeline and to highlight new methods and algorithms showing most promise for AGO requirements, with increased focus being

placed upon multi-temporal aspects and the modelling of change.

Professor Clive Fraser is the Science Director for the Defence Program. Because of its confidential nature within the CRC SI, there is no Program Board.

Program 4.4 (Health)

Through 2015-16, the Health Program has concentrated on delivering existing project commitments, stronger engagement with the health sector and development of future research themes to steer research efforts and drive sustainability beyond 2018.

In line with the appointment of a new Program Manager, an operational strategy was developed to deliver on Program milestones. At the core of this strategy is greater health sector engagement to identify areas where research efforts are most needed and to encourage the uptake of previously developed capabilities.

This year saw the completion of **Project 4.406** '*Cliniface: Facial Analysis Streamlining for Clinical Translation*' and **Project 4.45** '*Geographic variations in natural disaster impact and spatial links to non-injury related health outcomes*'. Two new projects commenced: **Project 4.49** '*Real time environmental sensors to improve health in the Sensing City*' and **Project 4.405** '*Utilisation of Spatial Cancer Models: A National Cancer Atlas*'. **Project 4.403** '*Technology transfer and utilisation of Epiphaneé*' continued focusing on commercial due-diligence and growing end-user engagement.

Project 4.406 '*Cliniface: Facial Analysis Streamlining for Clinical Translation*' built on capabilities developed under **Project 4.404** '*3D-FAST (Facial Analysis Streamlining for Clinical Translation) tool*'. In consultation with project partner, Genetic Services Western Australia, researchers were able to improve the existing 3D facial analysis pipeline

to enhance clinician workflows. As part of this project, a clear pathway for future development was determined and will be pursued in an extension project which will expand 3D-FAST to determine if relationships exist between syndrome classification and patient genetic information. 3D-FAST is expected to significantly improve existing methods of automated facial analysis for syndromic diagnosis, especially in the realm of rare diseases where there is a paucity of clinical data. This approach is also crucial to timely and equitable diagnosis of other conditions such as foetal alcohol spectrum disorder, autism and sleep apnoea.

Project 4.45 *‘Geographic variations in natural disaster impact and spatial links to non-injury related health outcomes’* was completed this year with the graduation of a PhD student at the University of Canterbury, New Zealand. This project investigated the effect of exposure to the Christchurch earthquakes of 2010-11 on mental health outcomes. The findings have been disseminated to health agencies in Australia and New Zealand, providing a systematic evidence-based approach to prioritising geographic and cohort areas to ensure limited resources are spent wisely and essential care is directed where most needed post-disaster. The Canterbury District Health Board has modified how it will respond to future natural disasters as an outcome of this research.

Project 4.49 *‘Real time environmental sensors to improve health in the Sensing City’* is making significant progress. Air quality data collection has commenced in Christchurch through a newly established air quality sensor network with unique resolution and spatial density. Patient data collection, including time and usage of medication, has also commenced and will be used for future spatio-temporal analysis. Through joint project partner, Future Position X in Gävle, the Swedish component of the project has also commenced with significant knowledge sharing taking place to ensure lessons learned can be exchanged between the two cities.

Researchers on **Project 4.405** *‘Utilisation of Spatial Cancer Models: A National Cancer Atlas’* have documented the recommended spatial modelling methodology critical for disease burden estimation in areas with small populations for input into the National Cancer Atlas. This work will utilise outputs from project **4.42** *‘Spatial-temporal modelling of cancer incidence, survival and mortality’* to deliver an online, interactive geo-visualisation application that allows users to work with cancer data to reveal geospatial relationships that are likely to lead to improved Government programs and clinical or diagnostic outcomes.

Project 4.403 *‘Technology transfer and utilisation of Epiphancee’* continued with a focus on commercial due-diligence activities and end-user engagement. The Epiphancee™ prototype was developed in collaboration with Curtin University and the WA Department of Health in response to a need to manage and integrate health data and to improve analytic capabilities to sharpen decision-making, whilst maintaining patient privacy. A key challenge with this project has been the translation from research into practice. The first phase of this project is now complete with successful knowledge transfer from the Curtin team to the industry partner. Subject matter experts were commissioned to provide an independent review and recommendations regarding the technical robustness and acceptance of the privacy methodology at the core of the system in consultation with data custodians. In addition, consultation with the WA Department of Health is underway to determine how this technology could be integrated into a complete query, analytic and reporting tool for widespread deployment across the agency.

The Program has produced two refereed journal articles, one conference paper and three reports in 2015-16.

The Science Director for the Program is Professor Clive Sabel from the University of Bristol in the

UK. Two new Science Advisors were added to the Program, Dr Ori Gudes and Dr David McMeekin, both from the Department of Spatial Sciences at Curtin University. The Chair of the Program Board is Professor Tarun Weeramanthri, Executive Director of the Public Health Division, WA Department of Health.

Program 4.5 (Built Environment)

The new Built Environment Program is primarily focused on developing new spatial tools and strategies for use by professional planners, developers, infrastructure planners, administrators and the broader community to facilitate improved planning, re-development and investment decisions.

Project 4.55 *'Greening the Greyfields:*

Precinct visualisation and community

engagement' has been the core project within the Program, with a focus on the application of decision-making tools in the context of optimal redesign of the ageing suburbs of major cities in Australia and New Zealand.

This project is now transitioning to a utilisation phase through a new **project, 4.58** *'Developing and implementing the Greening the Greyfields frameworks and tools across Australia and New Zealand'*. This project will be completed in partnership with the CRC for Low Carbon Living, with a parallel project sharing some resources and focused on the process and creation of standards for urban regeneration focused community consultation.

The Project 4.55 team has finished developing ENVISION, a web-based spatial planning support system for identifying re-developable land and assessing redevelopment viability in terms of estimated financial returns. An Expression of Interest (EOI) for the ongoing development and commercialisation of this system has recently been released by the CRCSI.

Development of the Envision Scenario Planner (ESP) has also been completed. ESP is a web-based 3D precinct sketch scenario planning and assessment tool that allows planners, developers and the community to rapidly design and assess the environmental, financial, and social impacts of various precinct design options. In partnership with AURIN (Australian Urban Research Infrastructure Network), ESP will be released as an open source software package early in the 2016/17 financial year.

The rapid housing capacity planning tool, REZONE, was also completed this year. REZONE is a quick and simple-to-use system for determining the existing housing capacity of a Local Government Area (LGA) or suburb, and generating alternative capacity scenarios by enabling users to rezone land parcels. Currently the system is only available for Perth. However, a version for Melbourne is currently being developed.

Christchurch City Council applied ENVISION and ESP to prioritise earthquake recovery efforts and plan for the future redevelopment of the city. ENVISION and ESP are also being actively used in Victoria by local councils and DELWP to design a new planning framework and renew several urban precincts. In Western Australia the tools have been used to inform the housing strategies and strategic plans in both Canning and Stirling Councils. The City of Stirling is also utilising the tools, particularly REZONE, to assist with transport and energy planning, investment and communication activities.

The Program has produced three refereed journal articles and four book chapters in 2015-16. The program team, led by Professor Peter Newman, is currently working on producing a book highlighting the uniqueness and achievements of the Greening the Greyfields project.

2.2 Research Summary Of Program Highlights

Positioning Program

This Program continues to break new ground in multi-GNSS signal integration, PPP-RTK algorithm development, multi-GNSS signal testing, demonstration of satellite-delivered PPP augmentation messages and in the design and realisation of a new dynamic datum for Australia and NZ. This year has seen the completion of the first version of a new multi-GNSS PPP-RTK network platform, now being incorporated into the ACS. The CRC SI's work on datum modernisation continues to have a significant impact on government decision making and policy setting, with a new national datum for Australia being planned for first-phase implementation in 2017. Progress on the ACS has been significant with the development of software for GNSS data editing and quality control in real-time, and software for modelling the conservative and non-conservative forces acting on the GPS constellation nearing completion.

Rapid Spatial Analytics Program

This program has initiated a significant amount of activity and industry engagement in its first year, in addition to successfully launching a number of new collaborative research projects. The focus for 2016-17 will be on delivering high impact outcomes from the initial round of projects, continuing the successful components of existing projects and launching new projects to address partner interests. Launching a project in the area of real-time people movement technologies and applications is a high priority for the program.

Spatial infrastructures Program

The core research activities focus on utilising the capabilities of the Semantic Web to improve spatial infrastructures and support the discovery, use, integration and dissemination of raw and productised spatial information. The Program

represents the largest concentration of researchers and coordinated research activity directed at the problem of next generation spatial infrastructures in Australia and New Zealand. The team is deeply engaged with the end-user community, comprising land agencies at the state and federal levels and a range of 43pl companies. Indeed, there is growing engagement with the private sector where opportunities for skill sharing, capacity building, utilisation and commercialisation are being explored.

Applications Programs

Agriculture, Natural Resources, and Climate Change

The agriculture component of the Program targets better estimation of on-farm biomass, whether using hand-held active optical sensors or remotely sensed information from satellites, while the natural resources management component has completed a demonstrator environmental reporting tool which provides non-specialist users with the ability to undertake complex spatial and temporal queries. Analysing grazing circles, which previously took hours or days to execute, now only takes minutes due to the development of an online property planning and information system (www.nrmhub.com.au). The project has delivered what might be a world-first capability that allows individual property managers to routinely analyse time-series Landsat data over the last 30 years.

Defence Program

Current developments focus on automation within the 3D point cloud generation and analysis process, with interaction of the Program within the CRC SI being concentrated on data fusion, feature extraction, 3D modelling and change detection.

Health Program

Outcomes of the program include: a spatial modelling methodology critical for disease burden estimation in areas with small populations for input into a National Cancer Atlas; successful linkage

of environmental data with medicine usage for patients with lung disease; improved clinician workflows through an innovative 3D facial analysis tool and a systematic evidence-based approach to prioritising geographic and cohort areas of need to ensure limited resources are spent wisely and essential care is directed where most needed, post exposure to disaster. All of these outcomes were made possible through successful cross-sector collaboration in traditionally silo oriented domains.

Built Environment Program

The Greening the Greyfields project continues to be the leading project within the Program, with the focus now moving to utilisation of the project outputs, and measurement of the project impacts. The next phase will focus on creating and measuring processes for change with our partners, and will be run in parallel with the CRC for Low Carbon Living. The analytics and visualisation tools, linked with the strong relationships developed between the project team and key stakeholders, will lead to a strong, sustainable future for the project outputs, namely the ENVISON precinct identification tool, the ESP scenario planning tool and the visualisation tool, and the REZONE housing capacity analysis tool.

Extent to which the CRCSI is on target to achieve its research outputs

By 2015-16 the CRCSI has completed 82% of its research milestones. There were four research milestones delayed, largely due to project commencement delays. On a program basis, overall progress can be summarised as:

- Program 1 (Positioning): 61% of milestones completed, with nine projects addressing outstanding milestones. The program is slightly delayed against original estimates.
- Program 2 (Rapid Spatial Analytics): 100% complete. The program achieved all its research milestones ahead of schedule.

- Program 3 (Spatial Infrastructures): 67% complete. The program is delayed approximately two years against the original schedule but is now proceeding well.
- Program 4 (Applications): 89% complete. The separate research programs Agriculture Natural Resources and Climate Change (100% completed), Health (50%) and Built Environment (100%) are all proceeding well.

Key research achievements and evidence of the research quality

The quality of research being performed by the CRCSI is partially evidenced by the number of publications being prepared by CRCSI researchers in the form of books, book chapters, refereed journal and conference papers and reports for government and other partners. A full list of publications is provided in Appendix 1. The emerging influence and uptake of a number of research outputs (reported in Results) acts as a further indicator of quality and achievement. By this latter criterion, the CRCSI is increasing its impact as research activities reach maturity and deliver practical outputs for industry uptake. The CRCSI is also having an identifiable influence on government policy formulation. Examples of the latter include efforts by government to progress the National Positioning Infrastructure concept, the agreed plan to adopt a new dynamic datum beginning in 2017, the move to a cross-jurisdictional national spatial data infrastructure, the formulation of the national cancer atlas and the influence of the CRCSI's "greening the greyfields" research on state and local planning policy in both Australia and NZ.

Any issues, including technical or scientific impediments

There continues to be substantial growth in new technologies impacting on the spatial industry. Simple, low cost, and highly sophisticated devices are being regularly released. The consequence is unprecedented growth in the availability of spatial

information. Whether the sensor platform is a satellite with a multi-million-dollar payload or a citizen with a smart phone or a personal health monitoring device, the availability, frequency, diversity and volume of spatial information continues to grow.

The challenge for the CRC SI is to keep abreast of the technology advancements and to deliver new ways of identifying and extracting the embedded value in a timely and meaningful way. The new Rapid Spatial Analytics Program is core to this capability.

From a management perspective, this dynamic environment challenges conventional research paradigms. The classic three to four-year project cycle, with embedded PhD students is not serving the needs of partners as it used to. The CRC SI has responded by adopting a more flexible approach to execution and delivery of research outcomes. Researchers are now required not only to understand the needs of end users but to work collaboratively with them to maintain relevance and ensure utilisation goals are met. A complementary challenge continues to be to maintain standards of research quality.

Level of end-user involvement and evidence the research is meeting end user needs

All CRC SI projects have end-user involvement either as direct project participants or via a rigorous consultative process. These participants are drawn from the academic, government and private sectors, supported by the increasing uptake of research outputs amongst partners.

Our Program Board structure, where each Board is chaired by an end user and is dominated by End-user members, ensures that the research is designed to meet the needs of partners. Mid-term project reviews and quarterly project management group meetings likewise facilitate deep engagement with partners.

Any changes proposed to future research directions

A major revision of the CRC SI's research program was conducted in 2014 and implemented in 2015. The new program is now well established, has been well received by partners and the changes have resulted in a new suite of research projects with deep end-user involvement. It is anticipated that this new structure will endure to June 2018 and will form the basis of research beyond that time. In the meantime, partners have begun to articulate the need for a focused program of work in the geodetic area, with an emphasis on capacity building for state and federal agencies and priority to be given to projects in the realm of dynamic datum implementation, vertical datum realisation and the modernisation of the Australian and NZ cadastral systems. Planning for new projects addressing some of these issues is underway, with a project on the vertical datum of Australia already commenced this year and making good progress.

Publications

As shown in Appendix 1, 50 program related publications were produced in 2015-16 including 11 book chapters, 18 refereed journal papers, 16 refereed conference papers and five internal reports.

2.3 Education and Training

Four postgraduate students commenced in 2015-16 with either full or top-up scholarships, bringing the total cohort of active students to 26 at 30 June 2016. During the year eight students completed their studies meaning the CRC SI has achieved 39 completed post-graduates since its inception in 2010. With 65 active and completed postgraduates the CRC SI has exceeded the Commonwealth target of having invested in (enrolled or graduated) at least 51 PhD and Masters students with our university partners by 30 June 2018.

A full list of CRC SI PhD and Masters students commenced, completed and withdrawn for 2010-16 is included in Appendix 2.

Extent to which the CRCSI is on target to achieve its education/training outputs

The CRCSI has exceeded its education and training targets.

Key risks, issues and strategies in place to address the risks and any unmet milestones

The milestones have been met.

Details of the education activities conducted during 2015-16

Postgraduate: The 2015 CRCSI Student Day had a focus on research “pitches” to industry. Students were required to craft a clear and succinct three-minute pitch of their research, and to construct it into a story so that the audience could both remember and engage with the research. Four of the students were selected to share their stories in the main Conference program.

The CRCSI student newsletter continued with four editions being published during this reporting period. The students continue to provide strong support for the newsletter, and is a major source for linking the activities of the student cohort.

The CRCSI began a student leadership program in 2016, with a student leader nominated for each of three regions: Western Australia, Eastern Australia and New Zealand. The student leaders meet with the CRCSI every month to discuss issues, events and opportunities in each region. The feedback from the first six months of this program has been extremely positive.

Professional Development: The CRCSI’s professional development initiatives are focused around the Annual Conference and regional workshops.

These workshops are tailored to the needs of the partners, and provide opportunities for partners (and occasionally clients) to more actively engage

with the CRCSI at a direct level. In addition, occasional technology briefings are provided to the CRCSI participants.

Evidence of the level of student involvement in the CRCSI activities

Students are involved in numerous CRCSI major projects. All students are invited to attend the CRCSI Annual Conference which has a specific session for students.

In mid 2016, the CRCSI conducted a communication audit with the student cohort. Ninety-five per cent of our students told us they have a broad understanding of the work of the CRCSI across its three core programs and four end-user applications. These students also told us they felt part of an inclusive cooperative research centre. This sense of understanding and belonging is 12% higher than the 2015 results. Comments from the students included: gaining a clear insight into future engagement and opportunities and how their PhD work integrates into a profession within spatial information.

The students valued the Annual Conference, the student day and the student newsletters were recorded as the most valued communication channels between the students and the CRCSI. Eighty-five percent of students felt the mentoring program is ‘useful to very useful’ in understanding the CRCSI. Eighty per cent believed mentoring helped with wellbeing, and 90% said mentoring increased networking opportunities.

Graduate destinations

Graduates are tracked following completion.

Of the student completions to date:

- Three are working for a 43pl member company e.g. Fugro Roames, Think Spatial
- 10 are working in non-member companies e.g. Geomatics Technologies, Electronic Arts

- 12 are in CRCSI partner research institutions e.g. 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 e.g. NICTA, CSIRO
- One is between jobs
- Two ex-student locations are unknown.

2.4 SME Engagement

The CRCSI strategy for engaging with SMEs SMEs are deeply integrated into the CRCSI's activities with a unique structure for its consortium of companies.

Members purchase units in a unit trust (43pl Pty Ltd or '43pl') through which each can participate in the CRCSI with appropriate flexibility. Importantly this firewalls the risk to the unit trust, which assumes the indemnity for each SME without obligating each SME to take out the costly levels of public liability and professional indemnity insurance required of each Essential Participant. It also permits each SME to enjoy equivalent 'Essential Participant' status so can access the CRCSI Centre Intellectual Property and participate in all the activities of the CRCSI. A resourced set of strategies to engage with these companies is implemented through the Business Development team. The Company Secretary function and administrative support for 43pl are provided by the CRCSI.

The 43pl strategies are based on individual company 'Expectations and Engagement Plans', which are reviewed annually with each company. Key themes and strategies arising from these plans are explored further with the 43pl Board and merged into the CRCSI strategic planning process.

Examples of these strategies include:

- The Annual Conference, which is a confirmed highlight for many companies
- Allied CRCSI Roadshows (Participants Forums and Focus Workshops) around the regions, which bring the CRCSI culture to the regions and spread the benefits across Australia and New Zealand
- Building clusters or ecosystems of activity, which create an environment where SMEs can more easily engage with customers and researchers
- Matching company expertise and technology aspirations with current and developing projects, which brings companies, when ready, to engage with relevant innovation activities and the CRCSI's Intellectual Property.

A company from each jurisdiction provides a Director to the Board of 43pl following a process of nominations. These directors aid communication with members with the support of the CRCSI Communication Manager and the regionally located Business Development team. As at 30 June 2016, the 43pl Directors were: Mr David Sinclair (Independent Chair), Mr Mark Watt (Queensland), Mr Jim Curnow (SA and NT), Mr Nathan Eaton (WA), Mr Mark Freeburn (NSW & ACT), Mr Rob Rowell (Tasmania and Victoria) and Mr Simon Jellie (New Zealand & International). 43pl also has a representative presence on the CRCSI Board through Mr Malcolm McCoy from 43pl partner, AAM Group.

The current membership of 43pl is 38. In addition, a further 24 organisations have contributed as third parties to CRCSI activities, most of them SMEs. The number fluctuates as companies merge, leave the industry, spin off new companies or choose to leave the CRCSI. New applications for

membership of 43pl are encouraged. Nearly 100 companies have benefitted from 43pl membership over the last 10 years.

The CRCSI also has an MOU with the Spatial Industries Business Association (SIBA). This body represents around 300 companies. SIBA and the CRCSI work closely together, particularly with respect to the development of new programs for encouraging innovation in the industry and in improving its skills capacity. The CRCSI also has close ties with the Geospatial Information and Technology Association (GITA) and the Australian Information Industry Association (AIIA).

Demonstration of how the CRCSI is assisting SMEs to build innovation capacity and utilise research and development outputs of the CRCSI

The 43pl value proposition includes the provision of:

- A cluster or ecosystem of spatial companies, clients and researchers that provides an open model of innovation, reducing the barriers to collaboration and R&D and a neutral ground to meet clients and suppliers
- Project engagement and learning through 43pl participation being sought in every project
- Involvement in commercial activities to provide services to the CRCSI projects, totaling millions of dollars to dozens of companies over the last 10 years
- Access to R&D initiatives and the CRCSI IP for commercialization, e.g. Scanalyse, a spin-off company from the CRCSI research and development
- Skills development and capacity building, including the recruitment of the CRCSI postgraduate students

- Meaningful networking into government and academia to bring the end user close to the researcher, allowing the 43pl company can participate where niche expertise can be best applied
- Assisting companies develop submissions for grant funds for innovation and business development
- Assisting with technical advice on the development of intellectual property.

All research outputs are available for companies to use internally under certain conditions. Opportunities to commercialise specific project outputs are presented to companies through expressions of interest in taking on the innovation, with the CRCSI Board selecting the most appropriate business case.

3. Results

3.1 Utilisation and Commercialisation

Extent to which the CRC SI is on target to achieve its utilisation and commercialisation outputs
The CRC SI to date has met 74 of its 119 utilisation milestones to date, or 64% of the total.

The milestones achieved to date have yielded numerous success stories. These include: the expanded utilisation of the Flight Assist System (FAS) through the growth of Fugro Roames across Australia and internationally; increased evidence of government data access policy changes related to earlier CRC SI creative commons work; enhanced use of elevation products released through the CRC SI partners; use of the CRC SI www.coast-alrisk.com.au website; expanded continued use of the CRC SI software by government agencies, researchers and industry (Barista, Vertical Datum Transformation Tool, LiDAR Quality Assurance Tool, VicRivers tools); continued use of the HealthTracks™ tool inside WA Department of Health; policy acceptance and use of the Greyfields scenario planning tools inside government; rapid uptake of the NRM Hub tool in the grazing industry; the acceptance of recommendations from CRC SI work in the move to a dynamic datum for Australia; and the use of the CRC SI research in shaping policy and resourcing decisions in Queensland Health. Those milestones, achieved ahead of plan, were largely due to three reasons:

- (1) Successful response of local government partners in trialling and adopting prototype software in relation to planning;
- (2) Partners exceeding previous estimates for adoption – in particular research outputs in the energy industry related to Fugro Roames; and

- (3) Achieving our targets for graduated students quicker than anticipated.

Key risks, issues and strategies in place to address the risks and any unmet milestones

Almost all utilisation milestones set out for 2016-17 are on track and should be met. In general, CRC SI is on track to meet its targets, however there are seven milestones which are behind schedule and require close attention. Four delayed milestones relate to the CRC SI Health Program where there has been delayed deployment of both the Geovisualisation HealthTracks™ and related Epiphane™ software in other state government departments. Usage will build from the current usage base of the WA Department of Health and Queensland Cancer Council. The research outputs have already resulted in significant policy and resourcing impacts within these two organisations and the ongoing benefits will continue to build. A gradual ramp-up to state and Commonwealth health departments and other cancer councils and research institutes will follow. However, the capacity of government health agencies to absorb and roll out the software is an impediment to broader utilisation progress. A re-focus on specific data analysis units within health agencies and to analysts in non-health agencies (i.e. other government applications) is also expected to assist in meeting the target impact levels.

Under the Spatial Infrastructures Program there are two laggard milestones as a result of delays in research progress. In the Positioning Program there has been deferred software testing due to slower than anticipated research results. This milestone will be met in 2016-17.

The strategies for ensuring uptake by end users of the research outputs and the current levels of uptake

The technology transfer and utilisation strategy are built into the CRCSI proposals before the CRCSI Board will approve funding and enter into a project agreement. Criteria for project funding approval include a requirement that prospective utilisers and/or end users have significant involvement in the project. There must be a clear and credible route to industry application. Moreover, the work plan has to reflect an appropriate degree of commercialisation capability and awareness.

Every project is governed by a project agreement which details intellectual property ownership, the proposed route to application, and the role to be played by the entities involved. All parties committing resources to a project sign the agreement.

Quarterly meetings of the Project Management Groups consider potential commercialisation.

Projects are structured to include end users and market channel partners early within the project proposal process. Utilisation cases are developed for consideration by the CRCSI Board with input from the Project Management Group and CRCSI Executive. If approved, the utilisation case is progressed through the CRCSI commercial agent, Spatial Information Systems Research Limited (SISR), with an expression of interest to develop the commercial proposition sought from the CRCSI participants.

Utilisation and commercialisation arrangements with industry, including SMEs and other end users

SISR is the legal owner of the CRCSI Intellectual Property (CIP), with the beneficial rights of the property belonging to the Essential Participants of the Centre in proportion to the annual cash contributions. SISR is responsible for the commercialisation of CIP including marketing, seeking potential licensees and other commercial applications.

The CRCSI Board is guided by two principles when selecting organisations to lead the utilisation of the CRCSI research outputs. Firstly, preference is given to those participants who have played a lead role in the research and development phase. Secondly, the flow of benefits from the outcomes of the utilisation must be in the overall best interests of all CRCSI partners. The strength of the business case presented following an expression of interest process for utilisation is a key factor in helping the CRCSI Board with its final decision.

The CRCSI strives to ensure the best commercialisation mechanism is available to the project partners while at the same time balancing the expectations of its Essential Participants. In the case where the CRCSI enters co-funding arrangements with partners, there is a clear understanding of the ownership and rights to CIP, as well as a defined mechanism for the adoption of any research outputs.

Details of any new or improved products, services or processes, and specific benefits to end users (including SMEs), the nature and scale

Specific continuing benefits to partners from improved endeavours resulting from 2015-16 activities included:

Project 2.02 ‘Topographic Mapping Feature Extraction (Barista)’: The CRCSI Barista software system continued to be used by government partners and companies and was made available in open source format. Barista is a photogrammetric software system for the generation of spatial information products from satellite imagery. Additional software functionality facilitated the continued rollout to partners.

Project 4.55 ‘Housing Redevelopment Planning Platform’: The CRCSI researchers continued the development of a decision-making tool called ENVISION to predict where housing developments are likely to occur. This tool assists

planners with housing redevelopment decisions. The ENVISION Toolkit is a sustainable urban regeneration tool – an architect, modeller and analyst at your fingertips – to assist in planning, and the understanding and analysis of economic, social and environmental impacts in suburbs. The ENVISION Toolkit allows planners, landowners and developers to work together and collaborate urban designs to ensure the development of more sustainable, liveable and economically viable cities in ageing suburbs. In the ENVISION/ESP toolkit non-expert users can carry out an extensive workflow from redevelopment site identification scenario design, visualisation and assessment without the time expense of a consultancy to prepare the same. The toolkit serves up information from the perspective of landowners, developers, planners, utilities and infrastructure providers. It has been used by several councils across two states in Australia as well as New Zealand. It has also been used both by the Western Australian and Victorian governments.

CRCSI finalised discussions with a number of state governments for the inclusion of their data in a national Digital Elevation Model (DEM) of Australia derived from LiDAR 5 Metre Grid. This product is developed and distributed by Geoscience Australia. The DEM has been derived from some 236 individual LiDAR surveys between 2001 and 2015 covering an area in excess of 245,000 square kilometres. These surveys are licensed under Creative Commons. It has been used as a base layer in the CRCSI website at www.coastalrisk.com.au which to date has attracted over 120 000 users.

CRCSI rolled out the Natural Resources Management Spatial Hub (www.nrmhub.com.au) which continues to create impact across rural Australia through its online mapping tool that allows farmers and land managers to map and analyse 30 years of data in just a few minutes. The data results create information knowledge that allows farmers to develop best practice applications

to increase profitability on a paddock-by-paddock basis and increase probability outcomes that can reduce the costs of capital borrowings. It has over 300 users and is an initiative of the Rangeland NRM Alliance members comprising 14 NRM regional bodies; the CRCSI, the Queensland Remote Sensing Centre, the Queensland Department of Agriculture, Fisheries and Forestry, the NT Departments of Primary Industries and Land Resource Management, and multiple other organisations across Australia.

Australia's current geocentric datum will not be able to support the requirements of Australians in a spatially connected world. The first Datum Modernisation Roadmap was released in 2011 and CRCSI followed up with a series of recommendations for the implementation process aligned to a modern Australian geocentric datum. They have been accepted by the lead agencies ANZLIC and the Intergovernmental Committee on Mapping and Surveying (ICSM).

CRCSI provided spatial expertise, development and support to the Western Port Biosphere Story Maps project. The Western Port Biosphere is supported by five Victorian local governments (Bass Coast, Cardinia, City of Casey, Frankston City, and Mornington Peninsula Shire), and Parks Victoria (www.biosphere.org.au).

Status and current performance of existing spin-off companies

The CRCSI maintains a small equity stake in one company through the transfer of previous research efforts. Australian company, iintegrate Systems Pty Ltd (www.iintegratesys.com), is commercialising IndjiWatch™ (www.indji.com), a product based on 'HazWatch' which was an outcome of one of the first round the CRCSI projects. IndjiWatch is a product for fully automated monitoring and analysis of natural hazard information and enterprise spatial information dissemination. The company provides software and online services

that enable its customers to transform massive amounts of real-time, location-based data into valuable, targeted information.

3.2 Intellectual Property management

IP management arrangements

The effective management and utilisation of IP is fundamental to achieving the objectives set out in the Strategic Plan. The management of IP is guided by the following practices:

- Facilitation of rapid uptake (and capability) by end-user Participants and stakeholders for national benefit
- Innovative use of IP including all Participants having a licence to use IP for internal research purposes
- Endeavouring to make prior decisions about the commercial potential of investments in IP from research. Where an impact maximising an outcome of public good is sought or where there is no commercial uptake (and no national security or privacy issues) then the IP will be placed into the public domain
- Operating an end-user uptake pathway with emphasis on partnering SMEs and government organisations, supported by research providers. Appropriate consideration is also given to the needs of corporate Participants
- Use of an EOI process to seek utilisation plans from the CRCSI Participants for IP deemed by the Board to be ready for end-user adoption
- Recognition of the substantial public benefits of the principle of open access
- Preferentially supporting end-user Participants who have been active in research projects and who wish to utilise research outputs

- Exercising judgement at all times to maximise the collective benefit to the CRCSI as a whole.

The CRCSI IP comprises any IP developed by the Participants in carrying out the activities of the CRCSI (normally via project agreements). The CRCSI IP is beneficially owned by the Essential Participants as tenants-in-common in proportion to respective participating shares in the CRCSI. The management of the CRCSI IP is the highest priority of the CRCSI.

Each Essential Participant has a non-exclusive, royalty-free licence to use the CRCSI IP for the purposes of the CRCSI activities and a non-exclusive, royalty-free, irrevocable right to use the IP to carry out internal research and development, and training or teaching.

The legal owner of the CRCSI IP is SISR, which holds the IP in trust for the CRCSI Participants. SISR is responsible for protecting, registering, patenting and utilising the IP. SISR is the company that has been established as the holder and utilisation agent of the CRCSI IP, and is responsible for the utilisation of the CRCSI IP, including the marketing of the IP, the seeking of potential licensees of the IP, and seeking other users of the CRCSI IP for commercial purposes.

If SISR intends to utilise the CRCSI IP, it must advise each of the CRCSI's Essential Participants in writing and identify the particular CRCSI IP and the terms of the proposed utilisation. Each Participant must, within 10 working days of receipt of the notice, advise SISR whether it desires to utilise or participate in the utilisation of the IP. If no Participant desires to commercialise, then SISR is free to utilise the CRCSI IP. No CRCSI Participant can commercialise, dispose of or encumber any interests which it might hold in the CRCSI IP, except where authorised.

The CRCSI adopts the principle that researchers should be encouraged to actively participate in research, utilisation and commercialisation activities of the CRCSI and be rewarded for doing so. Accordingly, all financial incentives for researchers who are employees of participating organisations will be paid in accordance with the relevant policies and employment conditions of those organisations.

Overview of current pieces of IP currently held by the CRCSI

The CRCSI Intellectual Property Register is a vital element in ensuring that information and methods generated by the CRCSI are recorded and, where appropriate, developed for commercial benefit.

The CRCSI IP Register serves to facilitate the use of new developments either by way of utilisation, or by contributing to other research activities within the CRCSI. It also provides a mechanism which helps both to identify material which is the property of the CRCSI and should be treated as confidential, and to identify material which should be protected.

Each CRCSI researcher is obliged to disclose any invention that may have commercial potential. The onus is on the individual researcher to promptly communicate details of any IP to the relevant Project Leader, who has the responsibility to communicate the notification to the CRCSI CEO.

Mechanisms in place to ensure adherence to the National Principles of IP Management for publicly funded research

The CRCSI has an IP Policy and IP guidelines which adhere to the National Principles of IP Management. A research project management manual provides research project leaders with access to best practices for the identification, protection and management of IP.

This strategy intends to optimise the national benefits and returns from the CRCSI research.

How the CRCSI's IP arrangements will ensure maximum benefits accrue to end users and Australia
As described above under the IP Management Section, each Essential Participant has a non-exclusive, royalty-free licence to use the CRCSI IP for the purposes of the CRCSI activities and a non-exclusive, royalty-free, irrevocable right to use the IP to carry out internal research and development, and training or teaching. SISR is responsible for protecting, registering, patenting and utilizing the IP. If SISR intends to utilise the CRCSI IP it must follow the process set out under the IP management section.

Titles of patents held and /or applied for in Australia and internationally

CRCSI submitted two provisional patent application in 2015-16, with one previously submitted patent moving into the PCT phase. CRCSI has no active patents.

Table 5 gives a brief overview of select intellectual property items held by the CRCSI which are either under licence or being pursued.

3.3 Communication

Internal communication activities undertaken during the period

Communication Plan 2015-2018

A communication plan was developed to reflect the key findings of the CRCSI Communication Audit 2015 and the CRC Programme review conducted in 2014.

The Communication Purpose

The purpose of our communication is to:

1. Convey an accurate sense of what the CRCSI is doing and by whom to our partners and stakeholders

Table 5: Brief overview of select intellectual property items held by the CRCSI which are either under licence or being pursued.

Description	Pathway
Real-Time Quality Control Software for Positioning	Under licence to Project Participants
Photogrammetric software for the generation of spatial information products from satellite imagery (Barista)	Made available in Open source
Aircraft guidance and path planning software	Under licence option to CRCSI Participant
National Nested Grid Standard, Workflow Management System Software Platform and data model based on a grid cell (raster) approach for management of spatial information	Made available for use under Open Source licences https://github.com/VPAC/rsa
Health Software Spatial Augmentation Module for increased analytical and GIS capability	Continuing project and under licence to CRCSI Participants
Laser Scanning Segmentation Software (NN Clean)	Under licence to CRCSI Participants
Optimised flight management through planning, aircraft control and in-flight point capture with this 2D and 3D quality assurance capture technology. Developed application for fixed wing surveys of linear infrastructure. It has application to all large data capture activities (linear flying, grid flying or combinations) and into other areas such as search and rescue. Australian Provisional Patent Application No. 2013904709.	Currently seeking licencees
The Envision Toolkit is a sustainable urban regeneration tool – to assist in planning, and the understanding and analysis of economic, social and environmental impacts in suburbs.	Currently exploring commercial opportunities
Easy-to-use tool for graziers to determine feed availability in improved pastures. This tool brings together calibration and active optical sensors for pasture biomass estimation with smartphones and innovative crowdsourcing data techniques. Using existing low cost sensors, producers can access on-demand feed availability through green dry biomass data. The tool assists in answering practical questions related to paddock stocking rates, supplement feed requirements and paddock productivity.	Commercialisation options for the technology to be fully after completion of beta trialling
Tools and a methodology that can be used to reliably estimate the forage availability at the end of wet season tropical savannah environments. The provision of seasonal and annual objective estimates of pasture biomass will assist managers in self-regulating to maintain the health and condition of the landscape while delivering sustainable profits. Encapsulated as a Total Green Biomass estimation tool; A Pasture Growth Rate tool; and a Total Biomass estimation tool.	Licensed to CRCSI Participant
An approach for automatically aligning overlapping mobile mapping system (MMS) data has been developed. An algorithm has also been developed to reduce noise within MMS datasets. The calibration and cleaning of MMS datasets is of interest to mapping, MMS and GIS companies with TLS or MLS datasets, companies acquiring laser scan data, and agencies involved in road corridor management and resource management.	Currently seeking a licensee for technology
Epiphanee™ – a powerful spatial query and visual analytics tool that uses sophisticated privacy filters to maintain anonymity compliance and a novel data agent approach to identify and intelligently join data at the foundation level from practically any source. Originally used in the health sector, Epiphanee™ has the architectural design for web based big data applications. Provisional patent filed (Australian Patent Application No. 2014259493, USSN is 62/074,970).	Seeking to establish additional partnering relationships to undertake market development and sustainable commercialisation activities into the future.
Bringing to life infrastructure from the mapping process, this software automatically highlights buildings from LiDAR data. There are two modules: software to automatically reconstruct city-scale building footprints from classified airborne LiDAR point clouds and software tool and callable library routines to detect buildings from complex scenes and fused LiDAR and aerial imagery and creation of building masks from fused LiDAR and ortho imagery.	Currently seeking a licensee
Quality Assurance – LiDAR Capture. Software acts as one stop data check will increase data processing with quality transparency. This software toolkit is used to enable an automated and detailed quality assurance (QA) check of captured data for compliance supply and audit purposes.	Commercialisation options for the technology to be fully xxx after completion of beta trialling

2. Promote the CRCSI, our partners, our outputs and our benefits to the wider community building a sense of the novel and foundation spatial research we conduct that leads to improved wellbeing and social good across contemporary Australia and New Zealand
3. Reinforce a sense of pride and achievement in the work we do.

The content focus of our communication is based on four core areas:

1. Investment in research across our program areas
2. Project and education outcomes, applications and adoption of new technologies
3. Commercialisation opportunities and intellectual property investment
4. Project summaries, achievements and awards.

We are to tell our stories in a practical applicable way to the private sector, government and our partners. Our conversations beyond the immediate spatial community will seek to grow the spatial value chain by substantially increasing the impact of our activities and those of our partners. The value and connectedness of the CRCSI relationship of collaborative research across the spatial information sector will underpin our words. The communication plan sits under the strategic direction of the CRCSI Strategic Plan 2015-2018 and focuses on the operational goals of the current business plan – strengthening relationships, leveraging expertise and commercialisation opportunities. The communication plan incorporates key messages with target audience messaging for partners and participants, the user community, and the broader community (citizens). Using a communication matrix, channels of communication are matched to target audience groupings.

Profile Raising

The challenge for the CRCSI communication relates to communicating directly to the user community (seeking them out and finding their communication space), and gaining traction from the broader community about the value of the CRCSI and its role in bringing about lasting spatial technologies to all Australian and New Zealand people. The communication plan highlights three specific channels in which to address this challenge. These are:

1. **CEO e-alerts:** ad hoc to test the interest and provide a direct connection between the head of the organisation and our network. With social sharing capabilities, these alerts can be easily shared beyond current contacts.

2. **Focus workshops** for the user community. The workshops will target the major clients and government contractors of 43pl members and the CRCSI participants and partners. Key program areas to be represented are:

- Positioning
- Rapid Spatial Analytics and Spatial Infrastructures
- Agriculture and Natural Resource
- Built Environment
- Health

The workshops will be held around Australia and New Zealand. Each workshop will host a selection of the research programs that target the interests of local partners.

3. **Media stories** to build general community awareness about the work of the CRCSI, its impact and future opportunities that will improve the social wellbeing of Australian and New Zealand people living in a contemporary spatially connected world. These stories will also highlight our partnerships with government (all levels) and the impact of our work that delivers

social benefit (social good) to the community through these government relationships.

To raise the profile of the CRCSI amongst the general (citizen) community, a number of specific opportunities will be explored including radio, television, opinion pieces and TEDx Talks.

Central to these opportunities is the identification of “CRCSI talent”, a series of research outcomes/applications identified that are relevant to the general community with maximum appeal, and a story pitch without jargon nor industry specific language. A “Rosetta Stone” of spatial language is in progress and will continue to build upon the practical language needs of the general community.

Measure of Success

The overarching measurements of success for the communication activities will be the growth of the Spatial News database, connection with and exposure to general media and the positive impact the communication activities have on the work of the CRCSI business development team.

Specific measurements for 2015-2016 are:

- Spatial News database growth from 2 800 to 3 100 subscribers (achieved) with a 40% open rate (not achieved, open rate currently at 33%)
- Media story in a new consumer forum (achieved). 3RRR radio (Einstein A Go Go) story about sea level rise and the impact climate change has in the Pacific Islands. This citizen focused interview with Dr Nathan Quadros, CRCSI Program 2 Manager, talked about the technology behind this work with easy-to-understand examples of what it means.
- What our partners say about the CRCSI and the value we contribute. Achieved through the 2016 communication audit.

Communication Audit

An online communication survey was conducted over a three-week period in April 2016. The CRCSI newsletter (Spatial News), social media channels and direct electronic mail ensured all stakeholders had an opportunity to participate in the survey. There were nine survey questions.

The Results

- 56% of responders believe they have a detailed understanding of the work of the CRCSI across its three core programs and the application of the four end user research areas.
- Most responders identify as interested in the spatial information industry (36%) or as a 43pl member (32%). Committee members, project partners, essential partners and industry bodies made up the remaining 32%.
- 83% of responders confirmed that the regular consistent communication from the CRCSI provides the breadth and depth of the CRCSI activities. This reflects the focused content of the newsletter, along with content delivered through CRCSI workshops, events and the conference.
- The monthly newsletter (Spatial News) was recognised as the most valuable communication (42%) followed by one-on-one engagement (29%) and the conference (21%). Participant forums (4%) and program/project teleconferences (4%) were the least valued.
- There is a 50% equal split between the responders stating they did and did not receive enough detailed information from the CRCSI about research outcomes, project outcomes and summaries and application of new technologies and findings.

The final question in the survey related to the value of the relationship with the CRCSI. Survey participants were asked to provide examples of the

CRCSI value to business, organisation or work. These examples included:

- **Access** to consultancies, raised profile of industry generally, peer networking and business opportunities, new/additional services to clients because of developed technologies through CRCSI funding, partnerships in projects, keeping up to date with the industry and engaging staff (43pl staff members) in the industry, knowledge and exposure to new technologies and innovations.
- **Awareness** of the development of spatially related issues, interactions and presentations at the conference stimulate future partnerships, trusted external expertise, and “do my job better”.
- Two responders commented there were no dollar returns, with the comments “no added value to current profitability. Future profitability will be assessed once a definite CRCSI-3 model has been described”.

The findings of the communication audit led to the following two actions:

1. Highlight the research programs and applications diagram in the CRCSI newsletter and use the Annual Conference to introduce all the CRCSI staff.
2. News updates (online – website and social media) when research programs and project pages are updated and reports are made available on the CRCSI website.

Internal Communication

The CRCSI directly employs 31 people across Australia and New Zealand. Team CRCSI performs a number of key roles including the executive, management team, business development team, program and project managers, science

directors, researchers and technical staff. Located in partner organisations, Team CRCSI comes together once a year at the Annual Conference. The management team holds monthly teleconferences and the Business Development team connects weekly.

Beginning in February, the CRCSI implemented “The Lull”, the internal monthly newsletter to Team CRCSI. This light-hearted look at life, at personalities and “what we do” also offers an insight into how some of our employees are doing great things to help our partners or benefit the community.

Communication Activities

The CRCSI has five main communication activities to communicate success and research achievements.

CRCSI Website. The website front page has been refreshed to reflect a contemporary feel and connect more readily with our stakeholders and the general community. With flexibility in the rolling messaging and images on the home page, we are able to update this from time to time.

Spatial News. The monthly e-newsletter is received by 3 200 subscribers, segmented into key groups. This newly segmented database allows the CRCSI to specifically target messaging and communication.

Participant Forums. These closed forums, held in conjunction with Board meetings, are designed to bring together regionally located Essential Participants and partners to showcase research outcomes, project opportunities and provide an update on the activities and future plans of the CRCSI. This year, the CRCSI held three forums in Brisbane, Perth and Sydney.

Focus Workshops. This new program of workshops is open to partners of the CRCSI and new business.

The purpose is to connect the work of the CRCSI application and utilisation to our stakeholders and their clients. It provides opportunities to better understand our stakeholders and the business tensions and emerging industry requirements. This year we hosted our first series of workshops:

- Sydney: Rapid Spatial Analytics and Spatial Infrastructures
- Perth: Built Environment
- Christchurch: Rapid Spatial Analytics and Spatial Infrastructures, and Built Environment
- Canberra: Spatial Infrastructures
- Sydney: Health

CRCSI Annual Conference. In 2015, this event was held in Melbourne across two and a half days with a dinner and awards ceremony held during the final evening. Two hundred and forty-four delegates attended the Conference, representing the CRCSI Essential Participants, support partners and 43pl members. The three colleges were also well represented; government, research and education and industry. The CRCSI students (PhD and masters) attended the Conference and hosted an exhibition of their work. Five of the students “pitched their research stories” during a plenary session at the conference. The conference was opened by Ms Helen Owens, Principal Advisor, Public Data Policy, Department of Prime Minister and Cabinet, followed by Ms Claire Foo, Executive Director, Information Services, Information Services Division Corporate Services, DELWP. The Conference also heard from Dr Leonie Walsh, Lead Scientist, State Government of Victoria. There were international keynotes speakers from Planet Labs (US), Geospatial Media (India) and Catapult Centre (UK). Senator Bridget McKenzie, Senator for Victoria represented the Hon Christopher Pyne, Minister for Industry, Innovation and Science as an opening speaker on the final day of the Conference. The event was closed with a keynote address from Samsung Australia.

Other activities

The CRCSI attended as an exhibitor and program presenter at LOCATE16, the premier spatial industries conference in Australia. Attracting over 600 delegates from government, private sector and university and research agencies, the event also hosted the Asia Pacific Spatial Excellence Awards. The CRCSI and partners Digitalglobe and NGIS Australia won the People and Community Award and JK Barrie Award for Overall Excellence for the Cyclone Pam Crisis Map.

Social Media

The CRCSI continues to gain traction and extend our communication across two key social media platforms. LinkedIn (company page) has increased by 40 per cent to 236 followers who seek news and updates on employment opportunities. Twitter has grown by 22 per cent to 620 followers. This is the most active of our social platforms, with retweets, likes and comments, @crcsi twitter attracts on average 219 profile visits per month with tweet impressions up to 23 500 in a single month.

In May, the CRCSI launched an Instagram account @crcsi to support its work through images and connect into the general community beyond the boundaries of the spatial industry. The impact of this platform will be developed during the next 12 months.

YouTube

The CRCSI YouTube channel is used as a host for its video content and that of our partners to support and showcase the collaborative research we conduct. In November 2015, we created the CRCSI Impact video in preparation for the Annual Conference and to more readily explain the work we collaborate and the breadth of our partnerships. This eight-minute video has been well received beyond our community in our activity to broaden community understanding of spatial information. By hosting the video in CRCSI staff email signatures, it has become a reminder with all our

communication of the work we do. This video will be updated and shortened to three minutes in 2016 as a showpiece at the Annual Conference in October 2016.

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 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 agricultural at paddock level. The 43rd 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. 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.

Media

The CRCSI continues to attract regular media attention, across spatial information publications, business media and rural outlets. Following is a sample of leading media stories:

- Coastal Risk Australia; 200 radio clips and three live-to-air interviews, six television interviews and one discussion, 30+ online news media outlets (newspapers and blogs), 11 social media posts/tweets.
- United Nations Lighthouse Award; 3RRR Radio, Position Magazine, Rust Report, GIS User online.
- Spatial Hub; NASA, ABC News, MLA Feedback Magazine, Queensland Country Life.
- Urban Renewal Value Creation; Sydney Morning Herald, Australian Financial Review.

Program Communication

Rapid Spatial Analytics (RSA) is a new research program of the CRCSI. Starting in July 2015, this program now collaboratively funds four projects. In keeping with the research theme, RSA publishes fortnightly Rapid News to project partners and participants, and potential users of the outcomes of the research. Rapid News is well received with an average 63 per cent open rate.

The Spatial Infrastructures Program hosts a monthly teleconference with program partners and participants. The purpose of this communication activity is to increase partner engagement around utilisation, proof of concept opportunities and end user connections. These teleconferences are well attended and have increased partner collaboration and understanding of the commercial opportunities within this research area.

Overall strategies used to ensure effective internal and external communication

The communication plan is the framework of our communication messaging, activities and channels to our target audience groups. A content management plan provides the structure for each of the activities; with particular focus on program and project research updates, outcomes and utilisation opportunities. The newly segmented CRCSI database (3 200 connections) allows a more targeted message to our network. The annual communication audit provides the feedback loop required to ensure our communication activities are relevant, on message and of value.

4. Resources

4.1 Governance and Management

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

SISR is a charitable organisation under Subdivision 50-B of the Income Tax Assessment Act 1998 and section 123E of the Fringe Benefits Tax Assessment Act 1986. The tax exempt status means that SISR will not be liable for company taxation and will not be required to complete a tax return. SISR will still be liable for Goods & Services Tax (GST) and has reduced Fringe Benefit Tax (FBT) at a 50% rebate.

Each Essential Participant may be a member of SISR and there are seven Essential Participants who have chosen to do so. They 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

There are 62 formal participants in the CRCSI from the government, private and research (university) sectors, with a further 59 Third Party organisations that have committed cash or in kind to the Centre over the period. Formal participants have been formed 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 its 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 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. As a result, the CRCSI is known as the Australia and New Zealand CRC for Spatial Information.

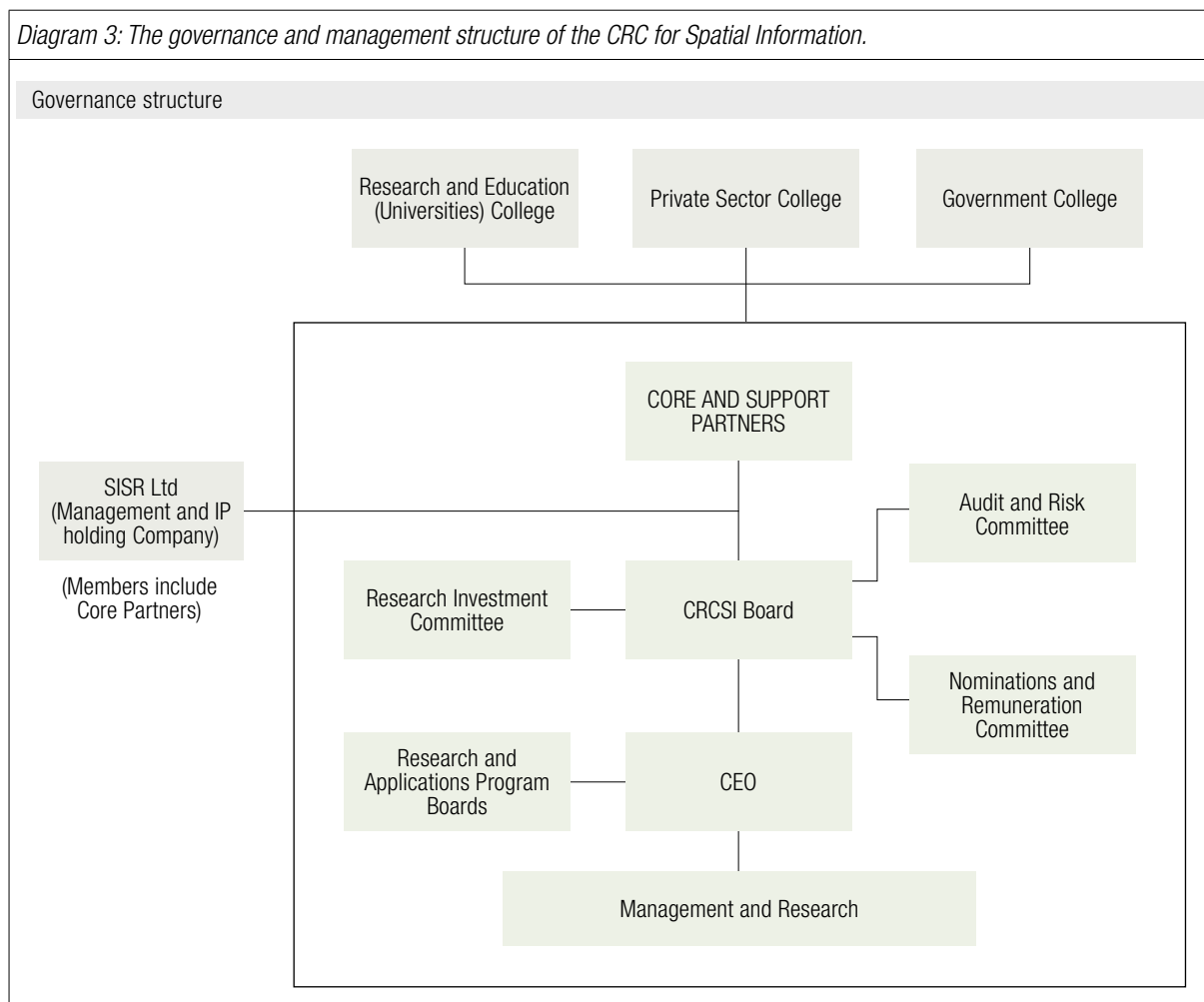
Board membership and key skills

The seven member skills-based Board met formally five times in 2015-16. The majority of Directors of the CRCSI are independent.

The 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 Committees and Executive Management team.

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

Diagram 3: The governance and management structure of the CRC for Spatial Information.



and applications programs. A comprehensive suite of governance protocols, policies and guidelines has been implemented. The Board and supporting Committees review these periodically to assess the performance of the CRCSI and to ensure policies remain up to date and consistent with current regulatory requirements and best practice. An annual agenda of activities is maintained by the Board.

Table 8 shows the Board and Committee membership during 2015-16.

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. These Boards are chaired by a lead end user and meet several times a year. It is a requirement of the CRCSI that the Program Board signs off on each project proposal before it is considered by the Research Investment Committee and the CRCSI Board. By signing off in this way, the Program Board is also attesting that if the research is successful then the end users intend to take up the research outputs for use beyond the CRCSI. On a project by project basis Project Management Groups then meet quarterly to review each project's progress. Reports from these meetings are referred to the relevant Program Boards and the CRCSI's Board. The Project Management Groups have the

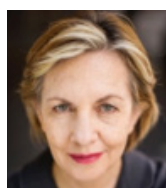
Table 6: Roles and Accountabilities within the CRCSI Governance Structure

Board	Executive	Science Directors	Project Leaders
Strategic Direction	Strategic Planning	Science and research excellence, project	Research leadership
Policy	Operational Management	input and advice (project development;	Project stakeholder
Budget	Business Development	work quality; technical and commercial	communication and relations
Strategic Plan	Commercialisation	networks)	Project management (staff and budget),
Achievement	Communication	Internal links	meeting milestones and report
CEO appointment	Adoption Pathways	Market interface	Internal liaison
	Relationships	Research utilisation	Adoption
	International	International	

ability to recommend continuation, variation or termination of each project.

Diagram 3 summarises the CRCSI's governance and management structure. Table 6 summarises the roles and accountabilities within the CRCSI's Governance Structure.

Directors



Mary O'Kane (Chair)

Mary is a consultant and company director. She is Executive Chairman of O'Kane Associates, advising governments and the private sector on innovation, research, educa-

tion and development. She is also NSW Chief Scientist & Engineer. Mary was Vice-Chancellor of the University of Adelaide from 1996- 2001 and Deputy Vice- Chancellor (Research) from 1994-1996. Mary has served on several boards and committees in the public and private sectors. She was Chair of the Australian Centre for Renewable Energy, a Director of FH Faulding & Co Ltd and was a Member of the Australian Research Council, the Cooperative Research Centres Committee and the Board of the Commonwealth Scientific and Industrial Research Organisation. She is currently Chair of the Boards of the Space Environment Management CRC and of the Institute of Marine and Antarctic Studies at the University of Tasmania. She serves on the boards of Business Events

Sydney Ltd, the New Zealand Antarctic Research Institute, the Development Gateway, the Integrated Manufacturing CRC, and the Capital Markets CRC. Mary is a Fellow of the Australian Academy of Technological Sciences and Engineering and an Honorary Fellow of Engineers Australia.



Peter Woodgate

Peter was appointed to the position of CEO of the CRCSI in June 2003. He is a Board Member of the Terrestrial Ecosystems Research Network; Foundation

Chair of the Global Spatial Network; Board Member of the UNESCO International Centre on Space Technologies for Natural and Cultural Heritage; Founding Chair of the Open Digital Earth Foundation; Co-Chair of the Australian Government Space Cross-Sectoral Interest Group; and Board Member of AuScope Limited. Peter was previously CEO of RMIT's Geospatial Science Initiative where he helped establish Spatial Vision Innovations Pty Ltd, RMIT's first ever spin-off, the Risk and Community Safety Research Centre and RMIT's Global Sustainability Institute. Peter has a Doctorate in Business Administration from RMIT University, a Masters of Applied Science from the University of New South Wales, a Degree in Forest Science from the University of Melbourne, and is a Graduate of the Mastering the Boardroom course of the Australian Institute of Company Directors.



Malcolm McCoy

Malcolm McCoy is a Business Development Consultant with AAM and has in excess of 25 years' experience as a director of survey and spatial companies and close to 40 years in the industry. He was previously Managing Director of Vekta, prior to it becoming part of AAM. Malcolm has a profound understanding of survey and spatial disciplines and has contributed to the profession at local, national and international levels. His areas of expertise are land and engineering surveying but also strategic planning, project management, and financial management.



Graeme Wright

Graeme retired as the Deputy Vice-Chancellor, Research at Curtin University in July 2016. He had held this position for the period 2011 – 2016 and has been awarded the title of Emeritus Professor in recognition of his contribution to the University. He has extensive knowledge and experience in education and research, including engagement with higher education policy at a strategic level. Graeme has previously held appointments in the vocational educational sector and more recently across higher education at executive level, and has a profound understanding of the university research environment and its application to industry and the community. Graeme has extensive experience on Boards and Committees of research centres and CRCs, liaison with industry and negotiation of funding agreements, and broad research knowledge in spatial information sciences. He has been closely involved with the CRC for Spatial Information since 2003, then as a member of Research and Education Advisory Committee and the CRCSI Board. Graeme was the inaugural Chair of the Research and Education College and currently chairs the CRCSI Research and Investment Committee, which is a CRCSI Board Committee.

Graeme led the engagement of Curtin with the CRCSI during its inception and his research background is in remote sensing.



Tina McMeckan

Tina has 20 years' experience as a company director and senior executive in listed and private companies, partnerships, not for profit entities and with government businesses. Her specific industry skills are in the energy sector and in commercialisation of science and technology.

Key competencies include corporate governance, risk management, enterprise development, and investment analysis. Tina has extensive board expertise in public and private utility infrastructure including power production, networks and retailing businesses in the gas and electricity industries. Currently she is a Director of the Global Carbon Capture and Storage Institute and Ausnet Services Ltd. Her other appointments as a Director have included Alinta Limited and United Energy Limited. Her significant experience in technology development includes past appointments as the Chair of the Centre for Eye Research Australia and as a Director of Circadian Technologies Ltd, Director of the Vision CRC, Member of the Funds Management Committee of the AusIndustry Research and Development Board and Member of the Victorian EPA Hazwaste Fund Advisory Panel.



Colin MacDonald

Colin MacDonald is Chief Executive of New Zealand's Department of Internal Affairs, Secretary for Internal Affairs, Secretary for Local Government, and the Government Chief Information Officer (GCIO). In his GCIO role, Colin is the ICT Functional Leader for government and works collaboratively across the state sector to transform

government ICT to support radically transformed public services. Colin is also responsible for the success of the Government's Better Public Services Result 10 initiative, which strives to improve citizens' digital interaction with government.

Colin has had more than 30 years of public and private sector experience in information technology and general management, beginning with studies in computer science at Glasgow University, and then starting his career in the UK. In New Zealand, he was previously Chief Executive of Land Information New Zealand, Deputy Commissioner Business Development and Systems at Inland Revenue, and Chief Operating Officer for the ANZ Banking Group (NZ).



Steve Jacoby

Steve is the Executive Director of Land and Spatial Information (LSI) in the Department of Natural Resources and Mines (DNRM).

The LSI division is responsible for spatial data, systems, services and infrastructure. Steve has chaired the Queensland Spatial Information Council (QSIC) since 2009, and represents the State Government on a number of spatial information expert panels, peak bodies, committees and boards. Steve commenced his career with Land Victoria as a trainee. Steve went on to lead the Department's Land Information Group for seven years. In 2003, he commenced with the Queensland Government as Chief Information Officer for the Department of Natural Resources and Water.

Steve holds a Bachelor of Applied Science from RMIT University and a Research Master of Surveying Science (Information Technology) from The University of Melbourne. Steve is currently an Adjunct Professor with the Institute for Future Environments at the Queensland University of Technology (QUT). Steven was awarded the Public Service Medal for services to land and spatial information in the 2014 Queen's Birthday Honours List.

Board meeting dates and attendance

Table 7 sets out the number of Board and Board Committee meetings held and the number of meetings attended by each Director and/or Board Committee member.

Changes to board membership

Mr Steve Jacoby, the Executive Director of Land and Spatial Information in the Queensland Department of Natural Resources and Mines, joined the Board effective 1 July 2015.

Board committee membership, function, reporting arrangements and key skills

Audit and Risk Committee

The Audit and Risk Committee met twice in the period. Its function is to provide assistance and give advice to the Board to discharge its responsibilities pertaining to financial reporting, audit and risk management. The Committee has adopted a formal Charter outlining its functions and responsibilities. This three-member Board appointed Committee is comprised of two Board members and one member who has considerable accounting and auditing expertise, sourced from RMIT University (a CRCSI Other Participant).

BDO (formally PKF Australia Ltd) was re-appointed as the external auditors and tax advisers for the CRCSI, SISR and 43pl for the reporting period. The performance of the external auditor is reviewed annually by the Audit and Risk Committee through consultation with the CRCSI Management, and a recommendation provided to the Board to determine reappointment for the following year.

Research Investment Committee

The purpose of the Research Investment Committee is to advise the Board on investment decisions relating to the Research Program, including utilisation issues, market applications of the science and technology within the activities, and any technical, research and education issues.

Appointment to the eight-member Committee is by the CRCSI Board who has the right to vary membership numbers as required. The Committee met four times during the period to review research project proposals and initiatives. Funding recommendations for Board approval resulted in new projects in all four of the CRCSI research program areas. When the Committee meets it invites the Science Directors and Senior Executives of the CRCSI.

Nominations and Remuneration Committee

This Committee comprises three members and is chaired by the Chair of the CRCSI, Professor Mary O’Kane. It provides advice and recommendations to the Board on issues relating to Board composition and succession, annually reviews the performance of the CEO and Senior Executives, and oversees the establishment, maintenance, recruitment, retention and termination policies and practices for Senior Executives and Independent Directors. The Committee meets periodically as needed.

Table 7: CRCSI Board and Committee attendance in 2015-16

Directors/Committee Members	Board of Directors		Audit & Risk Committee		Research Investment Committee		Nominations & Remuneration Committee	
Number of meetings held	5		2		4		1	
Directors	Eligible	Attended	Eligible	Attended	Eligible	Attended	Eligible	Attended
Colin MacDonald	5	4					1	1
Graeme Wright	5	5			4	4		
Mary O’Kane	5	5					1	1
Malcolm McCoy	5	4	2	0				
Peter Woodgate	5	5						
Tina McMeckan	5	4	2	2				
Steve Jacoby	5	4					1	1
Committee Members	Eligible	Attended	Eligible	Attended	Eligible	Attended	Eligible	Attended
Arthur Berrill					4	4		
Scott Ramage					4	3		
Mike Goodchild					2	1		
Rob Freeth					4	4		
Ryan Keenan					4	4		
Ed Garvin					4	4		
John Trinder					4	4		
Wayne Poole			2	2				
Notes: 1. Board meetings were held on 3 September 2015, 7 October 2015, 17 December 2015, 29 February 2016, 20 May 2016. 2. Mike Goodchild resigned from RIC from 23 September 2015. 3. Steve Jacoby was appointed to the CRCSI Board effective 1 July 2015. 4. Steve Jacoby and Colin MacDonald were appointed to the Remuneration and Nominations Committee in September 2015.								

Table 8: Board and Committee membership 2015-16

Committee Name: Audit & Risk Committee			
Name	Role	Key Skills	CRCSI Affiliation
Tina McMeckan	Chair	Board Director, Corporate Governance, Intellectual Property Management and Capital Raising	Independent
Malcolm McCoy	Member	Board Director, Current spatial industry experience from SME industry perspective, Corporate Governance	AAM Pty Ltd (43pl member)
Wayne Poole	Member	Financial management and audit corporate governance	RMIT University (Other Participant)
Committee Name: Research Investment Committee			
Name	Role	Key Skills	CRCSI Affiliation
Graeme Wright	Chair	Board Director, Curtin University, Essential Participant – Perth WA	
Arthur Berrill	Member	Independent, DMTI Spatial and Scotiabank – Toronto, Canada	
Rob Freeth	Member	Independent, Freeth Computing Consultants – Perth, WA	
Mike Goodchild	Member	Independent, University of California – Santa Barbara, California, USA Note: Mike Goodchild left RIC September 2015	
Ed Garvin	Member	Omnalink Pty Ltd, 43pl participant – Sydney, NSW	
Ryan Keenan	Member	Leica Geosystems, 43pl participant – Melbourne, VIC	
Scott Ramage	Member	AAM Pty Ltd, 43pl participant – Sydney, NSW	
John Trinder	Member	University of New South Wales, Other Participant – Sydney, NSW	
Peter Woodgate	Member	Board Director, CRCSI – CEO Ex Officio	
Committee Name: Nominations and Remuneration Committee			
Name	Role	Key Skills	CRCSI Affiliation
Mary O’Kane	Chair	Board Director, Corporate and Academic sector experience	Independent
Colin MacDonald	Member	Board Director, Corporate Governance and Government experience	Independent
Steve Jacoby	Member	Board Director, Corporate Governance and Government experience	Qld Dept of Natural Resources & Mines (Essential Participant)
Notes: 1. From 1 July 2016, Professor Graeme Wright is an independent member of the Board following his retirement from Curtin University.			

Table 9: Time Commitments of Key Staff

Key Staff	Organisation	CRC Position / Role	Time committed
Peter Woodgate	CRCSI	Chief Executive Officer	100%
Graeme Kernich	CRCSI	Deputy CEO and Business Manager	100%
Phil Collier	CRCSI	Deputy CEO and Research Director	100%
Peter Teunissen	Curtin University	Professor and Science Director (Research Program 1: Positioning)	100%
John Dawson	Geoscience Australia	Program Manager, Research Program 1	55%
Matthew Duckham	RMIT	Professor and Science Director (Research Program 2: Rapid Spatial Analytics)	17%
Nathan Quadros	CRCSI	Education Manager and Program Manager (Research Program 2: Rapid Spatial Analytics)	60%
Geoff West	Curtin University	Professor and Science Director (Research Program 3: Spatial Infrastructure)	53%
Kylie Armstrong	Landgate	Program Manager (Research Program 3: Spatial Infrastructure)	60%
David Lamb	CRCSI	Professor and Science Director (Applications Program 4.1: Agriculture, Natural Resources and Climate Change)	20%
Philip Tickle	CRCSI	Program Manager (Applications Program 4.1: Agriculture, Natural Resources and Climate Change)	25%
Clive Fraser	CRCSI	Professor and Science Director (Application Program 4.2: Defence)	20%
Clive Sabel	University of Bristol	Professor and Science Director (Applications Program 4.4: Health)	6%
Geoff Jacquez	State University of New York	Professor and Science Director (Applications Program 4.4: Health)	3%
Paul Fievez	CRCSI	Program Manager (Applications Program 4.4: Health)	35%
Peter Newman	Curtin University	Professor and Science Director (Applications Program 4.5: Urban Sustainable Development)	10%
Phil Delaney	CRCSI	Program Manager (Applications Program 4.5: Urban Sustainable Development)	10%
Notes: Application Program 4.3: Energy Utilities is yet to demonstrate a need for a Science Director Geoff West retired from Curtin University in March 2016			

4.2 CRCSI Strategic Plan 2014-18

The CRCSI Strategic Plan is reviewed annually by the Board.

VISION: Spatial Enabling Australia and New Zealand The CRCSI will be widely recognised for under- taking 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 world-wide for the high impact of our research. A thriving spatial information industry will acknowledge the central

role of the CRC SI. 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 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 their spatial data supply chains to create value-added applications.

Program 4: Applications

To realise high impact use of the CRC SI's research in the following areas: Agriculture, Natural Resources and Climate Change (4.1) through creation of a biomass and carbon monitoring system for high resolution and high frequency application on farms and through improved environmental monitoring; Defence (4.2) by adapting the capabilities of the CRC SI's research portfolio; Health (4.4) by helping agencies to spatially enable clinical databases; and Built Environment (4.5) to develop new tools and strategies to support sustainable urban planning and built infrastructure development.

Program 5: Education

By 2018 the CRC SI 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 CRC SI 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 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 CRC SI's role in helping establish and value-add critical supply information chains
- High impact end-user applications adopted in each Application Program.

4.3 Participants

Participant List (including Essential, Other and Third Party Participants)

A total of 120 CRC SI contributors, including Essential, Other and Third Parties have provided either cash or in kind contributions to support the CRC SI's activities for 2015-16. Of these, 50 Participants are equity holding partners in the Centre (12 Essential Participants and 38 43pl members) holding beneficial ownership rights in Centre IP based in proportion to aggregate cash contributions to the CRC SI.

Table 10: CRCSI Participants 2015-16

Participant's Name	Participant Type	ABN or ACN	Organisation Type
43 Version 2 Pty Ltd	Essential	95 140 787 971	Industry / Private Sector
Curtin University of Technology	Essential	99 143 842 569	University
Department of Environment, Land, Water & Planning, VIC	Essential	90 719 052 204	State Government
Department of Finance and Services, Land and Property Information, NSW	Essential	84 104 377 806	State Government
Department of Natural Resources and Mines, QLD	Essential	46 640 294 485	State Government
Ergon Energy Corporation Limited	Essential	50 087 646 062	Industry / Private Sector
Geoscience Australia	Essential	80 091 799 039	Australian Government
Landgate, WA	Essential	86 574 793 858	State Government
Queensland University of Technology	Essential	83 791 724 622	University
Royal Melbourne Institute of Technology University	Essential	49 781 030 034	University
The University of New England	Essential	75 792 454 315	University
University of Canterbury	Essential	n/a	University
Australian Geospatial Organisation	Other	68 706 814 312	Australian Government
Department of Health, WA	Other	13 993 250 709	State Government
Energex Limited	Other	40 078 849 055	Industry / Private Sector
Land Information New Zealand	Other	n/a	International
Murray-Darling Basin Authority	Other	13 679 821 382	Australian Government
Office of Environment and Heritage, NSW	Other	30 841 387 271	State Government
Open Geospatial Consortium Inc	Other	n/a	International
Swinburne University of Technology	Other	13 628 586 699	University
The University of New South Wales	Other	57 195 873 179	University
University of Melbourne	Other	84 002 705 224	University
Western Australian Agricultural Authority	Other	86 611 226 341	State Government
Wuhan University	Other	n/a	University
AAM Pty Ltd	43pl	63 106 160 678	Industry / Private Sector
Alexander Symonds Pty Ltd	43pl	93 007 753 988	Industry / Private Sector
Amristar Solutions Pty Ltd	43pl	35 098 156 560	Industry / Private Sector
Brazier Motti	43pl	58 066 411 041	Industry / Private Sector
Brown & Pluthero Pty Ltd	43pl	55 010 117 236	Industry / Private Sector
Business Aspect Pty Ltd	43pl	24 100 876 015	Industry / Private Sector
C R Kennedy & Co Pty Ltd	43pl	50 008 458 884	Industry / Private Sector
Carbon Link Limited	43pl	35 127 225 370	Industry / Private Sector
Eco Logical Australia Pty Ltd	43pl	87 096 512 088	Industry / Private Sector
EOMAP GmbH & Co.KG	43pl	n/a	Industry / Private Sector

Participant's Name	Participant Type	ABN or ACN	Organisation Type
e-Spatial Ltd	43pl	n/a	Industry / Private Sector
ESRI Australia	43pl	16 008 852 775	Industry / Private Sector
FARMpos Pty Ltd (Precision Agriculture)	43pl	61 567 291 569	Industry / Private Sector
Fugro Spatial Solutions Pty Ltd	43pl	52 008 673 916	Industry / Private Sector
Gaia Resources	43pl	94 119 508 824	Industry / Private Sector
GHD Pty Ltd	43pl	39 008 488 373	Industry / Private Sector
Global Scanning Solutions Pty Ltd	43pl	98 163 964 083	Industry / Private Sector
GPSat Systems Australia Pty Ltd	43pl	47 056 077 902	Industry / Private Sector
Insight GIS	43pl	80 059 212 798	Industry / Private Sector
Jacobs Group (Australia) Pty Ltd	43pl	37 001 024 095	Industry / Private Sector
Land Equity International Pty Ltd	43pl	42 097 054 165	Industry / Private Sector
Leica Geosystems Pty Ltd	43pl	18 000 112 765	Industry / Private Sector
Lester Franks Survey & Geographic Pty Ltd	43pl	25 098 991 210	Industry / Private Sector
Mercury Project Solutions Pty Ltd	43pl	57 141 118 194	Industry / Private Sector
NGIS Australia Pty Ltd	43pl	56 061 264 793	Industry / Private Sector
Omnalink Pty Ltd	43pl	80 056 793 723	Industry / Private Sector
Photomapping Services	43pl	30 005 552 876	Industry / Private Sector
Position Partners Pty Ltd	43pl	56 130 367 065	Industry / Private Sector
PSMA Australia Ltd	43pl	23 089 912 710	Industry / Private Sector
Spatial Information Technology Enterprises Ltd	43pl	49 085 230 173	Industry / Private Sector
Spatial Vision Innovations Pty Ltd	43pl	28 092 695 951	Industry / Private Sector
Spookfish Pty Ltd	43pl	95 603 648 264	Industry / Private Sector
Sundown Pastoral Co Pty Ltd	43pl	86 000 334 190	Industry / Private Sector
Superair	43pl	25 990 899 338	Industry / Private Sector
Think Spatial	43pl	65 711 887 042	Industry / Private Sector
Twynam Agricultural Group Pty Limited	43pl	12 000 573 213	Industry / Private Sector
VPAC Ltd	43pl	59 093 732 426	Industry / Private Sector
Whelans (WA) Pty Ltd	43pl	68 074 363 741	Industry / Private Sector
AACO Pty Ltd	Third Party	87 077 456 476	Industry / Private Sector
Australasian Fire and Emergency Service Authorities Council Limited	Third Party	52 060 049 327	Industry / Private Sector
Australian Institute of Health and Welfare	Third Party	16 515 245 497	Australian Government
Australian National University	Third Party	52 234 063 906	University
Australian Wool Innovation Ltd	Third Party	12 095 165 558	Industry / Private Sector
Biosphere Reserve Foundation Ltd	Third Party	15 107 484 408	Industry / Private Sector
Bureau of Meteorology	Third Party	92 637 533 532	Australian Government
Canary Advanced Solutions	Third Party	n/a	International

Participant's Name	Participant Type	ABN or ACN	Organisation Type
Cancer Council (QLD)	Third Party	48 321 126 727	State Government
Canterbury District Health Board	Third Party	n/a	International
Cape York Natural Resource Management Ltd	Third Party	89 146 770 167	Industry / Private Sector
Capital Markets CRC Ltd	Third Party	80 096 930 406	Industry / Private Sector
Christchurch City Council	Third Party	n/a	International
City of Canning	Third Party	80 227 965 466	State Government
City of Stirling	Third Party	26 744 398 382	State Government
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Third Party	41 687 119 230	Australian Government
Delft University of Technology	Third Party	n/a	University
Department of Agriculture and Fisheries	Third Party	66 934 348 189	State Government
Department of Agriculture and Water Resources	Third Party	24 113 085 695	Australian Government
Department of Environment, Water and Natural Resources (SA Arid Lands Natural Resources)	Third Party	36 702 093 234	State Government
Department of Primary Industries (NSW)	Third Party	42 860 678 701	State Government
Department of Primary Industry and Fisheries (NT)	Third Party	84 085 734 992	State Government
Department of Prime Minister and Cabinet	Third Party	18 108 001 191	Australian Government
Department of Science, Information Technology and Innovation (QLD)	Third Party	41 841 375 926	State Government
Department of Transport and Main Roads (QLD)	Third Party	39 407 690 291	State Government
Desert Channels Queensland Incorporated	Third Party	38 323 082 163	Industry / Private Sector
DMTI Spatial	Third Party	n/a	International
Freeth Computing Consultants Pty Ltd	Third Party	67 054 190 297	Industry / Private Sector
Future Position X	Third Party	n/a	International
Griffith University	Third Party	78 106 094 461	University
Hitachi Australia Ltd	Third Party	34 075 381 332	Industry / Private Sector
Indigenous Land Corporation	Third Party	59 912 679 254	Australian Government
Intergovernmental Committee on Surveying & Mapping	Third Party	33 830 643 298	Australian Government
Japan Aerospace Exploration Agency	Third Party	n/a	International
Local Land Services - Central West and Western (NSW)	Third Party	57 876 455 969	State Government
Mallee Sustainable Farming Inc	Third Party	99 557 839 332	Industry / Private Sector
Maroondah City Council	Third Party	98 606 522 719	State Government
Massachusetts Institute of Technology	Third Party	n/a	University
Meat and Livestock Australia Limited	Third Party	39 081 678 364	Industry / Private Sector
Ministry of Business Innovation and Employment (NZ)	Third Party	n/a	NZ Government
Ministry of Natural Resources and Environment – Government of the Independent State of Samoa	Third Party	n/a	International
Murdoch University	Third Party	61 616 369 313	University

Participant's Name	Participant Type	ABN or ACN	Organisation Type
National Health Performance Agency	Third Party	19 620 357 003	Australian Government
North Central Catchment Management Authority	Third Party	73 937 058 422	State Government
Northern Gulf Resource Management Group Ltd	Third Party	94 106 450 355	Industry / Private Sector
Rangelands NRM Co-ordinating Group (Inc.)	Third Party	53 032 039 445	Industry / Private Sector
Resource Consulting Services Pty Ltd	Third Party	49 009 623 590	Industry / Private Sector
Satellite Applications Catapult Ltd	Third Party	n/a	International
South West NRM Ltd	Third Party	95 111 225 293	Industry / Private Sector
Southern Gulf Catchments Ltd	Third Party	15 030 795 778	Industry / Private Sector
Stanbroke Pty Ltd	Third Party	25 008 442 939	Industry / Private Sector
Territory Natural Resources Management Incorporated	Third Party	52 624 459 784	Industry / Private Sector
The Department of Internal Affairs (NZ)	Third Party	n/a	International
The World Bank	Third Party	n/a	International
TomTom International BV	Third Party	n/a	International
University of Ontago	Third Party	n/a	International
Western Australian Housing Authority	Third Party	56 167 671 885	State Government
What If?	Third Party	n/a	International
Note: This list comprises organisations which have executed a formal Commonwealth Participants agreement with the CRCSI or are actively participating in CRCSI activities. There are other partners who are unable to execute this agreement but are participating on the basis of an exchange of letters.			

A further 12 participants are Other (or support) Participants, and the remaining 58 Third Party Participants have entered into specific project agreements or been involved in other Centre activities within the period. For a full list of 2015-16 Participants see Table 10.

Key relationships have also been forged with non-equity holding partners including all of Australia's leading spatial peak bodies; ANZLIC (Australia New Zealand Land Information Council) representing the government interests, SIBA (Spatial Industries Business Association) representing the private sector interests and SSSI (Surveying and Spatial Sciences Institute) representing the spatial profession.

Changes to Participants

RMIT University transitioned from an Other Participant to an Essential Participant effective

1 July 2015. The Other Participant Agreement with Delft University of Technology ended at 30 June 2015, although they remain as participants in CRCSI Project 1.19.

4.4 Collaboration

The CRCSI has a College system to facilitate communication, accountability and decision-making across all Essential Participants and partners. The three Colleges are:

- Government College, led by ANZLIC
- Research and Education College
- SME College through 43pl

The Colleges are also the conduit for partners to explore the range of research opportunities and develop collaborative research proposals in conjunction with the CRCSI Program Managers

and Science Directors. The Colleges have ongoing access to commercialisation and intellectual property opportunities as a result of the research results and outcomes.

CRCSI Collaboration with other CRCs and Growth Centres

Over the last 12 months, the CRCSI has collaborated with CRCs and Growth Centres. These collaborative activities have included:

1. Capital Markets CRC

Formal collaborations began in 2015 with the newly appointed CM CRC Health Program Manager being allocated office space in the CRCSI head office in Melbourne. This physical connection has led to closer networks and co-research opportunities such as:

- Letter of support and intention to collaborate from CM CRC for the Australian Livestock Spatial Innovation Program which is a CRCSI initiative
- Joint project proposal to ACCC using Epiphane™ and CM CRC infrastructure and database monitoring expertise
- Early discussions with WA Health accessing national Medicare and pharmaceutical data to unlock the potential. Likely opportunities within CRCSI's Rapid Spatial Analytics program and Epiphane™ tool
- Joint panellists at the **Place and Health** session during the CRCSI Annual Conference, November 2015
- Panellist at the **Putting Place and Location in Health** focus workshop in Sydney in April 2016.

2. Low Carbon Living CRC

CRCSI Built Environment Science Director, Professor Peter Newman and Project Leader,

Professor Peter Newton provide shared expertise and hold senior roles with the LCL CRC.

This expertise and collaboration is particularly important in the Greening the Greyfields project (Built Environment Program) because of the opportunity to collaborate with a joint CRCSI and LCL CRC proposal for financial support from each of the CRCs. This proposal has subsequently been accepted and funded.

3. Lowitja Institute

The Lowitja Institute is interested in the CRCSI's Canterbury (NZ) Recovery project on the spatial distribution of mental health issues of the population associated with the location and intensity of earthquake impacts "impact disaster". Lowitja sees opportunities to transfer the learnings from this CRCSI project to Australian indigenous communities that are exposed to disaster impact relating to drug and alcohol abuse in immediate family and local communities.

The CRCSI Health Program continues to have ongoing discussions with the Lowitja Institute about the sharing of data and the implementation of relevant indigenous health projects, including the use of spatial mapping and modelling of health data and 3D facial analysis.

4. Antarctic Climate & Ecosystems CRC

The CRCSI and NGIS Australia Coastal Risk tool is built on some components of ACE CRC's Canute tool. This can be viewed at www.coastal-risk.com.au and the use of Canute is recognised via the useful links page.

5. Food and Agriculture Growth Centre

The Food and Agriculture Growth Centre has agreed to a process of cooperation with the CRCSI and to examine opportunities for deeper collaboration through the CRCSI's Australian Livestock Spatial Innovation Program in the first instance.

Participant and Partner Collaboration

The CRCSI has a nationally located business development network with managers located in key partner locations. The 10 business development managers are located in:

- Melbourne (head office) located close to Essential Participants DELWP, RMIT University and support partner, Swinburne University
- New Zealand (Wellington) at the office of support partner LINZ
- Canberra at the office of Essential Participant, Geoscience Australia
- Perth at the office of Essential Participants, Landgate and Curtin University, and support partner WA Department of Health
- Brisbane at the office of Essential Participant, Queensland University of Technology
- Sydney at the office of Essential Participants, Property NSW, formally Land and Property Information.

Collaboration between research participants, research participants, end-user participants and between the end users themselves

During 2015-16, the CRCSI distributed four Expressions of Interest (EOI) across the three Colleges. A summary of these prospects are as follows:

- Opportunities to invest in satellite delivery of augmenting positioning data. This EOI was sent to 130 partners and achieved a 55% open rate with 394 total opens. The SME College expressed the most interest in this opportunity.
- Rapid Spatial Analytics research proposals. This EOI was seeking research teams to collaborate

in developing two research projects. 161 partners received this EOI with an open rate of 49% and total opens of 787. The Research and Education College expressed the most interest in this opportunity.

- Spatial Infrastructures Programmer to manage proof of concept and prototype applications. This SME College targeted EOI was sent to all 43pl members and achieved a 53% open rate and a total of 89 opens. The EOI was delivered in conjunction with a general call for programmer skills on the open employment market. The offering, created by 43pl member Amristar, to provide the Spatial Infrastructures Program with core programmer skills, is an example of the collaboration that can be developed through significant partner relationships.
- Applied research proposals to deliver targeted spatial solutions to health agencies in Australia and New Zealand. This EOI was sent to 174 partners with a 45% open rate, achieving 953 total opens. The Research and Education College expressed the most interest in this opportunity. The purpose of this EOI was to encourage multiple agencies, research institutions and private technology companies to register expertise and capability to underpin the spatial information and spatial technologies in the health sector.

The series of EOIs created in 2015-16 led to the development of research proposals and the uptake of commercialisation and intellectual property opportunities, and the continuing solution delivery to end users.

External linkages and how it contributes to the CRCSI overall

During 2015-16, the CRCSI collaborated with 121 organisations who formally contributed to the activities of the Centre. Involvement can range from significant contribution to one or more of the

57 CRCSI funded projects, through to attendance at the annual conference or a program focused workshop.

National

There were 98 Australian based organisations who were participants in the Centre during 2015-16 and they are represented by the following:

- 10 organisations from research and education
- 31 organisations from government agencies
- 55 SME and corporate business
- Two non-profit organisations.

International

The CRCSI undertakes collaborative research work with organisations outside Australia.

During 2015-16 the CRCSI collaborated with 22 international organisations. These are represented as the following:

- Five organisations from research and education
- Seven organisations from government agencies
- Nine SMEs and corporate businesses
- One non-profit organisation.

The linkages through the three Colleges to the research community and end users contribute to the CRCSI by ensuring project concepts leading into full proposals are collaborative across the participant spectrum. The business development team underpins this collaboration by ensuring proposed research concepts are congruent to key CRCSI deliverables. This approach to project development builds upon existing intellectual property and commercialisation opportunities. It also encompasses the education program and its current student cohort to continue to increase expertise and indigenous knowledge and capacity in the Australian spatial information sector.

4.5 Financial Management

Overview of the financial position and management of CRCSI in relation to the activities

The CRCSI was in a healthy financial position at the end of the 2015-16 year, with \$12.7M cash at bank and has sufficient funding to meet its debts. The CRCSI finished the year with an operating deficit of \$4.4M against a budget deficit of \$8.5M. This is a favourable movement compared to budget, due to the lower spend in research by \$4.3M, and also under spend and savings within the Directorate, Business Development, Communication and Board expenditure areas. Total cash and in kind contributions were \$24.7M for the period, unfavourable to budget by \$0.6M, with favourable variances from cash and non-staff in kind contributions totalling \$2.7M, offset by unfavourable staff in kind contributions of \$3.4M. Cash received was 68% higher for the 2015-16 period than forecast in the Commonwealth Agreement.

BDO were reappointed as external auditors and the related financial reports and statements were prepared in accordance with the Australian Accounting Standards, International Financial Reporting Standards and Interpretations and Commonwealth Guidelines where required. At the conclusion of the audit process, no audit adjustments were required.

Assessment of the financial performance overall, including the level of participant contributions, details of any issues experienced and the strategies implemented to address the issues

Comprehensive reporting of the CRCSI financials can be found in the Commonwealth online report and company statutory accounts. In summary, the CRCSI received total cash funding for 2015-16 of \$12.6M, which was \$1.9M above budget including additional contributions from Essential Participants (+\$2.5M) offset against lower contributions from Commissioned Research and Non Participant payments (-\$0.6M).

Essential Participant contributions were ahead of budget by \$2.5M at \$5.7M, which includes additional project funds received from Geoscience Australia (+\$1.8M) for project contributions.

The increase in funding from Essential Partners is reflected in the spread of cash funding by source, with Essential Participant funding accounting for 45% of total cash funding for the year, compared to 27% prior year.

Table 11: Financial Statement

Financial Statement (\$'000s)				
Funds (Cash)	2014-15 Actual	2015-16 Actual	2015-16 Budget	2016-17 Budget
Essential Participants	4,329	5,688	3,205	3,450
Other Participants	645	584	639	437
CRC Program	3,767	3,572	3,572	3,498
Commissioned Research/Other	3,287	2,791	3,346	3,305
Total Funds	12,028	12,635	10,762	10,690

Expenditure (Accrual)	2014-15 Actual	2015-16 Actual	2015-16 Budget	2016-17 Budget
Governance & Administration	1,771	1,793	2,221	2,201
Business Development	745	908	1,137	1,356
Research Program	8,019	8,423	12,491	11,771
Communication & Education	406	156	181	233
Total Expenditure	10,941	11,280	16,030	15,561

In Kind Statement	Staff FTE in kind			Non-staff in kind (\$'000s)		
	Actual 2014-15	Actual 2015-16	Budget 2015-16	Actual 2014-15	Actual 2015-16	Budget 2015-16
Research Program 1	13.5	9.0	6.4	1,793	1,453	1,052
Research Program 2	2.9	2.3	12.3	514	447	995
Research Program 3	5.6	2.5	2.0	922	814	533
Research Program 4	16.4	15.1	20.4	1,858	2,045	1,361
Total	38.4	28.9	41.1	5,087	4,759	3,941

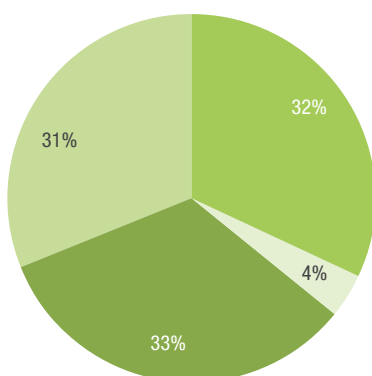
Total Contributions (\$'000s)	2014-15 Actual	2015-16 Actual	2015-16 Budget	2016-17 Budget
Cash	12,028	12,635	10,762	10,690
Staff In kind	9,596	7,264	10,694	10,666
Non-Staff in kind	5,087	4,759	3,941	3,698
Total Contributions	26,711	24,658	25,397	25,054

The full year expenditure of \$11.3M was under budget by \$4.7M, primarily due to under expenditure in research (\$4.0M), and savings in the CRCSI Operational and Business Development budgets (Table 11).

75% of CRCSI expenditure went into the Research Program in 2015-16. The remaining expenditure was attributed to Business Development (8%), Education and Communication (1%) and

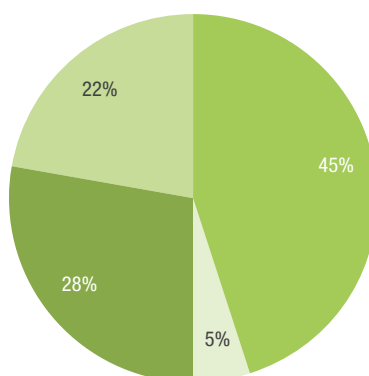
Administration (16%). When in kind contributions are taken into account the cost of Administration is 7% of the total investment of the CRCSI, which is consistent with the prior year. In kind contributions (FTE) were lower than budgeted by 12.2 at 28.9 FTE against a budget of 41.1. This has not impacted the CRCSI's ability to deliver research and utilisation milestones. Non staff in kind contributions were higher than budget (\$4.8M versus \$3.9M).

2016-17 Funding Budget



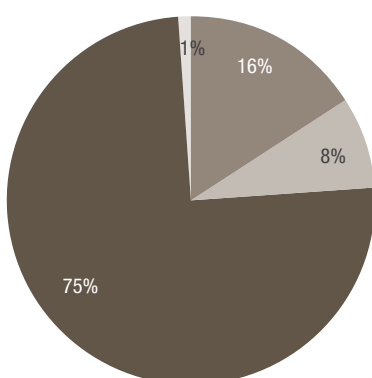
■ Essential Participants
■ Other Participants
■ CRC Programme Funding
■ Commissioned Research/Other

2015-16 Funding by Source



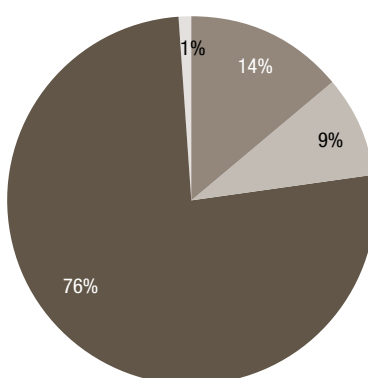
■ Essential Participants
■ Other Participants
■ CRC Programme Funding
■ Commissioned Research/Other

2015-16 Expenditure by Department



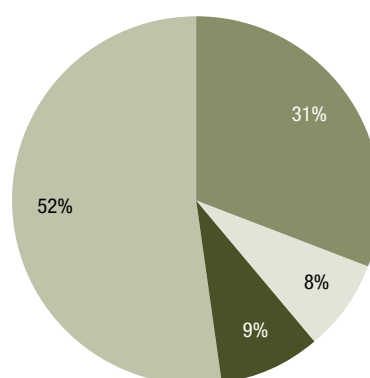
■ Governance & Administration
■ Business Development
■ Research Program
■ Communications & Education

2015-16 Budget Expenditure



■ Governance & Administration
■ Business Development
■ Research
■ Communications & Education

2015-16 Staff (FTE) in kind



■ Program 1
■ Program 2
■ Program 3
■ Program 4

5. Other Activities

Coastal Risk Australia Tool

The Coastal Risk Australia Tool went live in 2015/16 at www.coastalrisk.com.au and was developed using the latest high resolution elevation data compiled from more than 200 Commonwealth, State and Local Government acquisitions. The release of the elevation data under Creative Commons licence was facilitated by the CRCSI in negotiation with the relevant states under a previous project. During its first three months it was accessed 3 million times by more than 100 000 users.

Sea Level Rise Maps

CRCSI has developed a number of coastal maps indicating inundation against anticipated sea level rise scenarios for National Climate Change Adaptation Research Facility Coast Adapt product.

Collaborative Synthetic Aperture Radar Solutions for Australia – Forestry Demonstrator

This collaborative project with the United Kingdom explored the potential export of a robust, internationally comparable and sustainable National Forest Monitoring System (NFMS) service to public and private stakeholders within and outside Australia. Australian partners CRCSI and CSIRO and UK partners Catapult, Carbomap Ltd and the University of Aberystwyth addressed how such a service would enable a country to address all three components of measuring, reporting and verification to enable eligibility for the United Nations REDD+ program subsidies, and to also improve commercial provision of forest management services such as inventorying and commodity trading at a variety of scales.

Collaborative Synthetic Aperture Radar Solutions for Australia – Water resource Monitoring Demonstrator

CRCSI, Geoscience Australia, Catapult, CGG Services – NPA Mapping (UK) Ltd undertook a collaborative project to identify the barriers and opportunities to the development of an operational water resource monitoring system that harnesses both satellite borne radar and optical data through a flexible and high performance data infrastructure.

Geospatial Roadmap Consultancy

CRCSI has completed several geospatial advisory roadmaps for its government partners.

Bathymetric Surveys

CRCSI has provided advice on delivery of bathymetric related services in Samoa and Bangladesh.

Bushfire Fuel Loads

CRCSI completed an inventory on data sets relating to Australian Bushfire fuel loads.

Mosquito Management Tool

CRCSI completed development of a tool to enable real-time collection, management and sharing of mosquito survey data between State and Local Government in WA.

6. Performance Review

The CRCSI Board and Management accepted all recommendations from the Performance Review in May 2013 and developed an implementation plan to address the recommendations.

A regular update was provided to the CRCSI Board until all actions were complete and the final report was presented in 2014-15. The CRCSI Board has continued to monitor the ongoing outcomes from the Performance Review Implementation Plan as part of its annual strategic planning process.

Clark CRC Programme Review

This review addressed three principal questions of individual CRCs: 1) Are you meeting your funding targets; 2) are you meeting your impact targets; and 3) How do you propose to work with Growth Centres? In its assessment report to the CRCSI in May 2016, Mr Clark concluded that “*The CRC Advisory Committee, (of which Mr Clark is the Chair), was pleased to see that the CRC for Spatial Information is meeting all of its obligations against the Commonwealth Agreement and is on track to achieve its stated outcomes.*”

7. Glossary And Acronyms

43pl	43 Pty Ltd, a company representing the CRCSI's SME consortium
ABI	Activity-Based Intelligence
ACS	Analysis Centre Software
AIIA	Australian Information Industry Association
ANZLIC	ANZLIC – the Spatial Information Council formerly known as the Australia and New Zealand Land Information Council
AGO	Australian Geospatial Intelligence Organisation, Department of Defence
AURIN	Australian Urban Research Infrastructure Network
CDMA	Code Division Multiple Access
CEO	Chief Executive Officer
CIP	CRCSI Intellectual Property
CRC	Cooperative Research Centre
CRC Programme	Secretariat of the Commonwealth CRC Programme
CRCSI	Australia and New Zealand Cooperative Research Centre for Spatial Information
CRCSI-1	Name given to the 1st funding round of the CRCSI 2003-2009
CRCSI-2	Name given to the 2nd funding round of the CRCSI 2010-2018
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEM	Digital Elevation Model
DELWP	Victorian Government Department of Environment, Land, Water & Planning
ESP	Envision Scenario Planner
ETC	Expert Technical Committee
FAS	Flight Assist System
FAST	Facial Analysis Streamlining for Clinical Translation
FDMA	Frequency Division Multiple Access
FTE	Full Time Equivalent
GA	Geoscience Australia
GIS	Geographic Information Systems
GITA	Geospatial Information and Technology Association
GLONASS	GLObal NAvigation Satellite System
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GSN	Global Spatial Network
IP	Intellectual Property

ICSM	Intergovernmental Committee on Mapping and Surveying
IRNSS	Indian Regional Navigation Satellite System
LGA	Local Government Area
LiDAR	Laser Imaging Detection and Ranging
LINZ	Land Information New Zealand
LPI	Land & Property Information NSW
MIT	Massachusetts Institute of Technology
MOU	Memorandum of Understanding
NCCARF	National Climate Change Adaptation Research Facility
NEDF	National Elevation Data Framework
NFMS	National Forest Monitoring System
NICTA	National ICT Australia Ltd
NPI	National Positioning Infrastructure
NRM	Natural Resource Management
PPP-RTK	Precise Point Positioning - Real-Time Kinematic
QUT	Queensland University of Technology
QZSS	Quasi-Zenith Satellite System
REDD	Reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks)
REAC	Research & Education Advisory Committee of the CRCSI-1
RNSS	Radio Navigation Satellite Services
ROAMES	Remote Observation Automated Modelling Economic Simulation (Ergon)
RSA	Rapid Spatial Analytics
RTK	Real-Time Kinematic
SavBAT	Savanna Burning Abatement Tool
SIBA	Spatial Industries Business Association
SISR	Spatial Information Systems Research Ltd
SME	Small to Medium [sized] Enterprises
SSSI	Surveying & Spatial Sciences Institute
TERN	Terrestrial Ecosystem Research Network
UDEM	Urban Digital Elevation Model
UJV	Unincorporated Joint Venture
UK	United Kingdom
UNE	University of New England
UNSW	University of New South Wales

8. Appendix 1 – Publications

Program 1: Positioning

Book Chapters

Donnelly, N., Crook, C., Stanaway, R., Roberts, C., Rizos, C., Haasdyk, J. (September 2015). *A Two-Frame National Georeferencing System Accounting for Geodynamics*. International Association of Geodesy Symposia Series – http://link.springer.com/chapter/10.1007%2F1345_2015_188

Refereed Journal Papers

Nadarajah, N., Teunissen, P., Sleewaegen, J-M., Montenbruck, O. (July 2015). *The mixed-receiver DeiDou inter-satellite-type bias and its impact on RTK positioning*. *GPS Solutions* – <http://link.springer.com/article/10.1007/s10291-014-0392-6>

Khodabandeh, A., Teunissen, P. (November 2015). *An Analytical Study of Multi-Frequency PPP-RTK Corrections: Precision, Correlation and User-Impact*. *Journal of Geodesy* – <http://link.springer.com/article/10.1007/s00190-015-0838-9>

Zhang, B., Odijk, D. (2015). *A Method for Processing GNSS Data from Regional Reference Networks to Enable Single Frequency PPP-RTK User Models by means of S-system Theory*. *Chinese Journal of Geophysics* – http://espace.library.curtin.edu.au/R?func=dbin-jump-full&local_base=-gen01-era02&object_id=232251

Odijk, D., Zhang, B., Khodabandeh, A., Odilinski, R., Teunissen, P. (January 2016). *On the Estimability of Parameters in Undifferenced GNSS Network and PPP-RTK User models by means of S-system Theory*. *Journal of Geodesy* – <http://link.springer.com/article/10.1007/s00190-015-0854-9>

Choy, S., Harima, K., Li, Y., Choudhury, M., Rizos, C., Wakabayashi, Y., Kogure, S. (July 2015). *GPS Precise Point Positioning with Japanese Quasi-Zenith*

Satellite System (QZSS). *Journal of Navigation* – <http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=9719957>

Zhang, B., Teunissen, P. (November 2015). *Characterization of Multi-GNSS Between-Receiver Differential Code Biases Using Zero and Short Baselines*. *Science Bulletin* – <http://link.springer.com/article/10.1007/s11434-015-0911-z>

Zaminpardaz, S., Teunissen, P., Nadarajah, N. (April 2016). *IRNSS Stand-alone Positioning: First results in Australia*. *Journal of Spatial Science* – <http://www.tandfonline.com/doi/abs/10.1080/14498596.2016.1142398>

Odijk D, Nadarajah N, Zaminpardaz S, Teunissen P. (April 2016). *GPS, Galileo, QZSS and IRNSS Differential ISBs: Estimation and Application*. *GPS Solutions* – <http://link.springer.com/article/10.1007/s10291-016-0536-y>

Khodabandeh, A., Teunissen, P. (May 2016). *PPP-RTK and Inter-System-Biases: the ISB look-up table as a means to support multi-system PPP-RTK*. *Journal of Geodesy* – <http://link.springer.com/article/10.1007/s00190-016-0914-9>

Zaminpardaz S, Teunissen PJG, Nadarajah N, (May 2016). *GLONASS CDMA L3 Ambiguity Resolution and Positioning*. *GPS Solutions* – <http://link.springer.com/article/10.1007/s10291-016-0544-y>

Refereed Conference Papers

Verhagen, S., Teunissen, P. (July 2015). *Application-driven critical values for GNSS ambiguity acceptance testing*. International Association of Geodesy Symposia, 1-6 September Potsdam, Germany – http://link.springer.com/chapter/10.1007/1345_2015_36

Khodabandeh, A., Teunissen, P., Zhang, B. (July 2015). *Multi-GNSS multi-frequency PPP-RTK setup: mixed receiver network and user scenarios*. IAG proceedings: 26th IUGG General Assembly – http://link.springer.com/chapter/10.1007/1345_2016_232

Li, W., Nadarajah, N., Teunissen, P., Khodabandeh, A. (September 2015). *Single-frequency L5 PPP-RTK with GPS, IRNSS, QZSS and Galileo*. ION GNSS+ 2015, Tampa, Florida USA 14-18 Sept 2015 – <https://www.ion.org/gnss/abstracts.cfm?paperID=3024>

Harimea K., Choy, S., Choudhury, M., Rizos, C., Kogure, S. (July 2015). *Pilot Study on the use of Quasi-Zenith Satellite System as a GNSS Augmentation System for High Precision Positioning in Australia*. Proceedings of IGNS 2015, Gold Coast, Australia – <http://www.ignss.org/LinkClick.aspx?fileticket=nAZW8M6dM-WE%3D&tabid=147&mid=558>

Choy, S., Harima, K., Li, Y., Choudhury, M., Wakabayashi, Y., Rizos, C., Kogure, S., Collier, P. (July 2015). *Utilisation of the Japanese Quasi-Zenith Satellite System (QZSS) Augmentation System for Precision Farming in Australia*. Proceedings of IGNS 2015, Gold Coast, Australia – <http://www.ignss.org/LinkClick.aspx?fileticket=EPwJxOUD-Q4w%3D&tabid=147&mid=558>

Teunissen, P., Khodabandeh, A., Zhang, B. (July 2015). *Multi-GNSS PPP-RTK: mixed receiver network and user scenarios*. IAG proceedings: 26th IUGG General Assembly – http://link.springer.com/chapter/10.1007/1345_2016_232

Harima K., Choy S., Rizos C., Kogure S. (May 2016). *Performance of Real-time Precise Point Positioning in New Zealand*. FIG Working week 2016, Christchurch, New Zealand – http://www.fig.net/resources/proceedings/fig_proceedings/fig2016/papers/ts07b/TS07B_harima_choy_et_al_8010_abs.pdf

Choy S., Harima K., Choudhury M., Rizos C., Kogure S. *Real-time Precise Point Positioning using QZSS LEX Augmentation Corrections in Australia*. Proceedings of the ISGNSS 2015 Conference and Symposium, Kyoto, Japan

Internal Reports

Teunissen, P., Nadarajah, N., Odijk, D., Khodabandeh, A., Zhang, B., Li, W., Zaminpardaz, S., Choudhury, M. (March 2016). *Multi-GNSS PPP-RTK Network Processing – Midterm Review Report and Deliverables Nov 2014 – Mar 2016*. GNSS Research Centre.

Nadarajah, N., Odijk, D., Khodabandeh, A., Zhang, B., Li, A., Zaminpardaz, S., Choudhury, M. Curtin *Multi-GNSS PPP RTK Network Software Guide (vs 1.0)*. GNSS Research Centre.

Program 2: Rapid Spatial Analytics

Book Chapters

Wilkes, P., Jones, S., Suarez, M., Haywood, A., Mellor, A., Woodgate, W., Soto-Berelov, M. (August 2015). *Introduction*. AusCover Good Practice Guidelines – <http://www.auscover.org.au/xwiki/bin/view/Good+Practice+Handbook/WebHome>

Soto-Berelov, M., Jones, S., Farmer, E., Woodgate, W. (August 2015). *Review of validation standards of Earth Observation derived biophysical products*. AusCover Good Practice Guidelines – <http://www.auscover.org.au/xwiki/bin/view/Good+Practice+Handbook/WebHome>

Mitchell, A., Thankappan, M. (August 2015). *Good Practice Guidelines for calibration and validation of SAR data and derived biophysical products*. AusCover Good Practice Guidelines – <http://www.auscover.org.au/xwiki/bin/view/Good+Practice+Handbook/WebHome>

Schaefer, M., Farmer, E., Soto-Berelov, M., Woodgate, W., Jones, S. (August 2015). *Overview of ground based techniques for estimating LAI*. AusCover Good Practice Guidelines – <http://www.auscover.org.au/xwiki/bin/view/Good+Practice+Handbook/WebHome>

Schaefer, M. (August 2015). *Measurement of above ground biomass*. AusCover Good Practice Guidelines – <http://www.auscover.org.au/xwiki/bin/view/Good+Practice+Handbook/WebHome>

Quadros, N., Keysers, J. (August 2015). *Airborne LiDAR Acquisition and Validation*. AusCover Good Practice Guidelines – <http://www.auscover.org.au/xwiki/bin/view/Good+Practice+Handbook/WebHome>

Refereed Journal Papers

Wilkes, P., Jones, S., Suarez, L., Haywood, A., Woodgate, W. (August 2015). *ALS for the assessment of vertical canopy structure across diverse forest types*. *Methods in Ecology and Evolution* – <http://www.sciencedirect.com/science/article/pii/S0099111215302044>

Wilkes, P., Jones, S., Suarez, M., Haywood, A., Mellor, A., Woodgate, W., Soto-Berelov, M. (August 2015). *Understanding the effects of ALS pulse density for metric retrieval across diverse forest types*. *Photogrammetric Engineering & Remote Sensing* – <http://www.sciencedirect.com/science/article/pii/S0099111215302044>

Woodgate, W., Disney, M., Armston, J., Jones, S., Suarez, M., Hill, M., Wilkes, P., Soto-Berelov, M., Haywood, A., Mellor, A. (December 2015). *An improved theoretical model of canopy gap probability for Leaf Area Index estimation in woody ecosystems*. *Forest Ecology and Management* – <http://www.sciencedirect.com/science/article/pii/S0378112715005253>

Program 3: Spatial Infrastructures

Refereed Conference Papers

Varadharajulu, P., Saqiq, M., Yu F., McMeekin D., Geoff West, G., Arnold, L., Moncrieff, S. (July 2015). *Supply Data Chains*. – ISPRS 2015, Sardinia, Italy – <http://search.proquest.com/openview/4ae76538a9fd0e4f6c-1535c5e1839c92/1?pq-origsite=gscholar&cbl=2037674>

Sadiq, M., Arnold, L., McMeekin, D., Moncrieff, S., West, G. (November 2015). *Provenance model for land administration workflow of spatial data supply chains*. *Proceedings IIT 2015 Dubai, UAE* – http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7381537&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxppls%2Fabs_all.jsp%3Farnumber%3D7381537

Goodhue, P., McNair, H., Reitsma, F. (October 2015). *Trusting Crowdsourced Geospatial Semantics*. *ISSDQ 9th International Symposium on Spatial Data Quality*, La Grande Motte, France, 29-30 Sept 2015 – ISPRS Geospatial Week – <http://search.proquest.com/openview/a3d3d6cdf220af11abaaa9d91bb73b1f/1?pq-origsite=gscholar&cbl=2037674>

Sadiq, M., Arnold, L., McMeekin, D., Moncrieff, S., West, G. (December 2015). *Feature and attribute level provenance for spatial data supply chain*. *Proceedings MODSIM 2015 Gold Coast Australia* – http://www.mssanz.org.au/modsim2015/documents/MODSIM2015_Abstracts.pdf

Yu, F., Arnold, L., McMeekin, D., Moncrieff, S., West, G. (January 2016). *Automated Geospatial Data Conflagration using Semantic Web Technologies*. *Proceedings Australia Computer Science Week, World Wide Web, Canberra, January 2016*.

Gulland, E., Moncrieff, S., West, G. (December 2015). *Automated calculation for term relatedness weights for semantic searches*. IEEE/WIC/ACM International Conference on Web Intelligence Singapore – http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7396822&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxppls%2Fabs_all.jsp%3Farnumber%3D7396822

Reed, T., McMeekin, D., Reitsma, F. (November 2015). *Browsing Spatial Knowledge with Linked Ontologies*. Proceedings IIT 2015 Dubai, UAE – <http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7381539>

Program 4.4: Health

Refereed Journal Papers

Kang, S. Y., Cramb, S., White, N., Ball, S., Mengersen, K. (May 2016). *Making the most of spatial information in health: A tutorial on Bayesian disease mapping*. Statistics in Medicine. Statistics in Medicine – <http://www.geospatialhealth.net/index.php/gh/article/view/428>

Kang, S. Y., McGree, J., Baade, P., Mengersen, K. (August 2015). *A case study for modelling cancer incidence using Bayesian spatio-temporal models*. Australian and New Zealand Journal of Statistics – <http://onlinelibrary.wiley.com/doi/10.1111/anzs.12127/abstract?userIsAuthenticated=false&deniedAccess-CustomisedMessage=>

Refereed Conference Papers

Marek, L., Campbell, M., Epton, M., Storer, M., Kingham, S. (June 2016). *Real-time environmental sensors to improve health in the Sensing City*. ISPRS 2016 – <http://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLI-B2/729/2016/>

Internal Reports:

Roberts, J., Cramb, S., Baade, P., Mengersen, K. *Communicating Statistical Outputs Through Health Maps*. Brisbane. Cancer Council Queensland and Queensland University of Technology (QUT). Cancer Council Queensland and Queensland University of Technology (QUT).

Roberts, J., Cramb, S., Baade, P., Mengersen, K. *Grey Literature Review: Internet Published Cancer Maps*. Brisbane. Cancer Council Queensland and Queensland University of Technology (QUT).

Cramb, S., Duncan, E., White, N., Baade, P., Mengersen, K. *Spatial Modelling Methods: Brisbane*. Cancer Council Queensland and Queensland University of Technology (QUT).

Program 4.5: Built Environment

Book Chapters

Newton, P., Glackin, S. (August 2015). *Regenerating cities: Creating opportunities for Greyfield precinct Infill development*. Instruments of Planning, Leshinshy, R., and Legacy, C. (2015) Routledge New York – https://books.google.com.au/books?id=5ABXCgAAQBAJ&dq=Engaging+the+Grefields:+Community+engagement+and+co-design+in+residential+redevelopment+of+public+housing&source=gbs_navlinks_s

Glackin, S., Newton, P. (August 2015). *Engaging the Grefields: Community engagement and co-design in residential redevelopment of public housing*. Instruments of Planning, Leshinshy, R., and Legacy, C. (2015) Routledge New York – https://books.google.com.au/books?id=5ABXCgAAQBAJ&dq=Engaging+the+Grefields:+Community+engagement+and+co-design+in+residential+redevelopment+of+public+housing&source=gbs_navlinks_s

Russo, P., Costabile, F., Lanzilotti, R., Pettit, C. (May 2015). *Usability of Planning Support Systems: an evaluation framework*. Planning Support Systems and Smart Cities. ISBN: 978-3-319-18367-1 (Print) 978-3-319-18368-8 (Online) – PP337-353 – http://link.springer.com/chapter/10.1007%2F978-3-319-18368-8_18

Newton, P., Glackin, S. (2016). Greyfield *Regeneration: a Precinct Approach for Urban Renewal in the Established Suburbs of Australian Cities*. In Kristian Ruming (Editor) *Urban Regeneration and Australian Cities: policies, processes and projects of contemporary urban change*, Ashgate, London (2016 in press)

Refereed Journal Papers

Dionisio, R., Kingham, S., Banwell, K., Neville, J. (April 2016). *Geospatial tools for community engagement in the Christchurch rebuild*. Sustainable Cities and Society – <http://www.sciencedirect.com/science/article/pii/S2210670716300609>

Glackin, S., Dionisio, R. (March 2016). ‘Deep engagement’ and urban regeneration: tea, trust and the quest for co-design and precinct scale. *Land Use Policy*, volume 52, March 2016, pages 363 – 373 – <http://www.sciencedirect.com/science/article/pii/S0264837716000028>

Trubka, R., Glackin, S., Lade, O., Pettit, C. (July 2016). *A web-based 3D visualisation and assessment system for urban precinct scenario modelling*. *ISPRS Journal of Photogrammetry and Remote Sensing*. December 2015 – <http://www.sciencedirect.com/science/article/pii/S0924271615002634>

GENERAL

Symbios Communications (2015), *Risks of Data Supply of Earth Observations from Space for Australia*. Report prepared for the CRC for Spatial Information, <http://www.crcsi.com.au/assets/Resources/CRCsi-Risks-of-Data-Supply-of-Earth-Observations-from-Space-for-Australia-Final-web.pdf>

ACIL Allen Consulting (2015), *The Value of Earth Observations from Space to Australia*, Report to the CRC for Spatial Information December 2015, <http://www.crcsi.com.au/assets/Resources/CRCsi-The-Value-of-Earth-Observations-from-Space-to-Australia-Final-web.pdf>

CRC for Spatial Information (2015), *Stakeholder Requirements for Modernising Australia’s Geocentric Datum*, <http://www.icsm.gov.au/geodesy/Stakeholder-Requirements-for-Modernising-Australias-Geocentric-Datum.pdf>

McIntosh, J., Trubka, R., and Hendricks, B., (2016) *Transit and Urban Renewal Value Creation – Hedonic Price Modelling Assessment of Sydney’s Key Transit and Transit-Oriented Urban Renewal Investments (2000–2014)* Published Online: <http://www.luticonsulting.com.au/wp-content/uploads/2013/12/Sydney-Transit-and-Urban-Renewal-Value-Creation-Report.pdf>

Space Community of Interest, for the Australian Government’s Trusted Information Sharing Network for Critical Infrastructure Resilience, co-Chaired by Peter Woodgate and Martin Nix, “*A first pass analysis of risks associated with Australia’s dependencies on space-based assets: Communications, Positioning, Navigation, Timing and Earth Observation.*” (2015), Restricted circulation.

9. Appendix 2: PhD and Masters Student List

Name	Research Program	Project Title	Research Organisation	Country	Start Date	Completion Date
PhD Completions						
Kui Zhang	2	Advanced InSAR Technologies	UNSW	Australia	2008	2010-11
Alex Ng	2	PsinSAR Radar Interferometry	UNSW	Australia	March 2006	2010-11
Matthew Hutchison	3	Developing an Agent-Base Framework for Intelligent Geocoding	Curtin	Australia	May 2004	2010-11
Anna Donets	1	Using Single Receiver GPS Observations to Analyse the Dynamic Motion of Large Engineering Structures	Melbourne	Australia	February 2007	2010-11
Michael Filmer	1	An Examination of the Australian Height Datum	Curtin	Australia	April 2009	2010-11
Eric Zhengrong Li	2	Aerial Image Analysis Using Spiking Neural Networks with Application to Power Line Corridor Monitoring	QUT	Australia	2010	2010-11
Jun Wang	1	RTK Integrity	QUT	Australia	August 2008	2012-13
Marco Marinelli	3	Assessing Error Effects in Critical Application Areas	Curtin	Australia	April 2005	2010-11
Roman Trubka	4	Agglomeration Economies in Australian Cities: Productivity benefits of increasing density and accessibility by way of urban transport infrastructure planning	Curtin	Australia	2010	2011-12
Tao Chen	4	Augmented Reality Integration and Live Communication between GIS and SIEVE	Melbourne	Australia	March 2005	2011-12
Haohui Chen	4	Collaborative Virtual Environment for Knowledge Management – A New Paradigm for Distributed Communications	Melbourne	Australia	February 2008	2011-12
Marcos Nino-Ruiz	4	Application of Rural Landscape visualization for Decision Making and Policy Development	Melbourne	Australia	September 2008	2012-13
Michael Schaefer	4	Advanced Biomass Sensing Using Active Optical Sensors	UNE	Australia	March 2011	2011-12
Xin Lui	2	Determination of the High Water Mark and its Location along a Coastline	Curtin	Australia	March 2012	2012-13
Eldar Rubinov	1	Stochastic Modelling for Real-Time GNSS Positioning	Melbourne	Australia	January 2010	2012-13
Steven Mills	4	Visual Guidance for fixed-wing unmanned aerial vehicles using feature tracking	QUT	Australia	July 2013	2013-14

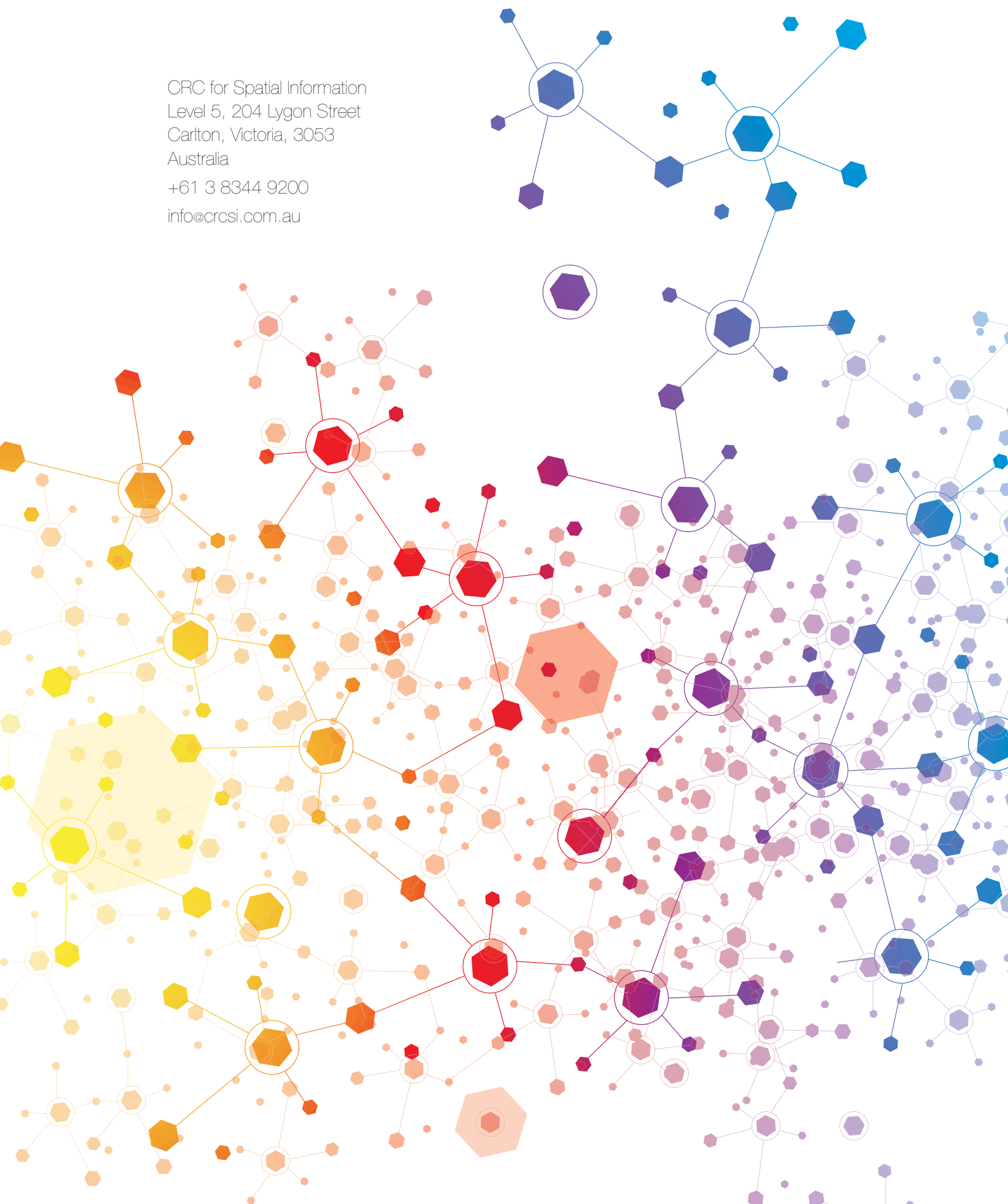
Name	Research Program	Project Title	Research Organisation	Country	Start Date	Completion Date
PhD Completions (continued)						
Grant Hausler	1	National Positioning Infrastructure: Technical, Organisational and Economic Requirements	UNSW	Australia	January 2011	2014-15
Jonathan Kok	4	Robust and Efficient Hardware-based Evolutionary Technique for Multi-objective Optimisation in Aerospace	QUT	Australia	June 2010	2014-15
Xiaoying Wu	3	Schema Evolution in a Federated Database Environment	Curtin	Australia	July 2012	2014-15
Mark Broomhall	4	A Method For the Remote Sensing of Aerosol s Based on MODIS Time Series Data Within an Operational System for Near-Real Time Atmospheric Correction	Curtin	Australia	October 2004	2014-15
Yuxiang He	2	Automated Building Reconstruction from Aerial and LiDAR Data	Melbourne	Australia	June 2011	2014-15
Cole Hendrigan	4	Building on Spatial Relationships in the Urban Fabric to Inform Higher- order Transport and Land Use Policy and Planning	Curtin	Australia	July 2012	2014-15
Su Yun Kang	4	Comparison of Spatial Modelling Using Point-process Data and Aerial Data	QUT	Australia	February 2011	2014-15
James McIntosh	4	Funding Sustainable Transport Through an Integrated Land Use and Transport Planning Framework Utilising Value Capture	Curtin	Australia	July 2011	2014-15
Abdul Nurunnabi	2	Mobile Mapping of Transport Corridors and the Extraction of Assets from Video and Range Data	Curtin	Australia	March 2011	2014-15
Robert Odolinski	1	GPS and Galileo Integer Ambiguity Resolution Enabled PPP (PPP – RTK)	Curtin	Australia	February 2011	2014-15
Jessica Roberts	4	Spatially Enabled Livestock Management: Improving Biomass Utilisation in Rotational Systems	UNE	Australia	March 2010	2014-15
William Woodgate	2	Derivation of Leaf Area Index and Associated Metrics from Remotely Sensed and In Situ Data Sources	RMIT	Australia	July 2011	2014-15
Lei Wang	1	Generalised Ambiguity Resolution Approaches to Processing Multiple GNSS Signals	QUT	Australia	April 2012	2015-16
Ebadat Ghanbari	2	Automated Registration of Multi-source, Multi-sensor Data	Melbourne	Australia	July 2011	2015-16

Name	Research Program	Project Title	Research Organisation	Country	Start Date	Completion Date
PhD Completions (continued)						
Daniel Hogg	4	Modelling Spatial Variations in Natural Disaster Impact	Canterbury	New Zealand	February 2013	2015-16
Charity Mundava	4	Biomass Assessment Tools to Assist Grazing Management in the Kimberley Region of Western Australia	Curtin	Australia	October 2011	2015-16
Richard Palmer	2	Automated Generalised Methods for the Extraction and Analysis of High Level Information From Mobile Mapping Data	Curtin	Australia	March 2011	2015-16
Niva Kiran Verma	4	Above-ground Biomass and Carbon Determination in Farmscapes Using High Resolution Remote Sensing	UNE	Australia	September 2011	2015-16
Phil Wilkes	2	Scale Variance as Applied to Woody Attribution of Eucalypt Forests	RMIT	Australia/The Netherlands	February 2012	2015-16
Susanna Cramb	4	Spatio-temporal Modelling of Cancer Data in Queensland Using Bayesian Methods	QUT	Australia	July 2011	2015-16
Name	Research Program	Project Title	Research Organisation	Country	Start Date	Anticipated Completion Date
Current PhD Students						
Elizabeth Kate Gulland	4	Improving Usability of Online Health Geovisualisation Tools	Curtin	Australia	July 2013	July 2016
Cynthia Yu	2	Semantic and syntactic methods to match real world data to models for change detection and recognition	Curtin	Australia	March 2014	March 2017
Premalatha Varadharajulu	3	Spatial Data Supply Chain Modelling in Australia and New Zealand	Curtin	Australia	January 2014	September 2016
Nic Donnelly	1	Integration of Interferometric Synthetic Aperture Radar into a National Geodetic Datum	UNSW	Australia	February 2013	August 2017
Mohsen Azadbakht	2	Processing LiDAR Waveforms to Extract Features Accurately	Melbourne	Australia	January 2012	July 2016
Jannah Baker	4	Spatial Interactions Between Chronic Diseases, Risk Factor Exploration and Effects of Health Screening	QUT	Australia	January 2012	November 2016

Name	Research Program	Project Title	Research Organisation	Country	Start Date	Anticipated Completion Date
Current PhD Students (continued)						
Michael Borck	2	Feature Extraction from Multi-modal Mobile Mapping Data	Curtin	Australia	February 2011	July 2016
Ben Fitzpatrick	4	Experimental Designs and Bayesian Spatiotemporal Models for Carbon in Farmscapes	QUT	Australia	October 2011	October 2016
Paul Goodhue	4	Crowd sourcing validation for the Biomass Business 2 Project	Canterbury	New Zealand	February 2014	December 2018
Tristan Reed	3	Semantic Search and Discovery of Web-Based Services	Curtin	Australia	February 2014	January 2017
Patrizia Russo	4	Understanding Barriers, Bottlenecks and Opportunities for Adoption of Spatial Information Tools in Land use Planning in Australia and New Zealand: A Visual Analytics Usability Approach	Melbourne	Australia	February 2013	December 2016
Jeremy Siao Him Fa	3	Federated Data Models	Curtin	Australia	February 2014	February 2017
Chet Bin Tan	3	Integration of various available search tools and methods	Curtin	Australia	May 2014	May 2017
Ahmad Ridhwanuddin Tengku	1	Initiating the Development of a Test Track for Positioning System Validation and Certification	Melbourne	Australia	May 2012	December 2016
Yongchao Wang	1	QZSS/BDS Precise Orbit Determination Using Triple Frequency Code and Phase Measurements	QUT	Australia	July 2012	August 2016
Peiyuan Zhou	1	Ionospheric Delay Variance Modelling	UNSW	Australia	February 2013	August 2016
Azeem Sadiq	3	Investigating governance along supply chains and concentrating on provenance	Curtin	Australia	May 2014	May 2017
Feiyan Yu	1	Automatic Data Conflation	Curtin	Australia	August 2014	August 2018
Hamish McNair	3	Integrating crowdsourced data/ info/knowledge into supply chains processes	Canterbury	New Zealand	January 2015	January 2018
Levi Mutumbo	3	Crowdsourcing a Spatial Data Infrastructure	Canterbury	New Zealand	July 2014	January 2018
Arjan Wilkie	4	Improved measurement and estimation of biomass and soil carbon in diverse landscapes using high-resolution remote-sensing	UNE	Australia	August 2015	August 2018

Name	Research Program	Project Title	Research Organisation	Country	Start Date	Anticipated Completion Date
Current PhD Students (continued)						
John Lewis	4	Enhancing information systems to support the care of colorectal cancer survivors by GP led primary care services	UNSW	Australia	March 2016	November 2018
Teuku Aulia Geumpanau	2	Information priority model for GIS-based mobile cloud application in disaster emergency response	UNSW	Australia	April 2016	December 2017
Samuel Hislop	4	Using time-series satellite imagery to characterise land use change in South East Australian forests at the large area scale	RMIT	Australia	February 2016	February 2019
Name	Research Program	Project Title	Research Organisation	Country	Start Date	Completion Date
Masters Completions						
Jiang Li	4	Intelligent Object Placement and Scaling in Virtual Decision Environments	Melbourne	Australia	January 2008	2010-11
Pan Peter Wang	4	Real-Time Data Visualisation in Collaborative Virtual Environments for Emergency Management	Melbourne	Australia	February 2008	2011-12
James Head-Meares	4	Human Interface Technology: Accurate Wide Area Tracking	Canterbury	New Zealand	April 2013	2013-14
Name	Research Program	Project Title	Research Organisation	Country	Start Date	Anticipated Completion Date
Current Masters Students						
Josh Neville	4	Meeting Housing Demand in Christchurch within the Existing Urban Footprint.	Canterbury	New Zealand	January 2014	August 2016
Luis Elneser	1	Industry expectations for using a real-time, australia-wide, multi-GNSS PPP-RTK service for dynamic applications	RMIT	Australia	March 2015	January 2019

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