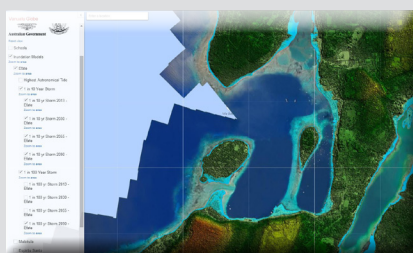
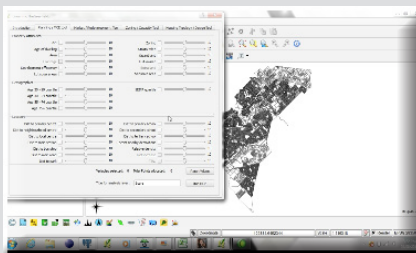
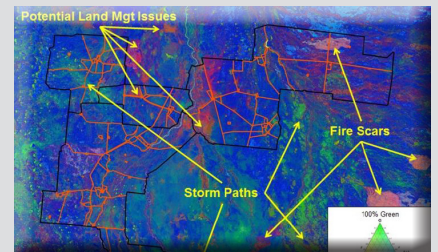
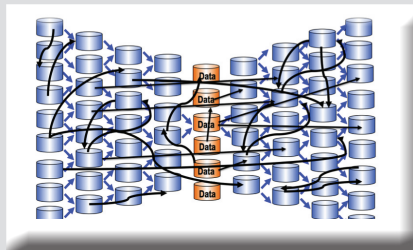
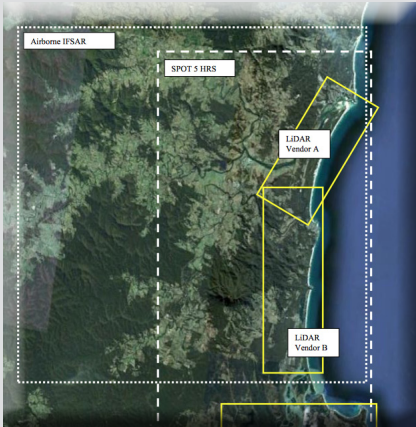


ANNUAL REPORT 2013-14

Australia and New Zealand CRC for Spatial Information



Essential participants

43 Version 2 Pty Ltd

Curtin University of Technology

Department of Natural Resources and Mines, QLD

Department of Environment and Primary Industries, VIC

**Department of Finance and Services, Land and Property
Information, NSW**

Ergon Energy Corporation Limited

Geoscience Australia

Landgate, WA

Queensland University of Technology

The University of New England

University of Canterbury



Australian Government
Department of Industry

Business
Cooperative Research
Centres Program

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* Due to privacy issues some content has been removed from this version of the CRC SI Annual Report 2013 - 14

■ Statement of Purpose¹

The Cooperative Research Centre for Spatial Information (CRCSI) is an unincorporated joint venture set up under the Cooperative Research Centres Program of the Australian Commonwealth Government through the Department of Industry. The purpose of the CRCSI is to build critical mass in research ventures between end users and researchers tackling clearly articulated, major challenges for the end users using the fundamental spatial technologies of global navigation satellite systems, spatial data infrastructures, data fusion and spatial feature extraction. 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 in key end users, spawning major innovation and productivity advances in the key industry sectors of Health, Defence, Energy and Utilities, Sustainable Urban Development and Agriculture, Natural Resources and Climate Change.

This report has been prepared in accordance with the 2013-14 Cooperative Research Centres Program Annual Report Guidelines and is submitted to comply with the requirements of Section 4 of the Guide.

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¹ Commonwealth Agreement 23 December 2009

1 Executive Summary

1.1 Achievements

Research

There were a number of notable achievements in 2013-14:

- The Positioning Program research has achieved a world first in identifying and reporting on the existence of previously unknown inter-satellite biases between different types of Beidou satellites. Commercialisation of the recent Array-PPP research carried out under the exceptional research ideas scheme has commenced. The Program has also delivered first time results for the generation of Beidou satellite orbits outside of China.
- Further research on an enhanced Flight Assist System (eFAS) has been carried out by the CRCSI team within the Energy and Utilities Program and is the subject of a patent application. eFAS takes the original FAS concept into the 3D realm for improved flight planning and control. In 2013-14, the eFAS successfully developed survey planning techniques to optimise both on-survey and off-survey paths, leading to reductions in survey length and better obstacle avoidance. It also undertook the development of new flight path design tools, which have led to further reductions in survey length by improving on-survey path design. Total flight path savings of up to 15% have been demonstrated.
- The Agriculture, Natural Resources and Climate Change Program has an agriculture component that targets better estimation of on-farm biomass, whether using hand-held active optical sensors or remotely sensed information from satellites.
- The natural resources management component of the Program has built critical mass in the past twelve months with new projects focused on the management of “big data” linking to Geoscience Australia’s data cube project, and a second project focusing on developing an enhanced spatial capability to support the sustainable management of Australia’s vast rangelands. SavBAT (Savannah Burning Abatement Tool) is a web-based tool produced by this Program that allows farmers and land managers to determine optimum times to use controlled fire management for the savannahs of the fire prone tropical north of Australia to reduce greenhouse gas emissions and thus earn carbon credits. The SavBAT project won the Victorian 2014 Asia Pacific Spatial Excellence Award.
- The United States Government announced the Climate Data initiative, with support from industry including Google, Microsoft, Intel and ESRI, which will provide resources and infrastructure to allow researchers to develop monitoring and mapping products from data made available. Google’s announcement made at the Whitehouse, showcased the high resolution DEM developed for Vanuatu by the CRCSI, with partners Geoscience Australia and NGIS Australia (a 43pl member) on behalf of the Australian Government.
- The Sustainable Urban Planning Program has been particularly successful in the past twelve months in securing a high level of co-investment and in engaging with New Zealand partners to undertake research relevant to the redevelopment of Christchurch.
- CRCSI Researchers and Research has again been recognised with several industry awards in 2013-14 as detailed in Table 1.

This year, the CRCSI’s research has produced two book chapters, 44 refereed journal articles and 59 papers in refereed conference proceedings. In addition, four of our postgraduate students completed their studies.

Awards

Project	Name	Organisation	Award
Creation of a Web based tool for operationalising the CFI reduction of Greenhouse Gas emissions through early dry season Savanna Burning Methodology	Prof Kim Lowell & Spatial Vision	CRCSI & 43pl	2013 Victorian Spatial Excellence Awards – Award for sustainability and environment for “CFI Savanna Burning Abatement Tool” & 2013 Asia Pacific Spatial Excellence Awards – Environment and Sustainability Award for “CFI Savanna Burning Abatement Tool”
Sustainable Urban Planning Program	Prof Peter Newman	Curtin University	Made an Officer of the Order of Australia in 2014 for “distinguished service to science education as an academic and researcher, through contributions to urban design and transport sustainability, and to the community”
Multimodal data acquisition and feature extraction from multi-sensor terrestrial mobile mapping systems	Xin Liu (PhD student now completed)	CRCSI/Curtin University	2013 WA Spatial Excellence Awards – Postgraduate of the Year Award for his study on “The Determination of High Water Mark Along the Western Australia Coastal Line”
Capacity building of GIS and spatial data skills for Pacific Island Countries	Nathan Quadros & NGIS	CRCSI & 43pl	2013 WA Spatial Excellence Awards – People and Community for “Pacific Islands sea level rise data capacity building program”
Greening the Greyfields: Precinct visualisation and community engagement	Stephen Glackin	CRCSI/Swinburne University	Swinburne University of Technology Vice-Chancellor's Early Career Research Excellence Award
High Accuracy Real-time Positioning Utilising the Japanese Quasi-Zenith Satellite System (QZSS) Augmentation System	GNSS Research Centre	Curtin University	European Space Agency award for the successful and early Galileo positioning analyses; awarded to the worldwide first 50 users of the Galileo System
Commercialisation Project	Scanalyse	Scanalyse	2013 Australian Museum Rio Tinto Eureka Prize for Commercialisation of Innovation for the creation of MillMapper and CrushMapper systems.

Table 1: Awards received by CRCSI Researchers in 2013-14

Commercialisation / Utilisation

The CRCSI met 16 of its 24 utilisation milestones for 2013-14 and an additional two milestones were achieved ahead of schedule. Delays in, and a re-focus of Research Program 3 and the resultant flow on effects into the utilisation of the outputs were responsible for four of the unmet milestones. The delayed deployment of both the Geovisualisation HealthTracks software in Government state departments was the primary reason for the remaining outstanding milestones. It is worth noting the utilisation strategy initially envisaged is no longer

the optimal pathway as the target audience has shifted to other analytical units within health agencies and analysts in non-health agencies (ie other government applications). There was continued utilisation of the Flight Assist System by Ergon Energy/Roames across Queensland; continued use of CRCSI software by government agencies (Barista, Vertical Datum Transformation Tool, LiDAR QA Tool); continued use of the HealthTracks tool inside Department of Health WA; and continued use of CRCSI IP in the development of the Unlocking the Landsat Archive project at Geoscience Australia.

Education/training

12 post-graduate students commenced in 2013-14 with either full or top-up Scholarships, bringing the total cohort of active students to 35 at 30 June 2014. During the year four students completed their studies, thus we have achieved a total of 19 completed post-graduates since 2010. With 54 active and completed post-graduates we are on track to meet and exceed our Commonwealth target of having invested in (enrolled or graduated) at least 51 PhDs and Masters with our university partners by 30 June 2018.

One-on-one interviews were conducted with all CRCSI postgraduate students during January 2014. Following the student interviews a private LinkedIn CRCSI Student Group was started to further engage the CRCSI students in activities and opportunities. CRCSI students, Ebadat Parmehr, Charity Mundava, Jannah Baker and Nuddin Tengku entered videos into the CRCA early career research competition. These can be viewed on the CRCSI website (<http://crcsi.com.au/Education/Students-List>). The first edition of the CRCSI student newsletter was published in April 2014 and was well received by the CRCSI community. The newsletter contained a number of articles and updates from students across the research program. The mentor scheme has continued throughout 2013-14, and this initiative has further strengthened the CRCSI's bond with its students.

SME Engagement

SME engagement is a strength of CRCSI, through its consortium called "43pl." Each 43pl company enjoys the status equivalent to an Essential Participant. 43pl has its

own elected Board with directors from across Australia and New Zealand. All of the functions of 43pl are provided by the management of the CRCSI. As at 30 June 2014 43pl had 45 full member companies, with several other companies engaged in the CRCSI as Other Participants or via letters of exchange or MOUs. 43pl, its members and the other companies, are deeply embedded in the activities of the CRCSI.

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 needs of the spatial industry and in designing 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. The register monitors 46 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:

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. Register available for circulation to participants under confidentiality agreements.
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 milestones monitoring through projects.

Table 2: Risk and Mitigation Strategies

Risk	Mitigation Strategies
Ensuring CRCSI 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 of more than one research program	The Investment Committee and Program Boards provide a regular due diligence and review. Quarterly reports from each project leader to be reviewed by the Project Board, Management and Board. No major points of failure evident. Mid-term reviews of every project are yielding improvements in quality.
Failure to develop and implement a sustainable business plan post CRC	Strategic Planning is an ongoing process. The Research & Investment Committee and 43pl will complete thorough strategic reviews which will feed into a Sustainability Plan to be submitted to the Commonwealth by June 2015.
Quality and quantity of inkind commitment from participants insufficient	CRCSI's ability to complete output milestones is not being compromised by inkind. Anticipated future shortfalls to be recouped by new projects commencing.

Table 2: Risk and Mitigation Strategies

1.3 End user Environment

2013-14 continued to be a tough environment for end users, in particular the government partners who are a key enabler of the utilisation impacts of CRCSI. Staff cutbacks over the past three years within partner state government departments have impacted the capacity of the agencies to resource their inkind commitments to projects as staff were either not replaced or assigned other duties. This has impacted their ability to both meet their inkind obligations and implement developed solutions within agencies. The flow-on effects have included some subtle changes in utilisation strategies to optimise uptake including re-orienting delivery pathways from direct deployment in government agencies to provision of outputs to service providers who enable utilisation within government. Company inkind contributions were also affected by increasing pressure to retain and drive revenue. CRCSI expects the challenge to attain contribution targets from the end user environment to be at least as challenging in future years as was the case in 2013-14. CRCSI monitors its inkind quarterly and consults with project teams on any potential issues through its quarterly project management group meetings. However, it is expected that given the current

life cycle of the CRCSI that end users will increasingly contribute to the utilisation of research outputs.

Notwithstanding this tough environment, CRCSI partners and third parties contributed an additional \$2.9M in funds over and above Commonwealth Agreement funding, reflecting the relevance of CRCSI activities.

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

The CRCSI 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 periodically. The collective knowledge from these plans makes an important contribution to the annual review of the CRCSI's Strategic Plan. A record is kept of the nature of the engagement for every partner in every aspect of the CRCSI's activities from projects, commercialisation activities, to Boards and Committees. A customer relations management system was implemented in 2013-14 to track meaningful contact with participants and to allow for early identification of potential 'red flag' issues, thus ensuring prompt action.

Opportunities for the CRC SI and strategies adopted to exploit these opportunities

The Program Boards meet regularly to review the strategic development within each research and application program. 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 CRC SI's strategic direction aligns with its end user environment

CRC SI 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 its end users.

There were no major changes in the end user environment that significantly affected the CRC SI's strategic direction in 2013-14.

1.4 Impacts

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

The CRC SI reviewed its outputs, usages and impacts in 2013-14 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 \$759M, at a benefit cost of 2.49, which is increased from the initial ratio of 1.63. 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 \$110M. 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 forms 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 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 have been a total of \$72M of benefits delivered to date via three impacts (1) \$46M largely through the implementation of the National Elevation Data Framework data distribution portal, publicly downloadable sea level rise maps, government oriented sea level rise visualisation tool, CRC SI commercial receipts, and implementation of the SAVBAT tool; (2) \$20M 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) \$6M 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 2022, is expected that the Program will deliver \$324M of benefits relating to (1) \$178M benefits resulting from reduction of costs of the vegetation management program through the introduction of software and improved technology solutions Australia wide (2) \$128M from the Urban Digital Elevation Modelling in High Priority Regions (UDEM) project, commercial receipts and the use of the Savbat tool and (3) \$17M 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 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 data sources. The expected benefits from the program have increased from the initial forecast of \$51M to \$324M.

3. Data Infrastructures Program: An estimated \$36M of benefits has been delivered to date through three impacts (1) \$6M through cost reductions of a more developed, expanded and nationally cohesive infrastructure as a result of adoption of new policies and online infrastructure technologies in government and industry; (2) \$1.2M through estimated industry growth impacts from the access, rights and governance usage; and (3) \$28.9M through the influence/adoption of policy through creative commons frameworks. An estimated \$84M of expected benefits will arise from the program (up from originally forecast \$42M) as a result of adoption of new policies and online infrastructure technologies, associated cost reductions and implementation of the creative commons framework. Benefits accrue through freer and more widespread use of ABS data.

4. Applications Program: Although the general thrust of the activities has not changed, outputs have been better tuned to partner needs and re-phased closer to timelines that can be achieved in conjunction with partners. We estimate the Program has delivered benefits of \$10M to date through (1) \$8M 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; and (2) \$1M cost savings through 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) \$1M 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 information. The program plans to deliver \$195M of expected benefits, up from \$138M originally estimated.

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

The CRCSI 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.

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 CRCSI reviewed the monetary impacts and expected benefits with programs due to the recent amendment of output and utilisation milestones as at July 2014. The overall expected program costs have increased from \$186M (2010) to \$305M (2014). The expected benefits have also increased from \$305M (2010) to \$758M (2014) resulting in a change in the CRC cost benefit ratio to 2.49, as compared to the 2010 value of 1.63. The changes on a program basis for Benefit: Cost ratio were:

Expected Benefit: Cost Ratio of Program 1 – the cost benefit ratio has increased from 2.52 (2010) to 2.76 (2014). This is due to an increase in expected benefits from \$74M (2010) to \$118M (2014) resulting from the inclusion of additional relevant industry sectors in the analysis and the addition of the economic impact of postgraduate research students.

Expected Benefit: Cost Ratio of Program 2 – the cost benefit ratio has increased by 103% from 0.95 (2010) to 2.80 (2014). 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 (\$128M), accelerated uptake

of impact 2.2 Energy activity (\$178M) and avoided labour costs for impact 2.1 – NRM management (\$17M).

Expected Benefit: Cost Ratio of Program 3 – the cost benefit ratio has increased from 2.15 (2010) to 2.38 (2014). This reflects the net change between the decrease in expected benefits of the original two impacts (-\$4M) and the identification of new benefits that have resulted from implementation of impact 3.3 (+\$4M).

Expected Benefit: Cost Ratio of Program 4 – the cost benefit ratio has increased from 1.65 (2010) to 2.05 (2014). This reflects the change to impact 4.1 Tools

for farm profitability (-\$28M) and impact 4.2 Health visualisation (+\$16M) and 4.3 Urban planning (+\$66M).

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

Actions the CRC SI will take to address any issues and maximise impact

The CRC SI is now four and a half years into an eight and a half year research program in its second term and the new programs are beginning to yield significant impacts.

Impact	Milestone Changes	Probability of usage to enable impact			Probability of impact occurring			NPV (\$M)		
		2010	2014	% change	2010	2014	% change	2010	2014	\$ change
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	\$110.32	\$36.43
1.3 Postgraduate completions	new	0%	90%	90%	0%	100%	100%	\$0.00	\$7.76	\$7.76
2.1 Avoided costs of labour (resource management)	moderate	50%	75%	25%	60%	75%	15%	\$25.00	\$17.03	-\$7.97
2.2 Avoided costs of (Energy) / business process improvement	rephased	21%	80%	59%	70%	90%	20%	\$25.82	\$177.85	\$152.03

Table 3: Summary of monetary impacts and expected benefits within programs due to amendment of output and utilisation milestones as at June 2014

Impact	Milestone Changes	Probability of usage to enable impact			Probability of impact occurring			NPV (\$M)		
Impact Reference	none / rephased / moderate / significant / new	2010	2014	% change	2010	2014	% change	2010	2014	\$ change
2.3 National Elevation Data Framework Portal and commercialisation Portal receipts	significant	90%	90%	0%	25%	90%	65%	\$0.68	\$128.60	\$127.92
3.1 Cost reduction - policy adoption and online technologies	rephased	49%	36%	-13%	20%	20%	0%	\$39.28	\$34.57	-\$4.71
3.2 Spatial industry growth	none	40%	30%	-10%	15%	15%	0%	\$2.86	\$3.30	\$0.44
3.3 ABS Implementation of Creative Commons license	new	0%	100%	100%	0%	75%	75%	\$0.00	\$84.22	\$84.22
4.1 Impact of tools on farm probability	significant	38%	30%	-8%	50%	50%	0%	\$101.24	\$73.17	-\$28.07
4.2 Impact of tools on health	moderate	8%	15%	7%	40%	60%	20%	\$9.86	\$26.49	\$16.63
4.3 Impact of tools on urban planning	moderate	8%	20%	12%	60%	60%	0%	\$28.76	\$95.15	\$66.39

Table 3: Summary of monetary impacts and expected benefits within programs due to amendment of output and utilisation milestones as at June 2014

2 Research

2.1 Performance against activities

Progress against the key challenges/outcomes.

The CRCSI aims to achieve the overarching goal of “spatially enabling Australia and New Zealand”. As described below, this goal is encapsulated in two strategic objectives, around which the research program has been designed.

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 2cm.

The CRCSI is conducting research to facilitate the creation of a coordinated national network of multi-GNSS reference stations (to be known as the National Positioning Infrastructure). This infrastructure will enable real-time, 3D positions of people, vehicles, built infrastructure and natural assets to be determined based on the emerging positioning paradigm of PPP-RTK (precise point positioning-real time kinematic). Realising the full potential of the NPI through the PPP-RTK model requires substantial research to optimise the use of existing and new global and regional navigation satellite systems and to design and implement PPP-RTK in a robust, efficient, versatile and user-accessible way.

Key deliverables from the current suite of projects addressing Objective 1 include:

- New integer inference theory to allow the estimation and validation of large integer ambiguity data sets under the emerging multi-GNSS/RNSS scenario.
- An indigenous capability for computing and delivering real-time, regionally enhanced orbit and clock products to support multi-GNSS real-time positioning.
- PPP-RTK parameter estimates and quality descriptors required by the end user including – (a) satellite and receiver clock errors, (b) multi-frequency satellite and receiver code biases, (c) multi-frequency satellite and receiver phase biases, (d) ionospheric delays, and (e) zenith tropospheric delays.
- Algorithms for the optimal and efficient integration of multi-GNSS constellations into the PPP-RTK network processor.

Program 1 (Positioning) Science Director Professor Peter Teunissen leads the research activities relevant to Objective 1, with Program management being provided by Dr John Dawson of Geoscience Australia. The Program Board, under the leadership of Dr Chris Pigram, CEO of Geoscience Australia, provides excellent strategic guidance for the research, and has recently published a list of research priorities for the period 2014-18.

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 products.

The National Innovation Systems Review documents the benefits that would flow from improved access to the vast stores of raw spatial information and derived spatial information products currently held by government agencies, but fundamentally inaccessible to the broader community. The semantic web emerges as a solution to this challenging and debilitating problem. The ability to structure data appropriately and then to undertake natural language queries, federate disparate data sets of different provenance and to utilise the emerging power of “citizens as sensors” (i.e. crowd sourcing) opens up a range of possibilities to secure the benefits of broadly accessible and fit-for-purpose spatial information products. Program 3 (Spatial Infrastructures) is focused on achieving Objective 2, but many other research activities within the CRCSI also touch on and contribute to this objective.

The research program has seven core activity areas:

- Search and discovery
- Data integration
- Web services orchestration
- Crowd sourced and authoritative data integration
- Querying big data
- Licensing, copyright and terms of use
- Mapping to other spatial infrastructures

Program 3 (Positioning) Science Director Professor Geoff West leads the research activities relevant to Objective 2, with Program management being provided by Ms Kylie Armstrong of Landgate, WA. The Program Board, under the leadership of Mr Steve Jacoby, Executive Director, Land and Spatial Information, Department of Natural Resources and Mines, Queensland, provides oversight and direction for the research program. Given the strong interface with government, regular interactions with ANZLIC and the federal Office of Spatial Policy also guide the activities of the Program.

Summary of Research Activities by Program and associated risks.

A total of nine new CRC SI funded projects were approved by the Board during 2013-14 and twelve projects were successfully completed. Table 4 shows the full research portfolio of active projects, with the nine new projects highlighted by an asterisk (*). The CRC SI also undertakes a number of commissioned research projects, but these are not discussed here.

The structure of the CRC SI's research program is shown in Figure 2, which highlights the three core research activities (in the centre) and the five targeted application areas (in the outer ring).

Program 1 (Positioning) comprises 10 active projects. A 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 facilitate utilisation and uptake by partners. The ACS will support the implementation of a new real-time positioning

paradigm known as PPP-RTK (Precise Point Positioning–Real-time Kinematic) which offers the prospect of accurate positioning anywhere (outdoors) with reduced dependence on dense and costly ground infrastructure. A second key deliverable for the Program is the design and implementation of a new dynamic datum for Australia and New Zealand, a project that falls at the cutting edge of international geodesy. This project is strongly supported by Geoscience Australia and Land Information New Zealand as the agencies fundamentally responsible for building and operating national geodetic infrastructure.



Figure 2: Structure of the CRC SI Research Program.

This year has seen the initiation of a project focused on the development of the ACS. The project is funded entirely by partners and supports the recruitment of a part-time Project Manager (in place), a full-time Technical Lead (in place) and two software developers (to be recruited). An expert technical committee (ETC) has been established, incorporating a small number of international scientists with wide experience in GNSS data processing systems. This group will oversight the activities of the ACS team, ensuring a cutting-edge implementation of the PPP-RTK approach to support the vision and capabilities of a multi-GNSS enabled national positioning infrastructure.

Full realisation of Program 1 goals is 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. Alternative strategies are also being implemented as required (e.g. the use of signal simulation) so that delays in satellite launches do not impact fundamentally on research progress.

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. Staff and student exchanges with international partners occur regularly with, for example, one CRCSI PhD student spending several months at the Delft University of Technology in early 2014 and visiting scholars from Wuhan University spending time in Australia and vice versa.

The fundamental direction and objectives of the Program have been recently reaffirmed by the Program Board, with the release of the 2014-18 Program 1 Research Priorities. This document will shape the research activities over the coming years with a clear emphasis on the capabilities of the ACS.

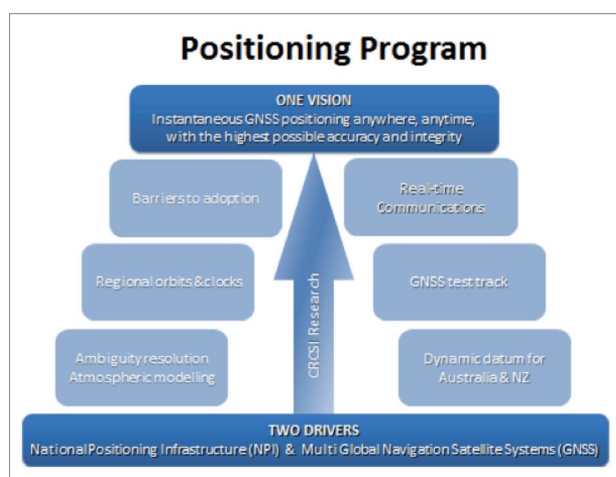


Figure 3 – Positioning Program outline

The Program produced one book chapter, 14 refereed journal papers and 15 refereed conference papers in 2013-14. 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 (Automated Spatial Information Generation) comprises six projects focussing on various aspects of automated feature extraction and 3D object and scene reconstruction from space-borne, airborne and terrestrial imagery, and airborne and terrestrial laser scanners. Functional models, algorithms and computational processes and procedures for the detection, identification and measurement of natural and man-made features are being developed as the principal research outputs. Moreover, research attention is focussed on enhanced feature extraction capabilities afforded by the integration of 2D imagery with 3D point cloud data – a data fusion process that effectively creates a '3D image'. This 3D Image concept yields a unified, geo-registered data source and thereby enhances the reliability and efficiency of the complex and computer-intensive feature extraction process. Two projects in the Program (2.01 and 2.02) concentrate on metric quality feature extraction, with one having a terrestrial sensor system focus and the other aimed at satellite and airborne imaging and ranging systems. A third project (2.07) aims at woody vegetation classification in Australian forests using advanced remote sensing technologies. A fourth project (2.09) focuses on the production of quality assurance software for LiDAR surveys, and a fifth, funded by the ARC, aims to automate building change detection and semi automate building map updates through the use of multispectral imagery and height data. The final project (2.08) relates to commissioned research in close range photogrammetry and is directly supported by the Australian Geospatial Organisation, Department of Defence.

New developments in feature extraction produced by Program 2 are implemented for testing and evaluation by industry and collaborating researchers. The CRCSI-developed Barista software provides the platform for this purpose, but has been unsuccessful in reaching more wide spread application in industry and government. To this end, engagement with commercial software

CRCSI ANNUAL REPORT 2013-14

CRCSI Projects: Current as at June 30, 2014				
Project Number	Title	Start	Finish	Partners
1.01	New carrier phase processing strategies for achieving precise and reliable multi-satellite, multi-frequency GNSS/RNSS positioning in Australia	1 Jul 11	30 Jun 15	12
1.02	Next Generation Australian and New Zealand Datum	1 Jul 12	1 Jan 16	8
1.03	Multi GNSS Processing Strategies and Services	3 Oct 11	30 Sep 15	11
1.04	GNSS test track	1 Mar 12	28 Feb 15	4
1.09	Spatial Information Applications in Rural Australia	1 Aug 11	21 Jan 12	4
1.11	High Accuracy Real-time Positioning Utilising the Japanese Quasi-Zenith Satellite System (QZSS) Augmentation System	1 Jul 12	30 Jun 14	5
1.13	Array Precise Point Positioning (A-PPP)	1 Nov 12	31 Oct 13	1
1.14*	Development of the Analysis Centre Software	1 Jul 13	30 Jun 15	1
1.15*	Program 1 Science Director & GNSS Research Professor	1 Mar 14	30 Jun 18	2
1.17*	Evaluating the positioning capabilities of Locata Terrestrial Signals in GNSS unfriendly environments – Phase 1	1 Apr 14	30 Sep 14	1
2.01	Multimodal data acquisition and feature extraction from multi-sensor terrestrial mobile mapping systems	1 Jan 11	31 Aug 14	13
2.02	Feature extraction from multi-source airborne and space-borne imaging and ranging data	1 Sep 10	30 Dec 14	14
2.07	Australian woody vegetation landscape feature generation from multi-source airborne and space-borne imaging and ranging data	1 Jul 11	30 Jun 14	4
2.08	Close-Range Photogrammetry Technology for Defence	23 Apr 12	30 Jun 14	1
2.09	Development of a Standard Software Procedure and Tool to Quality Assure Elevation Data	1 Jul 12	30 Jun 14	5
2.11	Building change detection using imagery and height data	1 Jul 12	30 Jun 15	1
3.01	Semantic Web Technologies for Next Generation Spatial Infrastructures	1 Jan 13	31 Dec 15	6
3.02*	Semantic Web Technologies for Supply Chain Management of Spatial Infrastructures	1 Apr 14	31 Mar 18	10
3.10*	Optimising the Supply Chain for Geocoded Addressing in Australia	28 Mar 14	31 May 14	2
4.12	Biomass business	1 Jul 10	30 Dec 14	11
4.15	Towards operational monitoring of key climate parameters from synthetic aperture radar	1 Jan 11	31 Dec 13	8
4.17*	Big data solutions for environmental monitoring	1 Oct 13	30 Sep 16	5
4.18*	Biomass business II - Tools for real-time biomass estimation in pastures	30 Aug 13	29 Aug 17	5
4.31	Enhanced flight assist system for automated aerial survey of powerline networks	1 Apr 11	31 Mar 14	2
4.41	Geovisualisation of health information	1 Jan 11	31 Dec 13	7
4.42	Spatial-temporal modelling of cancer incidence, survival and mortality	1 Apr 11	31 Mar 14	7
4.45	Geographic variations in natural disaster impact and spatial links to non-injury related health outcomes	1 Sept 12	31 Aug 15	4
4.402*	Place as a vital sign of health	1 Apr 14	30 Mar 15	1
4.51	Greening the Greyfields – A spatial information platform for 21st century sustainable urban planning	1 Jul 10	30 June 14	6
4.53	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	1 Sept 12	31 Aug 15	5
4.55*	Greening the Greyfields: Precinct visualisation and community engagement	1 Apr 13	30 Jun 16	9
5.01	Spatial Innovation & R&D - Baseline and Benchmark Study	1 Oct 11	31 Mar 14	2

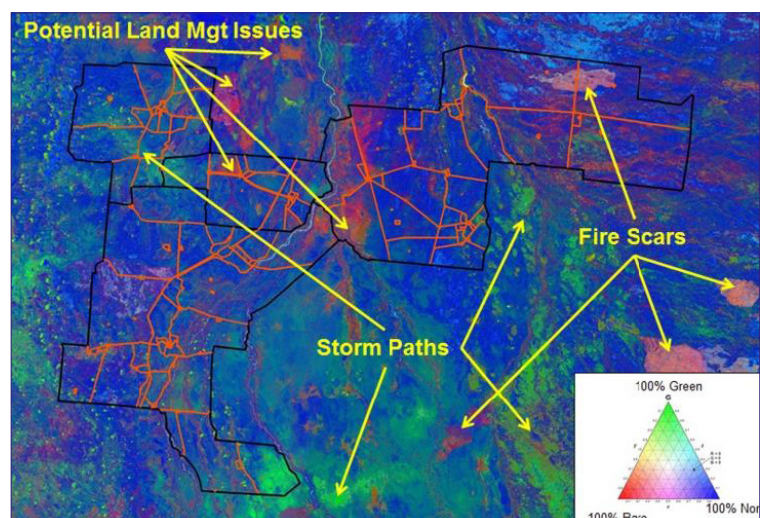
Table 4: CRCSI projects. * Newly funded CRCSI projects in 2013-14

providers is needed. This is proving a challenging utilisation pathway and alternative models are being explored for future uptake of the research outputs.

Research excellence in this Program is evidenced by the international profile of the research team and the substantial international engagement that occurs through project publications, conferences, scientific exchanges and participation on international review panels. In addition, the Program has produced 6 refereed journal papers and 29 refereed conference papers in the 2013-14 period. The Science Director for this Program is Professor Clive Fraser, a Professorial Fellow at the University of Melbourne and one of Australia's most respected researchers in this area. The Chair of the Program Board is Mr David Sinclair, formerly of AAM and now Chair of the 43pl Board.

Program 3 (Spatial infrastructures) comprises three projects with direct links into two other major projects in Program 4.1. Program 3 was late to initiate its first research activity due to the need for broad consultation with end users and the requirement to subsequently develop a user-endorsed research strategy in a complex and rapidly changing industry environment. With the strategy now in place, the Program is fully resourced and activity is underway, with a growing team of researchers

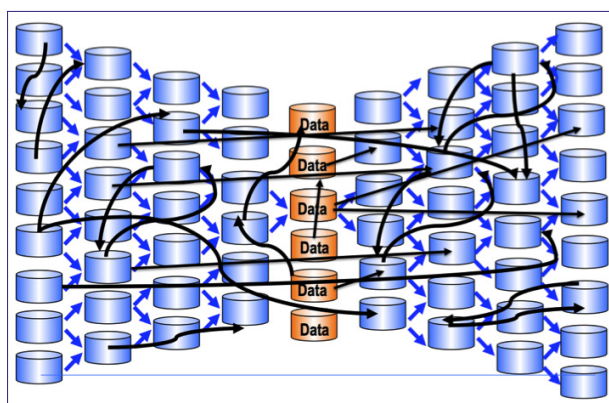
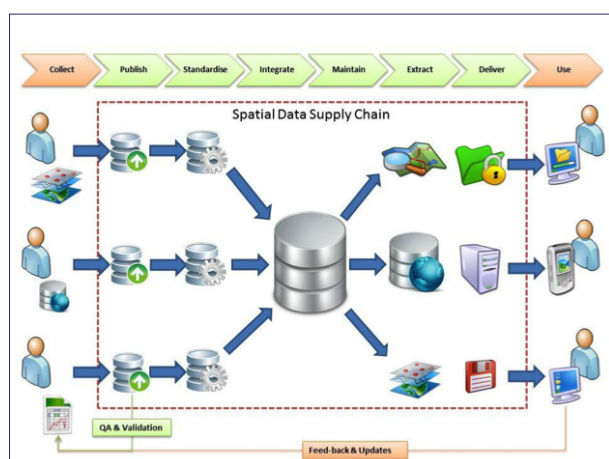
and PhD students and strong links to the end-user community. The research approach is two pronged with traditional multi-year projects hinging on the activities of several PhD students and post-doctoral researchers, coupled with more operationally focussed activities that see the research teams responding to the shorter term needs of end-user organisations. Projects 3.01 and 3.02 fall into the former category where data search and discovery, data federation, crowd sourcing and quality assurance lie at the heart of the research. Project 3.10 is in the latter category and is addressing supply chain issues around the compilation of geocoded address information for Australia. Partners have responded positively to this dual emphasis and Project 3.10 is set to create further research opportunities for the CRCSI. A joint project titled "Big Data Solutions for Environmental Monitoring" sees Program 3 and Program 4.1 (Agriculture, Natural Resources, and Climate Change) 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 and tools. Project 4.18 (Biomass Business 2) draws on Program 3 for crowd



NRM Spatial Hub - Left: The on-line Property Planning and Information System (OPPIS) will provide users with a secure, standards-based environment for capturing, managing, processing and disseminating information. Right: Land managers will have direct access to time-series satellite remote sensing products from government and science agencies to monitor ground cover and land condition and damage from storms, floods and fire.

sourcing expertise and, in particular, needs assistance to develop techniques to quality assure and validate crowd sourced information from farmers collected via a web service, which will be an output of the project.

Program 3 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.



Spatial Data Supply Chain - Program 3

The Program 3 Board is active in revisiting and revising research priorities in this very dynamic and somewhat crowded space. The impact of corporate entities such as Google, Apple and Microsoft is constantly being

monitored and the niche filled by the CRCSI is regularly 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 for all research activity.

Program 4.1 (Agriculture, Natural Resources and Climate Change)

Considerable effort has been made to develop a Program 4.1 research strategy to ensure that future activity focuses on the delivery of user-ready spatial information to achieve increased adoption of spatial technologies and capabilities by farmers and land managers. During this year, the Program has seen the successful completion of two major research projects. Project 4.12 has produced tools and techniques to allow farmers to determine biomass in the landscape for forage availability for grazing stock and to assist croppers to assess plant requirements for water and nutrients. A final outcome has been new methodologies to allow the estimation of standing carbon at farmscape level intended as an input to a future carbon trading scheme. Project 4.15 has assessed the applicability of satellite-borne and airborne Synthetic Aperture Radar (SAR) for estimating soil moisture and woody vegetation status at various scales of analysis.

At the same time, two new projects have commenced, both of which align with the Program strategy around data delivery and both of which have secured substantial co-investment to leverage the CRCSI contribution. Project 4.17 – Big data solutions for environmental monitoring, will identify and resolve issues associated with the use of large datasets (so-called “big data”) required for monitoring and managing natural resources at multiple scales over large regions; and Project 4.18 – Biomass Business 2 - Tools for real-time biomass estimation in pasture.

Both projects are conducted in collaboration with Program 3 on account of the strong focus on delivery of outputs and capabilities of end users.

Complementary activity under the banner of the NRM Spatial Hub is being conducted using funding provided by an Innovation Grant from the Federal Government's Caring for our Country program. The project (4.19) brings together CRCSI, Meat and Livestock Australia, CSIRO, Rangeland NRM Alliance, Department of Science, Information Technology, Innovation and the Arts (Qld), Department of Agriculture, Fisheries and Forestry (Qld) and Department of Primary Industries and Fisheries (NT) to develop tools to better monitor and manage Australia's vast rangelands (80% of the continent).

Program 4.1 demonstrates a high level of alignment with national research priorities and is demonstrating the power of collaboration and engagement within the CRCSI and beyond, through its ability to secure significant levels of co-investment for research. The Program has produced a total of nine refereed journal papers and three refereed conference papers in the last twelve months. Professor Kim Lowell from the University of Melbourne is the Program 4.1 Science Director, with the Program Board being chaired by Dr Matthew Adams, from Landgate.

Program 4.2 (Defence) is a different type of Program to others within the CRCSI. As in previous years, during 2013-14, the Australian Geospatial Organisation (AGO) has maintained a watching brief on research across a number of CRCSI programs. In addition, the AGO continued to support a highly targeted commissioned research project in close-range photogrammetry, being executed under the banner of Program 2. Because of its unique role in the CRCSI, Program 4.2 does not have a Science Director or Program Board. Nonetheless, there is a close working relationship between the Program 2 Science Director, Prof Clive Fraser, and senior Defence staff.

Program 4.3 (Energy) Aerial inspection of large powerline networks by low altitude, fixed-wing aircraft is a complex and potentially hazardous task. This need has motivated CRCSI research into new aircraft planning and control technologies to improve the safety and efficiency of powerline inspection. Since 2009, the CRCSI has worked with ROAMES (previously Ergon Energy) to develop flight-test-proven automated aerial powerline inspection technologies. To date, a single research project (4.31) has encompassed all the activities of the Program with the purpose of developing an enhanced Flight Assist System (eFAS). This project, which successfully concluded in June 2014, has extended 2D aircraft flight-path planning, data capture and flight assist concepts developed under previous CRCSI research to an active 3D capability.



eFAS in testing.

The demonstrated benefits of eFAS are:

- More accurate horizontal and vertical control of the aircraft
- Improved maintenance of safe horizontal and vertical separation from terrain/obstacles
- Enhanced positioning the aircraft relative to the asset at the correct altitude and speed
- More complete and more consistent data capture
- Reduced flight times and substantially improved operational efficiencies.

End user engagement in the Program is very strong and research outputs find direct application in the ROAMES system.

The Program has produced two refereed conference papers in the last twelve months. Because the Program is composed of a single project and serves a single end user organisation, it has not required a Science Director or a Program Board.

Program 4.4 (Health) The Health Program comprises an interdisciplinary research team developing new systems and methodologies for spatially analysing health service datasets. Research projects in this Program, aim to develop and apply spatial tools and technologies to problems currently facing the health sector, with a view to encouraging broad end-user engagement and achieving high impact outcomes for health agencies and the community more generally.

The long term objectives of this Program are to enable health agencies in Australia and New Zealand to adopt and draw value from spatial technologies and for spatial data to be routinely incorporated into health service planning and research. Such achievements will increase health sector effectiveness and improve quality of life for all.

The past year has seen the completion of two projects, one (Project 4.41) around geo-visualisation of health data and the second (Project 4.43) addressing issues of geocoding health records and undertaking a comparative assessment of geocoding tools. Project 4.42 is ongoing, though drawing to a close, and is developing new geostatistical analysis techniques to allow better decision making in the context of locating and evaluating the benefits of health services such as mobile breast screening facilities. Project 4.45 is based in Christchurch and aims to test the hypothesis that stress-related health

outcomes (e.g. cardiovascular risk or anxiety) are greater among people who have experienced greater physical damage to their communities and homes than those who have experienced less damage, but who also live in the city.

On the foundation of earlier research, the Program is increasingly shifting its focus to the utilisation needs of partners and to this end a new project has commenced this year with an emphasis on validation and further refinement of the geovisualisation tool developed in Project 4.41 (known as Epiphanee) and the identification and pursuit of subsequent commercialisation opportunities.

Program 4.4 also has a growing international profile, supported through engagement with Sweden's Geo-Life Region, Future Position X (FPX) initiative. Over time, it is expected that the FPX relationship will lead to co-funded research activity, thereby leveraging the CRC SI's funding capability and growing its impact in the Health area.

During the last twelve months, the Program has published six refereed journal papers and one refereed conference paper. Ms Narelle Mullan, from Curtin University, is the Program Manager and the Program Board is chaired by Professor Tarun Weeramanthri, Executive Director, Public Health and Clinical Services Division, Department of Health, Western Australia.

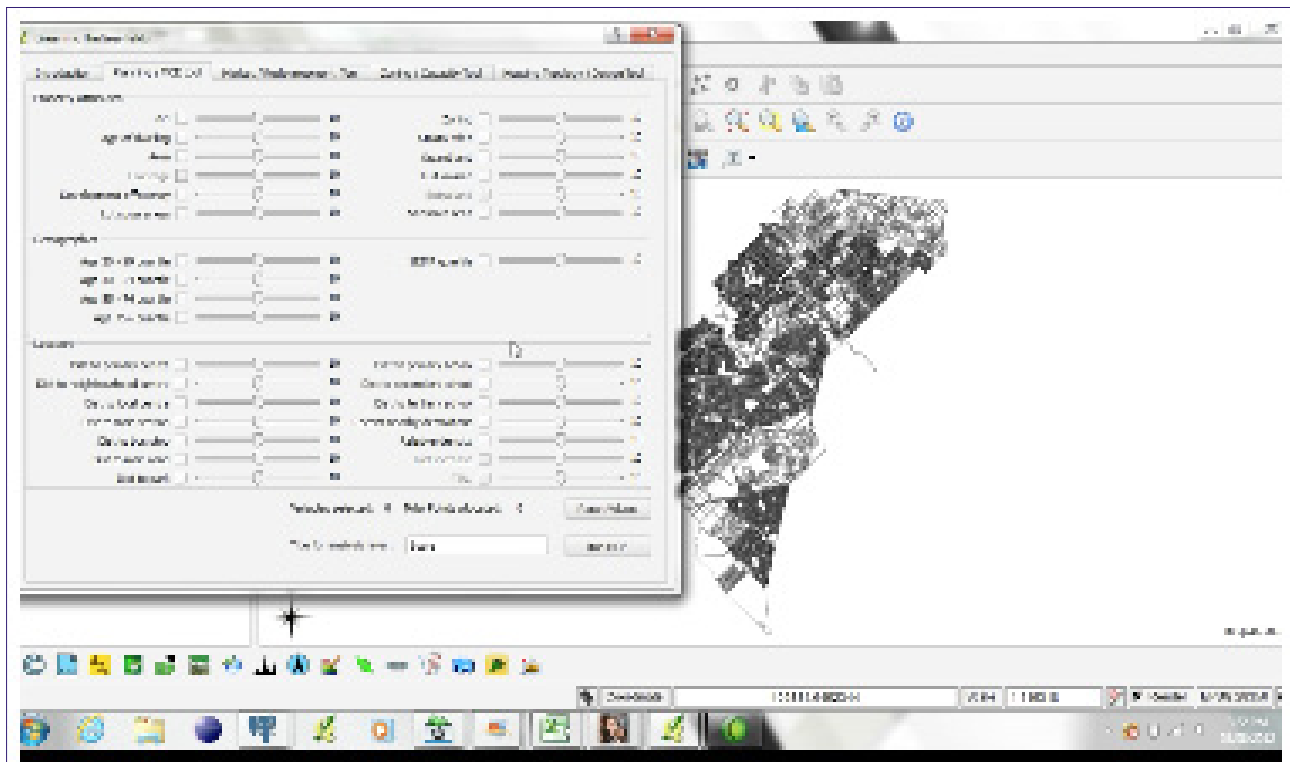
Program 4.5 (Urban Planning) This Program is developing new spatial tools and strategies for use by professional planners, developers, administrators and the broader community to facilitate improved planning, re-development and investment decisions in the context of optimal redesign of the ageing middle-ring suburbs of major cities in Australia and New Zealand. The growing suite of analysis and visualisation tools has found a unique test bed in Christchurch, following the devastating earthquakes of 2010-11 and the consequent rebuilding of the city. Indeed the P4.5 team has a considerable presence in Christchurch. The Christchurch link has also nurtured connections between this Program and the Health Program through work that is assessing the long

term personal and community health implications of the earthquakes and the recovery process.

The initial Greening the Greyfields project (P4.51) successfully concluded this year. Satisfyingly, the project has spawned a follow-on project (P4.55) with an expanded partner base and a substantial level of additional co-investment. P4.51 delivered a prototype decision support system (ENVISION) capable of assisting planners and stakeholders to formulate housing redevelopment strategies for the middle suburbs. The value of this capability has been identified by the Australian Urban Research Infrastructure Network (AURIN) who, in partnership with the CRC SI, is developing a web-based visualisation and assessment platform enabling planners and community members to engage in the virtual redevelopment of housing precincts, and subsequently to evaluate the performance of redevelopment scenarios according to a variety of key metrics. The next stages of the ENVISION development will include the application of the tools to real redevelopment projects identified in collaboration with local government partners to test how

new uses of existing data and spatial technologies can be leveraged to bring about better ways of planning future urban growth. Project 4.55 is working on the development of visualisation tools (including augmented reality) and community engagement tools to allow various redevelopment scenarios to be presented, compared and evaluated and to facilitate interaction between stakeholders at various levels. In this context, the link with the Christchurch rebuild program is proving invaluable but engagement with local government in Victoria and Western Australia is also providing useful test sites and opportunities to engage with end users to evaluate and refine the developed tools.

The Program's Science Director is Professor Peter Newman from Curtin University in Western Australia. Professor Newman was made an Officer of the Order of Australia in 2014 for distinguished service to science education as an academic and researcher, through contributions to urban design and transport sustainability, and to the community. The Program produced one book chapter, six refereed journal articles, and six refereed conference papers in 2013-14.



ENVISION

2.2 Research Summary of Program Highlights

Positioning Program

This Program continues to break new ground in multi-GNSS signal integration, PPP-RTK ambiguity resolution and validation, multi-GNSS regional orbit determination and dynamic datum design and realisation. This year has seen the launch of the Analysis Centre Software Development Project which aims to integrate outputs from the various research projects into a processing and analysis capability to support the National Positioning Infrastructure. The research has achieved a world first in identifying and reporting on the existence of previously unknown inter-satellite biases between different types of Beidou satellites. Commercialisation of the recent Array-PPP research carried out under the exceptional research ideas scheme has commenced. The Program has also delivered first time results for the generation of Beidou satellite orbits outside of China.

Automated Spatial Information Generation Program

Much of the activity in this Program focuses on metric quality, automated feature extraction from airborne, satellite-borne and terrestrial ranging and imaging sensors. Novel techniques are being developed and implemented that enhance the accuracy and repeatability of certain feature classes such as building footprints and roadside infrastructure. A new implementation of the Euclidian Distance Transform (EDT) has been achieved and demonstrated to be faster and more stable than existing state of the art implementations. The EDT is widely used in computer vision for edge and boundary detection. The Program has another project working on woody vegetation classification where recent research has developed a new method to estimate tree canopy height from LiDAR data.

Spatial Infrastructures Program

The core research activities focus on utilising the capabilities of the semantic web to improve spatial

infrastructures and thus support the discovery, use, integration and dissemination of raw and productised spatial information. The Program has initiated a short term, highly focused project by directly engaging researchers with 43pl service providers to look at the supply chain for geocoded addressing products. The aim of this activity is to examine the supply chain in a holistic sense, to identify areas for improvement and to make recommendations for consideration by stakeholders.

Applications Programs

Agriculture, Natural Resources Climate Change

The Program has an agriculture component that targets better estimation of on-farm biomass, whether using hand-held active optical sensors or remotely sensed information from satellites. A new allometric equation to compute tree diameter from breast height (DBH) using projected crown area from medium and high resolution imagery has been published as a significant outcome of the biomass estimation activity. The natural resources management component of the Program has built critical mass in the past twelve months with new projects focused on the management of “big data” linking to Geoscience Australia’s data cube project, and a second project focusing on developing an enhanced spatial capability to support the sustainable management of Australia’s vast rangelands. SavBAT (Savannah Burning Abatement Tool) is a web-based tool produced by this Program that allows farmers and land managers to determine optimum times to use controlled fire management for the savannahs of the fire prone tropical north of Australia to reduce greenhouse gas emissions and thus earn carbon credits. The SavBAT project won a 2014 Asia Pacific Spatial Excellence Award.

Defence Program

The Defence Program concentrates its interaction with the CRCSI on issues of data fusion and feature

extraction. Professor Clive Fraser coordinates the CRCSI's relationship with Defence, through the Australian Geospatial Intelligence Organisation (AGO), and leads the formulation and delivery of research projects designed specifically to meet the unique needs of AGO.

Energy and Utilities Program

The Flight Assist System (FAS) developed by the CRCSI under this Program, automates flight planning and execution for the acquisition of LiDAR and imagery data collected over power transmission and distribution assets. FAS has been licenced to Ergon/ROAMES and is presently saving Ergon Energy approximately \$13M per annum. Further research on an enhanced FAS (eFAS) has been carried out by the CRCSI team and is the subject of a patent application. eFAS takes the original FAS concept into the 3D realm for improved flight planning and control. In 2013-14, the eFAS successfully developed survey planning techniques to optimise both on-survey and off-survey paths, leading to reductions in survey length and better obstacle avoidance. It also undertook the development of new flight path design tools, which have led to further reductions in survey length by improving on-survey path design. Total flight path savings of up to 15% have been demonstrated.

Health Program

The Program continues to promote greater use of spatial data and geospatial and geostatistical analysis techniques and to develop server-based geovisualisation software and privacy tools to support the operational needs of public health agencies in Australia and New Zealand. The focus of the Program is broadening to include primary health care through a new project funded under the CRCSI's exceptional research ideas scheme, which engages with general practitioners in WA. The server-sided geovisualisation capabilities developed by the Program are attracting interest in other application areas such as agriculture and finance and these opportunities are being explored and evaluated.

Sustainable Urban Planning

The Science Director for this Program Professor Peter Newman, Director of Curtin University Sustainability Policy Institute was made an Officer of the Order of Australia in 2014 for "distinguished service to science education as an academic and researcher, through contributions to urban design and transport sustainability, and to the community". This Program has been particularly successful in the past twelve months in securing a high level of co-investment and in engaging with New Zealand partners to undertake research relevant to the redevelopment of Christchurch, following the devastating earthquakes of 2010 and 2011. The present focus of the Program is on the visualisation of redevelopment options in the middle-ring suburbs of major cities and on engagement tools to evaluate new design options through community consultation.

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

For 2013-14 the CRCSI met 29 of its 36 Research Milestones. In addition 23 research milestones for future years have been met.

The overall picture of conformance to Commonwealth Agreement milestones is a positive one.

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 that influence government policy initiatives. A full list of publications is provided in Appendix 1. It is notable that the overall number of publications has increased substantially since 2012-13. In addition the emerging influence and uptake of a number of research outputs (reported separately under the Utilisation section of this report) acts as a complementary indicator of quality and achievement. By this latter criterion, the CRCSI is increasing its impact as some early research activity reaches maturity and is delivering practical results for industry uptake. The CRCSI is also having an identifiable impact on influencing government policy with one prominent example being the release of the Federal Government's Satellite Utilisation Policy and the accompanying development of national infrastructure plans for positioning (aligning with Program 1) and earth observation (aligning with Program 2). The CRCSI has been a key player in the development of both these plans and is supporting their implementation through targeted research activity.

Any issues, including technical or scientific impediments

There is substantial growth in the domain of new spatial technologies, with simple to use but highly sophisticated sensor systems being regularly released. The consequence is unprecedented growth in the availability of spatial data from diverse and often disparate sources. 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 data being captured is growing exponentially. In the face of these happenings, the challenge for the spatial research community is to keep abreast of the technology developments and to deliver new ways of identifying embedded value in the data so that it can

be extracted, integrated, presented and delivered in a timely and meaningful way. Our aim is to facilitate the production of quality-assured and fit-for-purpose spatial information products to a growing, increasingly well informed and sometimes demanding user community. Many organisations (both private and government) are recognising the intrinsic worth of spatial information. Such information is helping to facilitate better decision making and to improve the operational performance and workflow efficiencies of businesses everywhere. This growing spatial awareness, coupled with the unprecedented availability of spatial data has heightened the need for and relevance of spatial information research. From a research management perspective, this dynamic environment challenges conventional research paradigms. The CRCSI is responding to this need by introducing a more agile mode of research delivery that is better able to respond to the changing needs of the end user community. This in turn is requiring researchers to have deeper and more frequent interactions with end users in industry and government to ensure relevance is maintained. A complementary challenge for the CRCSI is to maintain high standards of research quality and to deliver research outputs that rate well by accepted metrics of performance.

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

All CRCSI 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 our partners as detailed under the Utilisation section. Our Program Board structure, where each Board by mandate is chaired by a lead end user and is dominated by end user members, ensures that the research is designed to meet their needs.

Any changes proposed to future research directions

Up to June 2014, the original structure of the CRCSI research program, with three core science themes

(positioning, automated feature extraction and spatial infrastructures) and five targeted application areas (agriculture and natural resources, energy, defence, health and urban planning) has been maintained. This structure has served the organisation well and has provided a broadly agreed framework within which to pursue the research needs of partners. In June 2014, the CRCSI reached the midpoint of its current funding cycle. This important milestone provides a timely opportunity for reflection and re-phasing which will be used to recast future research priorities for the period 2014-18 and beyond. Such a process is justified in the face of the evolving needs of partners and the dynamic nature and growth of the spatial information sector. It is anticipated that the research priorities review will result in the re-affirmation of some existing activities, but will also lead to some activities being re-structured and some new activities being brought in. The outcomes of the review will be finalised by the end of 2014 and will be summarised in next year's annual report.

Publications

As shown in Appendix 1, 107 separate publications were produced in 2013-14 including, two book chapters, 44 refereed journal papers and 59 refereed conference papers. The numbers for journal and conference papers have increased by 18 (69%) and 9 (18%) respectively on last year.

2.2 Education and Training

12 post-graduate students commenced in 2013-14 with either full or top-up scholarships, bringing the total cohort of active students to 35 at 30 June 2014. During the year four students completed their studies, thus CRCSI have achieved a total of 19 completed post-graduates. With 54 active and completed post-graduates we are on track to meet and exceed our Commonwealth target of having invested in (enrolled or graduated) at least 51 PhDs and Masters with our university partners by 30 June 2018. A full list of CRCSI PhD commenced, completed and withdrawn for 2010-14 is included in Appendix 2.

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

The CRCSI is well on target to meet and exceed its education and training targets.

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

Delayed CRCSI postgraduate student recruitment in Program 3 has been addressed in 2013-14. The recruitment of eight students into this program in the past year has seen a significant increase in activities and focus to address the Program 3 milestones. These milestones will now be completed, although behind schedule.

Details of the education activities conducted during 2013-14

Postgraduate: One-on-one interviews were conducted with all CRCSI postgraduate students during January 2014. These interviews discussed various inputs into the education program's strategic plan. The education plan is currently being developed for completion later this year.

Following the student interviews a private LinkedIn CRCSI Student Group was started to further engage the CRCSI students in activities and opportunities. A number of students suggested this as a mechanism to find out more information about the CRCSI.

CRCSI students entered four videos into the CRCA early career research competition in February 2014. Ebadat Parmehr, Charity Mundava, Jannah Baker and Nuddin Tengku all participated in the video productions. These can be viewed on the CRCSI website. The competition for finalists was fierce, and even though none of our students were selected as finalists, they all did an amazing job in producing their videos.

The first edition of the CRCSI student newsletter was published in April 2014. The newsletter contained a number of articles and updates from students across the research program. The newsletter was identified as an important initiative by students at the 2013 Annual Conference in Christchurch.

The mentor scheme has continued throughout 2013-14. The mentor scheme enables each student to be matched with a member of the CRCSI management team to provide greater support, advice and awareness of issues and opportunities for both parties. This initiative has further strengthened the CRCSI's bond with its students.

Again, all CRCSI students are invited to the Annual Conference. The student days at the annual conference will be a mixture of intellectual property professional development and discussions to further develop the bonds between our students. There will also be a three minute thesis presentations integrated into the conference program.

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 their clients) to more actively engage with CRCSI at a direct level. In addition, occasional technology briefings are provided to CRCSI participants.

Evidence of the level of student involvement in the CRC's activities

Students are involved in all major projects. Each student is required to have an external end user supervisor. All students are invited to attend the Annual CRCSI Conference which has a specific session for students. Evaluation forms reported highlights being networking, cultural learning, meeting other PhD students, getting to know the roadmap of CRCSI, and improved interactivity and collaboration.

Support structures for postgraduate students, including the opportunities for interaction between students working in different parts of the CRCSI

As outlined above, all CRCSI students are invited to attend the Annual Conference and the Student Workshop. They are also invited to seminars, workshops, and the quarterly project meetings. The Student Workshop is explicitly

designed to increase the engagement of students in CRCSI. A student network is being explored, with a view to occasional "Research Student Colloquia" and increased interactions. An informal mentoring "buddy-system" has been put into place between the students and members of the CRCSI management team.

Graduate destinations

All graduates are tracked following completion. Of the student completions to date:

- two are working for a 43pl member company
- two are working in a 43pl non-member company
- nine are in academia or other research institutions
- one is a research fellow on a CRCSI project
- four are working in government departments

Evidence that the education / training activities are meeting the needs of end users

The CRCSI end user community, in a foundational survey, strongly stated preferences for informal learning (69%) and learning tools delivered online (49%). So the CRCSI end user program responds to expressed and perceived need (eg Health Program short courses) or through the provision of video learning through the website or through interactive events such as the roadshows and conference.

The evaluation forms from CRCSI's 2013 Conference showed that 100% agreed or strongly agreed that the conference 'met or exceeded expectations', and 60 % 'identified potential applications of new technology or innovation', with the top three benefits described as Networking; Presentations; Project interactions.

Roadshows have shown similar positive response and serve to introduce new organisations and people to geospatial technologies and the work of the CRCSI.

2.3 SME Engagement

CRCSI strategy for engaging with SMEs

SMEs are deeply integrated into CRCSI's activities. CRCSI has 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 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 they 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 Director of Stakeholder Engagement. The Company Secretary function and administrative support for 43pl is provided by CRCSI. The cost of administering 43pl is modest.

The 43pl strategies are based on individual company “Expectations and Engagement Plans”, which are reviewed annually with each company in confidence. Key themes and strategies arising from these plans are collated and presented through the 43pl Board 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 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 for the Board of 43pl following a process of nominations. These directors aid communication with members. As at 30 June 2014 the 43pl Directors were David Sinclair

(Independent Chair), Mark Watt (Queensland), Jim Curnow (SA and NT), David Purnell (WA), Ed Garvin (NSW & ACT), Rob Rowell (Tasmania and Victoria) and Simon Jellie (New Zealand & International).

The current membership of 43pl is 45. 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 ten years.

The CRCSI also has an MOU with the peak private sector body, 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 and the Australian Information Industry Association.

Demonstration of how the CRCSI is assisting SMEs to build their 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 as well as 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 CRCSI projects, totalling millions of dollars to dozens of companies over the last ten years
- Access to R&D initiatives and CRCSI IP for commercialisation, eg Scanalyse: a spin off company based on the CRCSI research and development

- Skills development and capacity building, including the recruitment of the CRC SI postgraduate students
- Meaningful networking into government and academia to bring the end user close to the researcher, so the 43pl company can participate where their 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 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/commercialisation outputs

The CRC SI accomplished 16 of its 24 utilisation output milestones for 2013-14 and completed a further two ahead of plan. The current outlook for the 2014-15 year is that the remaining five outstanding milestones will be completed by June 2015.

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

One Milestone requires concentrated effort in 2014-15:

- Utilisation 4.3: Usage for Outputs 4.4 and 4.5 are expected to build over the eight and a half year timeframe starting with the Department of Health WA, Telethon Institute for Child Health Research and Queensland Cancer Council. A gradual build up to all State Health Department, Commonwealth Department of Health & Aging (DoHA) and other

Cancer Councils and Research Institutes will follow. After the establishment of spatial health privacy protocols (Year 3) the front-line of health care - GP Divisions, Community Health Providers and Local Government Areas will benefit. The CRC SI anticipated the utilisation milestones of U4.3.4: roll-out to two further Health agencies, U4.3.7 Roll-out to four further Health Agencies, and U4.3.9 Results of population exposure modelling assessment used by health researchers at three Universities would be complete by 2013-14. The capacity of government health agencies to absorb and roll out the software is providing some impediment. As reported previously, the follow-on consequence is that subsequent rollout to other agencies may be slightly delayed. This has proven to be the case and will be addressed more comprehensively in 2014-15 via commercial partners to assist with achieving the CRC SI milestones.

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 CRC SI proposals before the Board will approve CRC SI 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 Board with input from the project management group and CRCSI Executive. If approved, the utilisation case is progressed through the CRCSI commercial agent, SISR, with an expression of interest to develop the commercial proposition sought from CRCSI participants.

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

SISR is the legal owner of 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 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 Board with its final decision.

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

Specific benefits to partners from new endeavours from 2013-14 activities included:

Project National Data Grid Project & ‘Unlocking the LANDSAT archive for future challenges’ (ULA) Project: These projects utilise CRCSI-1 Centre Intellectual Property created under the National Data Grid project. A decision was made to also release accompanying IP relating to enabling software, the Raster Storage Archive as open source to encourage broader adoption of the overall solution amongst government (<https://github.com/VPAC/rsa>).

Project 2.02 Topographic Mapping Feature Extraction (Barista): The CRCSI Barista software system continued to be used by government partners and companies. 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 4.51 Housing Redevelopment Planning Platform: CRCSI researchers developed a decision-making tool called ENVISION to predict where housing redevelopments are likely to occur. This tool assists planners with housing redevelopment decisions and has been used by two councils in their decision making. It is also now in use in the Victorian Government.

Status/current performance of existing spin off companies

The CRCSI maintains an equity position 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 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.

Scanalyse Pty Ltd (www.scanalyse.com.au), a spin out company of CRCSI funding, was sold in March 2013 to Outetec, a Finnish minerals and metals processing technology and services supplier. This resulted in CRCSI selling its stake in Scanalyse.

3.2 Intellectual property management

IP management arrangements

The effective management and utilisation of intellectual property (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 the IP for their internal research purposes
- Endeavouring to make a priori decisions about the commercial potential of investments in IP from the 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 put into the public domain
- Operating an end user uptake pathway with emphasis on partnering SMEs and government organisations, supported by the research providers. Appropriate consideration is also given to the needs of large corporate Participants
- Use of an Expression of Interest process to seek utilisation plans from 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

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

Each Essential Participant has a non-exclusive, royalty-free licence to use CRCSI IP for the purposes of 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 CRCSI IP is SISR, which holds the IP in trust for 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 CRCSI IP, and is responsible for the utilisation of CRCSI IP, including the marketing of the IP, the seeking of potential licensees of the IP, and seeking other users of CRCSI IP for commercial purposes.

If SISR intends to utilise CRCSI IP it must advise each CRCSI Essential Participant in writing and identify the particular CRCSI IP and the terms of the proposed utilisation. Each Participant must within ten 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 CRCSI IP, except where authorised.

The CRCSI adopts the principle that researchers should be encouraged to actively participate in research and utilisation/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 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 CRCSI research.

How 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 CRCSI IP for the purposes of 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 utilising the IP. If SISR intends to utilise 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 one provisional patent application in 2013-14 and has no active patents.

3.3 Communications

Internal communications activities undertaken during the period

With some one hundred key stakeholders the CRCSI places a great deal of emphasis on communications and relationships management. It has a network of three Colleges, each of which has a governing body: the Research and Education College has a Committee; 43pl has a formal Board that operates under Corporations Law; and the Government College operates under the aegis of ANZLIC the council of state and federal government agencies dealing with land information issues, including New Zealand.

The CRCSI produces regular communiqués to update members and interested stakeholders (1000 subscribers) on CRCSI activities. It conducts roadshows and workshops to foster good communication and participation in new initiatives, seeks the views and engenders the support and engagement of the participants and reaches into each of the jurisdictions to broaden the impact of CRCSI. In addition program board and project management group meetings support and foster dialogue.

Attendance at our conferences is limited to members and invited guests as requested by members. The annual conference runs over three days and involves presentations on research activities by researchers including postgraduate students; open forum sessions for members to debate and discuss critical issues; sessions for each college to discuss issues of mutual interest; presentations by selected international experts; and an interactive workshop for postgraduates on a range of issues. Post conference surveys consistently report a very high degree of satisfaction with the conference and the value it provides to members.

Participants attend the quarterly project meetings to review progress and discuss future plans. These are mostly conducted by teleconference. These communication activities help projects in gaining new participants and in providing materials and training courses to disseminate information and to help with the uptake of project outcomes.

CRCSI's communications allow for special attention to 43pl companies, many of which are not accustomed to research-based interactions with academic and government institutions. The Director of Stakeholder Engagement and the 43pl Company Secretary have roles in providing confidential and impartial advice to 43pl members to assist their CRCSI engagement.

Physical co-location of researchers, end users and CRCSI management is encouraged. In Melbourne the CRCSI headquarters are within the University of Melbourne. In Queensland, the Business Development Manager is located within QUT. In Canberra, another Business Development Manager is located within Geoscience Australia, and the New Zealand Director of Operations is located within Land Information New Zealand (LINZ, a Government agency.). The Western Australian office houses the CRCSI Director of Stakeholder Engagement, the Program Manager for Spatial Infrastructures, along with several researchers at WA's Technology Park in Bentley, adjacent to Curtin University.

External communications activities CRCSI has undertaken to communicate its successes

The website is used to regularly report on the progress of projects. Project video presentations are made available regularly through the website. Discussion groups on LinkedIn (640 members) and Facebook are maintained along with blog and Twitter (500+ followers) feeds. CRCSI also has wide exposure at national and international conferences and symposia.

The CRCSI has been instrumental in the organisation and support of all the major national events related to the spatial industry including the spatial@gov Conference; the Surveying and Spatial Sciences Institute (SSSI) Spatial Sciences Symposium; the Geospatial Information Technology Association (GITA) Conference; Spatial Industries Business Association of Australia (SIBA) events; several state based conferences, eg the Western Australia Land Information System (WALIS) Forum; as well as international conferences such as the International Society for Digital Earth Symposium.

Increasingly, as CRCSI activities gain momentum, media releases are prepared around significant centre and project achievements, with an emphasis on the participants involved and recognition of the collaborative nature of the event. Workshops are held when required to transfer knowledge to end users. These occur both in the construct of a proposed research activity and to promote the outcomes of a given project. Sometimes these coincide with the Annual Conference.

Overall strategies used to ensure effective internal and external communications

The previous sections describe a comprehensive suite of activities for internal and external communication. They are guided both by Board approved policies for the media activities including social media, and by a Communications Strategy.

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 (43pl Version 2 Pty Ltd)
- Curtin University of Technology
- Department of Environment and Primary Industries (VIC)
- Land and Property Information (NSW)
- Landgate (WA)
- Queensland University of Technology
- University of New England

There are 71 formal participants in the CRCSI from the government, private and research (university) sectors, with a further 31 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

45 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 their respective members especially in the formation of policy, the development of strategy, nominations of candidate directors to the Board and the admittance of new participants. They also provide a vital mechanism for two-way feedback and communication.

The CRCSI has significant membership from New Zealand including a lead government agency, Land Information New Zealand (LINZ), the University of Canterbury, and a number of 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 was appointed after an extensive College led nomination and selection process. The Board met formally four times in 2013-14. 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 its 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 and applications programs. A comprehensive suite of governance protocols, policies and guidelines have 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.

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

Roles and Accountabilities

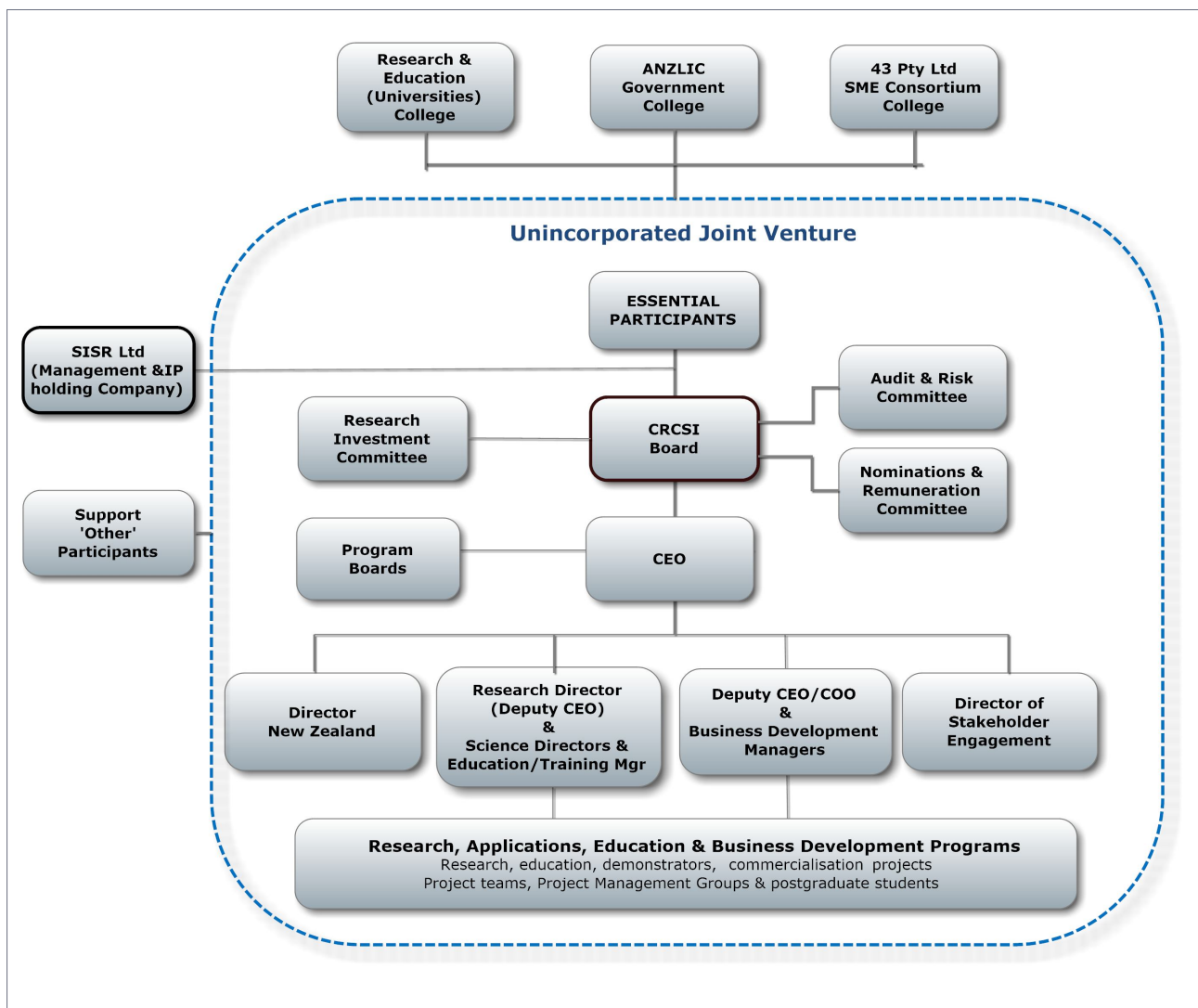
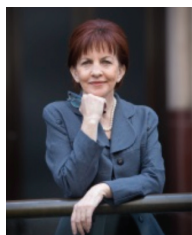


Figure 4: The governance and management structure of the CRC for Spatial Information (CRCSI)

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, education and development. She is also NSW Chief Scientist and Engineer and Chair of the Development Gateway Board. Mary was Vice-Chancellor and President 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 including being a Director of PSMA Ltd, National ICT Australia Ltd, Business Events Sydney Ltd, the New Zealand Antarctic Research Institute and the Capital Markets CRC. 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. 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 Cooperative Research Centre for Spatial Information (CRCSI) in June 2003. Peter was previously CEO of RMIT's Geospatial Science Initiative. During this period he was responsible for a number of developments that included helping 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 is currently a Member of the Executive Committee of the International Society for Digital Earth; 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; and Chair of VANZ Ltd.

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 Company Directors Course of the Australian Institute of Company Directors.



Drew Clarke

Drew Clarke is Secretary of the Commonwealth Department of Communications. The portfolio includes the ABC; SBS; Australia Post and the National Broadband Network Company (NBN Co). Drew was previously Secretary of the Commonwealth Department of Resources, Energy and Tourism. His earlier roles include Deputy Secretary for Resources, Energy and Tourism; Head of the Energy and Environment Division; Executive General Manager of AusIndustry; and leadership of science agencies. Drew has also chaired national committees in the energy and resources, tourism, and spatial information sectors, that are responsible for policy advice to the Commonwealth, state and territory governments. He holds a MSc from Ohio State University and is a Fellow of the Australian Academy of Technological Sciences and Engineering. He was awarded a Public Service Medal in 2009 for his work in energy market reform and clean energy. Drew began his public sector career as a surveyor working in Australia and Antarctica.



Malcolm McCoy

Malcolm has over 20 years experience as a Director of survey and spatial companies and 35 years in the industry. He has been instrumental in undertaking two recent mergers of survey companies to form Vekta and prior to that to create Survey21. As part of this process Malcolm has been involved in lengthy due diligence procedures, and accordingly has been appointed Managing Director

of Vekta, one of a few truly national survey and spatial consultancies.

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, financial management, contracts administration and QA and OHS.



Graeme Wright

Graeme is the Deputy Vice-Chancellor, Research and Development at Curtin University. He has extensive knowledge and experience in education and

research, engagement with higher education policy at strategic level. He has held appointments in the vocational educational sector and 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 Investment Advisory Committee and the CRC SI Board. Graeme was the inaugural Chair of the Research and Education College and currently Chairs the CRC SI Research and Investment Committee, which is a CRC SI Board Committee. Graeme led the engagement of Curtin with the CRC SI 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 current appointments as a Director of Circadian Technologies Ltd. She recently retired as Chairman of the Centre for Eye Research Australia. She is a past Director of the Vision CRC, a past Member of the Funds Management Committee of the AusIndustry Research and Development Board and a past Member of the Victorian EPA Hazwaste Fund Advisory Panel.



Mr Colin MacDonald

Colin MacDonald took up his position as Chief Executive and Secretary for Internal Affairs and Government Chief Information Officer in April 2012 and has held previous roles as Chief

Executive of Land Information New Zealand and Deputy Commissioner Business Development and Systems at Inland Revenue. Colin has 30 years experience in Information Technology (IT) and general management in both New Zealand and UK and was previously Chief Operating Officer for the ANZ Banking Group (NZ).

Prior to joining the ANZ in 1995, Colin was employed by KPMG as Associate Director in the consulting team. From 1980 to 1994, Colin held IT management roles in the oil industry and in the legal and retail sectors. Colin completed a Bachelor of Science in Computer Science at the University of Glasgow in 1980. He is a Chartered Engineer and a Member of the British Computer Society.

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

There have been no changes to Board membership during the year.

Board committee membership, function, reporting arrangements and key skills

Audit and Risk Committee

The Audit and Risk Committee met three times 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

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

Table 6: Roles and Accountabilities within the CRCSI Governance Structure

Directors/ Committee Members	Board of Directors		Audit & Risk Committee		Research Investment Committee		Nominations & Remuneration Committee	
Number of meetings held	4		3		3		2	
Directors	Eligible	Attended	Eligible	Attended	Eligible	Attended	Eligible	Attended
D. Clarke	4	4					2	2
C. MacDonald	4	3						
G. Wright	4	4			3	3		
M. OKane	4	4					2	2
M.McCoy	4	4	3	2				
P.Woodgate	4	4			3	3		
T. McMeckan	4	4	3	3				
Committee Members	Eligible	Attended	Eligible	Attended	Eligible	Attended	Eligible	Attended
J. Bangay					1	0		
A. Berrill					3	3		
S. Ramage					3	2		
M Goodchild					3	2		
R Freeth					3	3		
A. Held					3	1		
W.Poole			3	3				
J. Trinder					3	2		

Table 7: CRCSI Board and Committee attendance in 2013-14.

Notes:

1. Board meetings were held on 20 Sept 2013, 22 Nov 2013, 25 Feb 2014 and 22 May 2014.
2. Rob Freeth and Alex Held were appointed to RIC in Nov 2013. James Bangay resigned from RIC in Nov 2013.

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 – Toronto, Canada	
Rob Freeth	Member	Independent, Freeth Computing Consultants – Perth, WA	
Mike Goodchild	Member	Independent, University of California – Santa Barbara, California, USA	
Alex Held	Member	Independent, CSIRO – Canberra, ACT	
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 Governance, Academic sector experience	Independent
Drew Clarke	Member	Board Director Government and Spatial Industry Experience, Corporate Governance	Independent

Table 8: Board Committee Membership 2013-14

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) were reappointed 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 seven member Committee is by the Board who has the right to vary membership numbers as required. The Committee met three times during the period to review research project proposals and initiatives. Funding recommendations for Board approval resulted in new projects in all four CRCSI research program areas. When the Committee meets it also invites all of the Science Directors for all programs to attend each meeting. Senior Executives of the CRCSI also attend each meeting.

Names and 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)	77%
John Dawson	Geoscience Australia	Program Manager, Research Program 1	45%
Clive Fraser	CRCSI	Professor and Science Director (Research Program 2: Automated Feature Extraction)	80%
Geoff West	Curtin University	Professor and Science Director	80%
Kylie Armstrong	Landgate	Program Manager (Research Program 3: Spatial Infrastructure)	60%
Kim Lowell	CRCSI	Professor and Science Director (Applications Program 4.1: Agriculture, Natural Resources and Climate Change)	100%
Clive Sabel	University of Exeter	Professor and Science Director (Applications Program 4.4: Health)	6%
Geoff Jacquez	State University of New York	Science Director (Applications Program 4.4: Health)	6%
Narelle Mullan	Curtin University	Program Manager, (Applications Program 4.4: Health)	50%
Peter Newman	Curtin University	Professor and Science Director (Applications Program 4.5: Urban Sustainable Development)	14%

Table 9: Time Commitments of key staff

Note: Applications Program 4.2: Defence and Program 4.3: Energy Utilities are yet to demonstrate a need for a Science Director.

Nominations and Remuneration Committee

This Committee comprises two members and is chaired by the Chair of the CRCSI, Prof 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 practises for senior executives and independent directors. The Committee meets periodically as needed.

4.2 CRCSI Strategic Plan

The CRCSI Strategic Plan is updated annually by the Board.

Strategic Plan

Vision: Spatially enabling Australia and New Zealand

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

What success will look like

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

Our Values

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

Our strategic objectives

1. National precise positioning (Research Program 1)

Objective 1: 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 2 cm (x and y) accuracies.

2. Automated generation of spatial information products (Research Program 2)

Objective 2: To conduct research that improves ability of government and industry to undertake automated data

fusion and feature extraction from terrestrial, aerial and satellite based remote sensing sources.

3. Infrastructure for an Australia New Zealand spatial marketplace (research Program 3)

Objective 3: To identify and solve the research issues that will semantically web enable critical spatial data supply chains and enable CRCSI partners to create value-added applications with new technologies on their infrastructure.

4. Applications (Program 4)

Objective 4: To realise high impact use of the CRCSI's research in the following areas: Agriculture and Natural Resources (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 CRCSI's research portfolio; Energy Utilities (4.3) to enable remote monitoring of the condition of built assets in near real time; Health (4.4) by helping agencies to spatially enable their clinical databases; and Urban development (4.5) to build new tools to support sustainable urban development.

5. Education (Program 5)

Objective 5: By 2018 the CRCSI will have at least 51 PhD and Masters completions through our university partners all of whom have significant industry experience.



Phd and Masters students at the annual conference in Christchurch 2013.

6. Industry development and sustainability (Program 6)

Objective 6: Industry development; assist our partners, in particular 43pl, develop and exploit CRCSI IP

Objective 7: Commissioned research; expected to generate an additional \$11M of activity to 2017-18 tackling complex research needs involving multiple partners from both public and private sectors.

Performance indicators

1. A solution for the impediments of multi-GNSS signal processing and economic arguments for a continent-wide, ubiquitous, sparse, precise positioning network.
2. Adoption by our partners of new methodologies and software tools that enhance the level of automation of data fusion and feature extraction
3. Wide recognition by our partners of the CRCSI's role in helping establish and value-add critical supply chains.
4. 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 102 CRCSI contributors, including Essential, Other and Third Parties have provided either cash or in-kind contributions to support the CRC's activities for 2013-14. Of these, 56 Participants are equity holding partners in the Centre (11 Essential and 45 43pl) holding beneficial ownership rights in Centre IP based in proportional to their aggregate cash contributions to CRCSI. A further 15 participants are Other (or support) Participants, and the remaining 31 Third Party Participants have entered into specific project agreements or been involved in other Centre activities within the period. For a list of 2013- 14 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. All these organisations are involved in the programs of the centre.

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 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
Department of Finance and Services, Land and Property Information, NSW	Essential	84 104 377 806	State Government
Landgate, WA	Essential	86 574 793 858	State Government
Queensland University of Technology	Essential	83 791 724 622	University
The University of New England	Essential	75 792 454 315	University
University of Canterbury	Essential	n/a	University
Department of Environment and Primary Industries, VIC	Essential	90 719 052 204	State Government
Australian Geospatial Organisation	Other	68 706 814 312	Australian Government
Department of Health, WA	Other	13 993 250 709	State Government
Land Information New Zealand	Other	n/a	International
Department of Environment Climate Change & Water, NSW	Other	30 841 387 271	State Government
Delft University of Technology	Other	n/a	University
Energex Limited	Other	40 078 849 055	Industry / Private Sector
Open Geospatial Consortium Inc	Other	n/a	International
Murray-Darling Basin Authority	Other	13 679 821 382	Australian Government
Royal Melbourne Institute of Technology University	Other	49 781 030 034	University
Swinburne University of Technology	Other	13 628 586 699	University
Telethon Institute for Child Health Research, WA	Other	86 009 278 755	State Government
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
Business Aspect Pty Ltd	43pl	24 100 876 015	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
C R Kennedy & Co Pty Ltd	43pl	50 008 458 884	Industry / Private Sector
Critchlow Limited	43pl	N/A	Industry / Private Sector
CTF Solutions Pty Ltd	43pl	82 144 513 459	Industry / Private Sector
Eco Logical Australia Pty Ltd	43pl	87 096 512 088	Industry / Private Sector
e-Spatial Ltd	43pl	n/a	Industry / Private Sector
ESRI Australia	43pl	16 008 852 775	Industry / Private Sector
EOMAP GmbH & Co.KG	43pl	n/a	Industry / Private Sector
Fitzroy Basin Association Inc.	43pl	30 802 469 401	Industry / Private Sector
Fugro LADS Corporation Pty Ltd	43pl	62 067 368 192	Industry / Private Sector

Table 10: CRCSI Participants 2013-14

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[illegible]

[illegible]

Note: This list comprises organisations that have executed a formal Commonwealth Participants agreement with the CRCSI. There are many other partners who are unable to execute this agreement but are participating on the basis of an exchange of letters.

Changes to Participants

There were no changes to Essential Participants in the period and the loss of one Other Participant with the closure of GEOIDE in Canada.

4.4 Collaboration

The CRCSI has a detailed database of all participants and key stakeholders. It monitors about 100 organisations in this way. The database records details of all activities, each person, each project, each committee role and much more. It records management's view of the level of expectation that each participant has of the CRCSI, and Management's view of how well the CRCSI is performing in relation to meeting those expectations. This analysis is quantified and reviewed regularly.

The CRCSI has many participants across Australia and in New Zealand. Most 43pl companies and some external companies had formal collaborative arrangements with the CRCSI activities in the period, along with over a dozen government departments and a similar number of universities.

Respective organisational cultures differ between the various government agencies, small service provider companies and manufacturers, R&D based enterprises, and universities. These differences are well managed by the CRCSI when judged by the number of organisations prepared to participate. Fostering a CRCSI culture of excellence in cooperation is important to the Board and Management.

Collaborations between researcher participants, researcher participants and end user participants, and between the end users themselves

The CRCSI has a matrix structure so that partners are engaged with leading edge technology and service providers along the value chain and across parallel lines of business, drawing valuable new knowledge from the interdisciplinary experience. Indeed the CRCSI's three primary research programs (1 to 3) operate as platforms for all five applications programs encouraging innovative synergies that would not be possible with a silo approach.

In addition many partners are also suppliers of the data and infrastructure used by the market in devising new products.

Cooperation amongst geographically spread activities and entities is assisted through regular electronic and face to face symposia.

The level of collaboration varies across the CRCSI. For instance in Program 1 Positioning, there is close integration of the efforts from four universities across Australia as the recognised leaders in the field, orchestrated through the CRCSI's Program 1 Science Director. Another example is the Health Program, which has close ties across Curtin University, Queensland University as well as the Telethon Kids Institute in WA and the Queensland Cancer Council, with new alliances being developed with Australian National University and the Tasmania Department of Health.

End users are involved in all aspects of the CRCSI. Meaningful SME engagement is a particular strength of the CRCSI and is reflected in all aspects of the CRCSI's operations.

It is a prerequisite for Research Investment Committee (RIC) consideration of a proposal that all activities to be funded have meaningful input from academia, government and private sectors. Without the presence of these three a persuasive argument is required as to why the CRCSI should be operating in the area. RIC membership includes representatives from government and SME end users.

The internal interactions in the CRCSI are very strong in the government and industry sectors. The collaboration and communications strategies of the CRCSI support and encourage this. Within 43pl, there have been a number of corporate mergers brought about, in no small part, by the closeness of collaboration CRCSI engenders. A prime motivation for many 43pl companies in participating in CRCSI is the collaborative experience with both government and academia.

Commonly some agencies have released work packages to the CRCSI which then oversees the conduct of the research therein and brings into play the private sector in certain operational circumstances. The UDEM project is one example where twenty organisations were collaborating on behalf of the ultimate client, the then Department of Climate Change and Energy Efficiency.

CRCSI welcomes potential new partners to the Annual Conference, allowing them to investigate the benefits of its research and discuss membership options. Further, research and end user partners are invited to regional roadshows and project-specific workshops. This ensures that CRCSI's program of research is widely understood by our partners; that the research is up to date and relevant to end users; and that collaboration is increased as partners are involved from the outset.

In general there is a very high degree of collaboration between the researchers, and between researchers and end users irrespective of their physical location or organisational affiliation. The CRCSI College structure ensures strong collaboration between the end users themselves, particularly in the development of common strategies designed to benefit all through the creation of the largest possible national benefit. The wonderful degree of collaboration between all participants is one of the hallmarks of the CRC Program overall.

External linkages and how they contribute to the CRCSI overall

National

Strong links have been established with key stakeholder groups, notably the peak industry body the Spatial Industries Business Association (SIBA, and including the SIBA New Zealand chapter); Geospatial Information and Technology Association (GITA); the peak professional body the Surveying and Spatial Sciences Institute (SSSI) and the peak government body ANZLIC – the Spatial Information Council. Mechanisms include invitations to Board meetings, joint Board meetings, membership, committee representation, and invited presentations,

shared web links, and collaborations on important initiatives such as the National Spatial Education Leadership Group; leadership roles within the NCRIS organisations AuScope; AURIN and TERN, and related activities; and the commissioning of joint projects. These relationships are important to give strategic advice and context to the CRCSI on the one hand and on the other to effectively convey the work of the CRCSI to the broader spatial end user communities.

International

International collaborative alliances were maintained during the period with strategic advantage sought for specific projects. The following international links are well developed:

- New Zealand – the CRCSI has established a partnership with New Zealand through Land Information New Zealand (LINZ), the University of Canterbury and several 43pl members. The CRCSI is actively pursuing collaboration with new agencies and organisations in the region and has funded several projects involving New Zealand enterprises. The CRCSI proposed to the New Zealand Government that New Zealand develop a Geospatial Research Strategy to guide its priorities with the CRCSI. The New Zealand Government agreed and is now developing the strategy with help from the CRCSI.
- TECTERRA – of Canada “creates economic value for Canada through investment in geomatics technology solutions for various resource sectors and geospatial information management applications.” TECTERRA and the CRCSI collaborate through the exchange of ideas to stimulate industry innovation and have had a business to business exchange program developed through their respective conferences. This relationship is growing with particular emphasis on Business to Business relationships.
- Global Spatial Network (GSN) of which the CRCSI is a founding member. The GSN is a

global body made up of organisations with the same composition and objectives as the CRCSI. The CRCSI CEO is the Chair. This organisation has five founding members together with the CRCSI: South Korea (Korean Land Spatialization Group), Mexico (Centro-Geo), Sweden (Future Position X) and two affiliate partners; European Union (AGILE) and the US (UCGIS). CRCSI supported a successful Future Position X bid to establish a major funding stream in the health area in 2013-14, with a view to expanding the CRCSI Health Program’s reach and impact.

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 state at the end of the 2013-14 year. CRCSI ended the year with an operating deficit of \$2.4M against a budgeted deficit of \$5.7M. This is a favourable movement compared to budget, due to the lower spend in research by \$2.2M, higher interest income, and also under spend and savings within the Directorate, Business Development, Communication and Board expenditure areas. Total cash and inkind contributions were \$26.1M for the period, unfavourable to budget by \$1.4M, with favourable variances from cash and non staff in kind contributions totalling \$1.5M offset by unfavourable staff in kind of \$2.9M. CRCSI maintained a healthy cash position, with \$11.7M cash at bank at the end of the reporting period and has sufficient funding to meet its debts.

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 CRCSI financials can be found in the Commonwealth online Report and Company statutory accounts. In summary and as indicated in Table 11, CRCSI received total cash funding for 2013-14 of \$11.06M, \$0.7M above target including additional leveraged funding from Essential Participants (+\$1.1M) and additional Other Participant funds (+\$0.4M), offset against lower than budget Commissioned research funds (-\$0.8M). Payments in advance, delayed expenditure and the resultant high bank balances have also impacted on contribution levels, with bank interest of \$406k received for the period.

Essential Participant contributions were well ahead of budget by \$1.1M, at \$3.9M, with additional project funds received from Geoscience Australia (+\$951k), Landgate (+\$50k), Curtin University (+\$100k) and DEPI Vic (+\$100k), offset against deferred contribution receipts from Ergon Energy (-\$300k), and Queensland Department of Natural Resources and Mines (-\$94k). 43pl receipts were also under budget by \$24k, reflecting some partner withdrawals and a firmer ongoing membership number of closer to 45 than the 50 originally anticipated.

Negotiations with Ergon Energy are ongoing regarding their outstanding contributions and relationship with CRCSI, having sold ROAMES earlier in 2014. Contributions from the University of Canterbury have been deferred, with the \$150k contribution paid in 2013-14 relating to the prior year. Deferral relates to budget constraints as a result of the 2011 Christchurch earthquake, however the University has committed to paying the 2013-14 contribution by the end of 2014. The Queensland Department of Natural Resources and Mines payment deferral of cumulative \$958k is of concern, however partnership activity has increased during the period and several projects have been identified to reduce this gap further in 2015. The CRCSI

Executive will continue to negotiate to secure payment of the outstanding contributions with a view to having these issues resolved by the end of 2014-15.

The sources of CRCSI cash funding were evenly spread between Participant contributions, Commonwealth Program funds and contract research during 2013-14, a trend which replicates the prior year.

The full year expenditure of \$10.2M was under budget by \$2.9M. The variance was driven by the delays in research expenditure of \$2.2M, as well as savings in other cost centres including Directorate, Business Development and Communications.

75% of CRCSI expenditure went into the Research Program in 2013-14, a trend which is expected to be replicated in 2014-15. The remaining expenditure was attributed to Business Development (4%), Education and Communications (4%) and Administration (17%). When in-kind contributions are taken into account the cost of administration is 6.7% of the total investment of the CRCSI, which has dropped slightly from 8% the year before.

Participant FTE in-kind contributions trended lower than previous year (- FTE 6.4) at 39.7 FTE against a budget of 49.0 FTE. This negative variance has not however impacted the Centre's ability to deliver in its key project milestones. Non staff in-kind was higher than budget (\$5.2M versus \$4.4M) mainly due to higher than expected data contributions from partners for research projects, particularly in Program 4.

For the financial year ending 30 June 2014 CRCSI had a positive cash flow, and had sufficient funding to meet its debts. Of the \$11.7M cash at Bank at the end of the period, 86.5% are committed funds.

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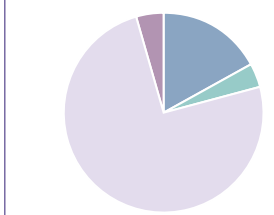
Financial Statement (\$'000s)				
Funding (Cash)	2012-13 Actual	2013-14 Actual	2013-14 Budget	2014-15 Budget
Essential Participants	2,472	3,938	2,841	3,444
Other Participants	807	730	335	505
CRC Program	4,452	3,925	3,925	3,767
Commissioned Research/Other	3,913	2,470	3,241	2,813
Total Funds	11,644	11,063	10,342	10,529

Expenditure (Accrual)	2012-13 Actual	2013-14 Actual	2013-14 Budget	2014-15 Budget
Governance & Administration	1,638	1,748	2,196	2,262
Business Development	360	397	658	899
Research Program	8,352	7,624	9,813	11,274
Communications & Education	370	452	511	687
Total Expenditure	10,720	10,221	13,178	15,122

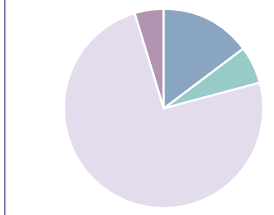
Inkind Statement	Staff FTE inkind			Non-staff inkind (\$'000s)		
	Actual 2012-13	Actual 2013-14	Budget 2013-14	Actual 2012-13	Actual 2013-14	Budget 2013-14
Research Program 1	14.7	12.5	7.2	1,402	1,321	1,147
Research Program 2	7.1	5.1	12.3	1,125	904	1,083
Research Program 3	3.2	3.9	2.8	858	549	473
Research Program 4	21.1	18.2	26.7	2,632	2,376	1,693
Total	46.1	39.7	49.0	6,017	5,150	4,396

Total Contributions	2012-13 Actual	2013-14 Actual	2013-14 Budget	2014-15 Budget
Cash	11,644	11,063	10,342	10,529
Staff Inkind	10,404	9,874	12,764	12,480
Non-Staff inkind	6,017	5,150	4,396	4,229
Total Contributions	28,065	26,087	27,502	27,238

Table 11: Financial Statement

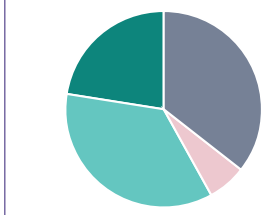


2013-14 Expenditure by Department



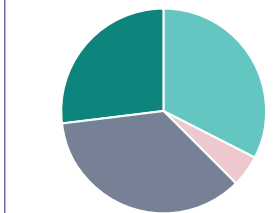
2014-15 Forecast Expenditure

2013-14 Funding by Source



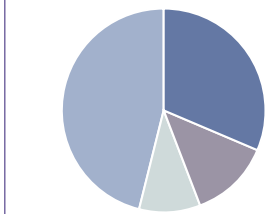
2013-14 Funding by Source

2014-15 Funding Forecast



2014-15 Funding Forecast

2013-14 Staff (FTE) Inkind



2013-14 Staff (FTE) Inkind

2013-14 Staff (FTE) Inkind

5. Other activities

The Urban Digital Elevation Model Project and the National Elevation Data Framework

Industry and government agencies at all levels are increasingly requiring high quality spatial data to understand and mitigate risks, and support effective responses for climate change adaptation, water and natural resource management, emergency management, and health and safety concerns. Digital elevation data and models that describe the land surface are a fundamental dataset to meet these demands.

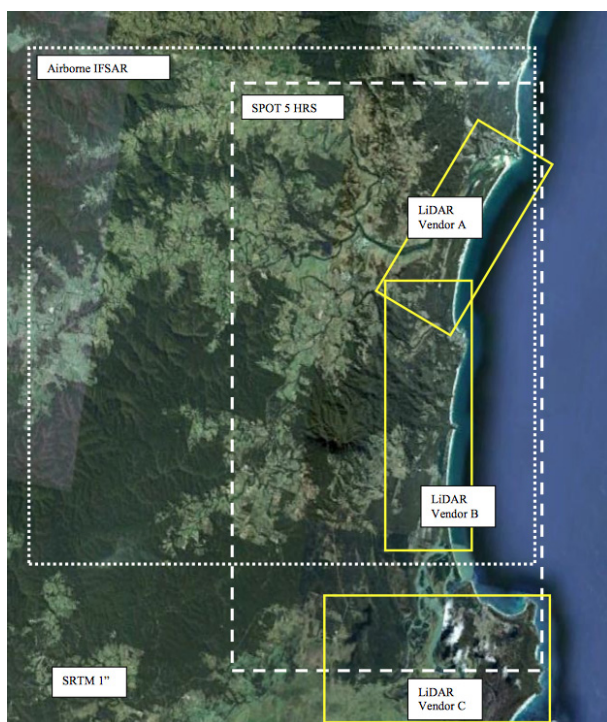


Figure 4. Illustration of need for DEM integration.

In 2007, the Council of Australian Governments (COAG) identified as a national priority the need for a fit-for-purpose coastal digital elevation model (DEM) to assess the potential impacts of rising sea levels. COAG also noted that a national DEM would have important benefits for catchment managers and natural resource managers, and that there were likely to be considerable cost savings through developing a national DEM.

There has also been growing recognition of the benefits of national frameworks for fundamental data types like DEMs

to: reduce duplication; increase data quality, consistency and access; deliver greater economic efficiencies from coordinated investment; enable opportunities from emerging applications to be realised; improve Australia's international competitiveness and support decision making by governments, industry and the community. The National Elevation Data Framework (NEDF) is one such framework. The NEDF was progressed through a partnership between the Australia and New Zealand Land Information Council (ANZLIC), the Commonwealth Department of Environment, Geoscience Australia (GA), and the CRCSI.

The Urban Digital Elevation Modelling in High Priority Regions (UDEM) project has implemented a model of improved management and governance of a fundamental, national elevation dataset. During 2013-14 outcomes included:

- Completed acquisition and licencing of coastal data from Queensland, NSW, Victoria and Tasmania, with almost the entire coast from Cooktown to Adelaide now being acquired as high resolution elevation data covering major urbanised coastal areas of Australia. This represents almost 200,000 square kilometres of data. The data is available for whole-of-government use through streamlined licensing arrangements and is discoverable and accessible via a national portal (nedf.ga.gov.au)
- A review of user requirements for bathymetric data collection and Bathymetry Acquisition Technologies and Strategies was completed. These addressed questions such as "How useful is the near shore DEM derived from bathymetric LiDAR to modellers and what are the alternatives for collection of near shore bathymetry to meet the defined needs?"
- A Vertical datum harmonisation tool has been completed and was made available in 2013-14.
- A sea level rise communication product was developed and made available in 2013-14.

The benefits of the NEDF and the UDEM will be long lasting, particularly in positioning Australia to understand and manage the risks of coastal inundation from climate change, in disaster mitigation, infrastructure and local planning and better management of insurance. The project also helped create an industry that is more robust and competitive; that delivers quality assured product to meet national standards.

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

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

Pacific Islands sea level rise related GIS training and capacity building

CRCSI and the Commonwealth Government have partnered as part of the Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP) Coastal Inundation Project. The project's goal is to develop the capacity within each Pacific Island to manage and use LiDAR data to support local sea-level rise planning and decision making in Tonga, Papua New Guinea, Vanuatu and Samoa. The sea level rise related GIS training and capacity building is being conducted by 43pl partner NGIS Australia. For populated coastal areas of low gradient elevation, such as Nuku'alofa in Tonga and the north coast of Papua New Guinea (PNG), sea level rise is a major concern. The NGIS component of the project sought to build on the LiDAR surveys by developing the capacity within each Pacific Island to manage and use the LiDAR and imagery data to support local sea level rise planning and decision. CRCSI has also provided services to the Commonwealth in relation to the management of airborne LiDAR surveys, capacity building and coastal modelling in the Pacific.



Vanuatu Globe

6 Glossary and Acronyms

43pl	43 Pty Ltd, a company representing the CRCSI's SME consortium
ANZLIC	ANZLIC - the Spatial Information Council formerly known as the Australia and New Zealand Land Information Council
ACS	Analysis Centre Software
ASC	Australian Spatial Consortium
AURIN	Australian Urban Research Infrastructure Network
AGO	Australian Geospatial Intelligence Organisation, Department of Defence
CEO	Chief Executive Officer
COAG	Council of Australian Governments
CRC	Cooperative Research Centre
CRC Program	Secretariat of the Commonwealth CRC Program
CRCSI	Cooperative Research Centre for Spatial Information, Australia and New Zealand
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
DEPI VIC	Department of Environment and Primary Industries Victoria
DoHA	Australian Government Department of Health & Aging
eFAS	Enhanced Flight Assist System
EO	Earth Observations
EPA	Environmental Protection Authority
FAS	Flight Assist System
FTE	Full Time Equivalent
GA	Geoscience Australia
GEOIDE	Geomatics for Informed Decisions (Canada)
GIS	Geographic Information Systems
GITA	Geospatial Information & Technology Association
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GSN	Global Spatial Network
IP	Intellectual Property
JAXA	Japanese Aerospace Exploration Agency
LIDAR	Laser Imaging Detection and Ranging
LINZ	Land Information New Zealand
LPI	Land & Property Information NSW
MDBA	Murray-Darling Basin Authority
MLA	Meat and Livestock Australia
MOU	Memorandum of Understanding
NCRIS	National Collaborative Research Infrastructure Strategy
NEDF	National Elevation Data Framework
NNG	National Nested Grid
NPI	National Positioning Infrastructure
PALSAR	Phased Array type L-band Synthetic Aperture Radar
PERS	Photogrammetric Engineering & Remote Sensing
PNG	Papua New Guinea
PNT	Position, Navigation and Timing
PPP-RTK	Precise Point Positioning - Real-Time Kinematic

PSM	Public Service Medal
QDNRM	Department of Natural Resources & Mines, QLD
RIC	CRCSI Research and Investment Committee
ROAMES	Remote Observation Automated Modelling Economic Simulation (Ergon)
SAR	Synthetic Aperture Radar
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
UCGIS	University Consortium for Geographic Information Science (USA)
UDEM	Urban Digital Elevation Modelling
UJV	Unincorporated Joint Venture
UK	United Kingdom
UNSW	University of New South Wales
WALIS	Western Australia Land Information System
QDNRM	Department of Natural Resources & Mines, QLD
REAC	Research & Education Advisory Committee of the CRCSI-1
ROAMES	Remote Observation Automated Modelling Economic Simulation (Ergon)
RTK	Real-Time Kinematic
SAR	Synthetic Aperture Radar
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
UAV	Unmanned Aerial Vehicle
UCGIS	University Consortium for Geographic Information Science (USA)
UDEM	Urban Digital Elevation Modelling
UJV	Unincorporated Joint Venture
UK	United Kingdom
UNSW	University of New South Wales
VANZ	Virtual Australia and New Zealand
VET	Vocational Education & Training
WALIS	Western Australia Land Information System

7 Appendix 1 - Publications

Program 1: Positioning

Book Chapters

Li, B., Teunissen, P. (2014). *Array-Aided CORS Network Ambiguity Resolution*. Peer reviewed proceedings from Earth on the Edge: Science for a Sustainable Planet, International Association of Geodesy Symposia. http://link.springer.com/chapter/10.1007/978-3-642-37222-3_79#page-1

Refereed Journal Articles

Hausler, G. (2013). Is PPP the next flavour of the month? Professional Surveyor Magazine – September 2013

Hausler, G. & Collier, P. (2013). National Positioning Infrastructure: identifying and evaluating high accuracy GNSS service coverage across Australia. Journal of Spatial Science – volume 58, issue 2.

Odolinski, R., Teunissen, P., Odijk, D. (2014). Combined GPS and BeiDou instantaneous RTK positioning. Journal of Navigation, volume 61, issue 2.

Odolinski, R., Teunissen, P., Odijk, D. (2014). First combined COMPASS/Beidou-2 and GPS positioning results in Australia. Part II: Single- and Multiple-frequency single-baseline RTK positioning. Journal of Spatial Science Volume 59, Issue 1.

Odijk, D., Arora, B., Teunissen, P. (2014). Predicting the success rate of long-baseline GPS+Galileo (partial) ambiguity resolution. The Journal of Navigation, DOI 10.1017/S037346331400006X.

Teunissen, P., Odolinski, R., Odijk, D. (2014). Instantaneous BeiDou+GPS RTK positioning with high cut-off elevation angles. Journal of Geodesy, DOI: 10.1007/s00190-013-0686-4.

Odolinski, R., Teunissen, P., Odijk, D. (2014). Combined GPS, BDS, Galileo and QZSS single-frequency RTK. GPS Solutions, <http://link.springer.com/article/10.1007/s10291-014-0376-6>

Nadarajah, N., Paffenholtz, J-A., Teunissen, P., Sleewaegen, J., Montenbruck, O. The mixed-receiver BeiDou inter-satellite-type bias and its impact on RTK positioning. GPS Solutions <http://link.springer.com/article/10.1007/s10291-014-0392-6>

Feng, Y., Gu, S., Shi, C., Rizos, C. (2014). A reference station-based GNSS computing mode to support unified precise point positioning and real-time kinematic services. Journal of Geodesy. <http://link.springer.com/article/10.1007/s00190-013-0659-7>

Choy, S., Harima, K., Rizos, C., Kogure, S. (2014). QZSS L-band Experimental (LEX) Signal: The Future of GNSS Satellite Navigation? The Journal of the Chartered Institution of Civil Engineering Surveyors, December - January issue, 31-33.

Li, B., Teunissen, P. (2014). *Antenna-array aiding of CORS ambiguity resolution*. Journal of Geodesy; Apr 2014, Vol. 88 Issue 4, p363

Odolinski, R., Teunissen, P., Odijk, D. *First combined COMPASS/Beidou-2 and GPS positioning results in Australia*. Part 1: Single-receiver code-only positioning. Journal of Spatial Science Volume 59, Issue 1, 2014

Odijk, D., Teunissen, P., Khodabandeh, A. *Galileo IOV RTK positioning: standalone and combined with GPS*. Survey Review, DOI .10.1179/1752270613Y.0000000084 (2013)

Odolinski, R., Teunissen, P., Odijk, D. *Combined GPS and BeiDou instantaneous RTK positioning*. Navigation: Journal of the Institute of Navigation 61 (2): 135-148.

Refereed Conference Proceedings

Hausler, G. & Collier, P. (2013). *National Positioning Infrastructure: Where are we now?* IGNSS Symposium 2013 Surfers Paradise QLD.

Hou, Y., Verhagen, S. *Model and data driven partial ambiguity resolution for multi-constellation GNSS*. Proceedings of CSNC 2014, Nanjing, May 2014.

Nadarajah, N., Teunissen, P., Giorgi, G. (2014). *GNSS Altitude Determination for Remote Sensing: On the Bounding of the Multivariate Ambiguity Objective Function*. Earth on the Edge - Science for a Sustainable Planet, International Association of Geodesy Symposia, Vol 139, Springer Berlin Heidelberg (2014)

Odolinski, R., Teunissen, P., Odijk, D. (2013) *Quality Analysis of a combined COMPASS/BeiDou-2 and GPS RTK positioning model*. Proceedings of IGNS Symposium 2013, Surfers Paradise QLD.

Odolinski, R., Teunissen, P., Odijk, D. (2014) *Combined GPS, BeiDou, Galileo and QZSS single-epoch, single-frequency RTK Performance Analysis*. International Association of Geodesy Symposia, 1-6 September Potsdam.

Odijk, D., Teunissen, P. (2013). *Estimation of differential inter-system biases between the overlapping frequencies of GPS, Galileo, BeiDou and QZSS*. 4th International Colloquium Scientific and Fundamental Aspects of the Galileo Programme, 4-6 December 2013, Prague, Czech Republic.

Odijk, D., Teunissen, P., Khodabandeh, A. (2014). *Single-frequency PPP-RTK: Theory and experimental results*. *Earth on the Edge - Science for a Sustainable Planet*, International Association of Geodesy Symposia, Vol 139, Springer Berlin Heidelberg.

Hou, Y., Verhagen, S. (2014). *Model and Data Driven Partial Ambiguity Resolution for Multi-constellation GNSS*. Nanjing, China Satellite Navigation Conference (CSNC) 2014 Proceedings: Volume II. Lecture Notes in Electrical Engineering Volume 304, 2014, pp 285-302.

Wang, L., Verhagen, S., Feng, Y. (2014). *Ambiguity acceptance testing: a comparison of the ratio test and difference test*. Nanjing, China Satellite Navigation Conference (CSNC) Proceedings: Volume II, Lecture Notes in Electrical Engineering Volume 304, 2014, pp 313-330.

Donnelly, N., Crook, C., Haasdyk, J., Harrison, C., Rizos, C., Roberts, C. & Stanaway, R. (2014). *Dynamic Datum Transformations in Australia and New Zealand*. In: S. Winter and C. Rizos (Eds): Research@Locate Canberra.

Haasdyk, J., Donnelly, N., Harrison, C., Rizos, C., Roberts, C. & Stanaway, R. (2014). *Options for Modernising the Geocentric Datum of Australia*. Research @ Locate 14, Canberra.

Donnelly, N., Dawson, J., Evans, G., Fraser, R., Haasdyk, J., Higgins, M., Morgan, L., Rizos, C., Sarib, R., Strong, S. & Stanaway, R. (2014) *Progress Towards a New Geodetic Datum for Australia*. Proceedings of XXV FIG Congress 16-21 June 2014, Kuala Lumpur, Malaysia

Wang, L., Verhagen, S., Feng, Y. *Ambiguity acceptance testing: a comparison of the ratio test and difference test*. Proceedings of CSNC 2014, Nanjing, May 2014.

Wang, Y. (2013). *Precise GNSS Product-Aided Flight Inspection System*. ION GNSS+ 2013 proceedings.

Harima, K., Choy, S., Li, L., Grinter, T., Choudhury, M., Rizos, C., Wakabayashi, Y., Satoshi, K. (2014). *Performance of Real-Time Precise Point Positioning Using MADOCA-LEX Augmentation Messages*. XXV FIG Int. Congress, Kuala Lumpur, Malaysia, 16-21 June 2014.

Technical Reports

Odijk, D., Teunissen, P., Khodabandeh, A. (2013). *Galileo IOV-RTK positioning: standalone and combined with GPS*. Survey Review, DOI 10.1179/1752270613Y.0000000084.

Program 2: Feature Extraction

Refereed Journal Articles

Thulin, S., Hill, M.J., Held, A., Jones, S., and Woodgate, P. (2014). *Predicting levels of crude protein, digestibility, lignin and cellulose in temperate pastures of Southern Australia using hyperspectral image data*. American Journal of Plant Sciences Vol.5 No.7(2014), Article ID:44171, 23 pages.

Chan, T., Lichti, D., Belton, B. (2013). *Temporal Analysis and Automatic Calibration of the Velodyne HFL-32e LiDAR System*. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. II-5/W2, pp 61-66.

Ghanbari Parmehr, E., Fraser, C.S., Zhang, C., Leach, J. (2014). *Automatic registration of optical imagery with 3D LiDAR data using statistical similarity*. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. <http://www.sciencedirect.com/science/article/pii/S0924271613002773>

Awrangzeb, M., Fraser, C.S. (2014). *An automatic and threshold-free performance evaluation system for building extraction techniques from airborne LIDAR data*. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6815675&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxppls%2Fabs_all.jsp%3Farnumber%3D6815675

Awrangzeb, M. (2014). *Automatic Segmentation of Raw LIDAR Data for Extraction of Building Roofs*. Journal of Remote Sensing http://www.itc.nl/external/ISPRS_WGIII4/ISPRSIII_4_Test_results/papers/MON_remotesensing-06-03716c.pdf

Fraser, C. (2014) *Automatic Camera Calibration in Close-Range Photogrammetry*. Photogrammetric Engineering & Remote Sensing, 79(4): 381-388, 2013 <http://essential.metapress.com/content/gk482673p7n48526/>

Refereed Conference Proceedings

Palmer, R., Tan, T., West, G. (2013) *Using depth to extend randomised Hough Forests for object detection and location*. DICTA 2013, Hobart, Tasmania.

Nurunnabi, A., West, G., Belton D. (2013). *Robust locally weighted regression for ground surface extraction in mobile laser scanning 3D data*. ISPRS Laser Scanning 2013 - Antalya, Turkey

Nurunnabi, A., Belton, D., West, G. (2013). *Robust Outlier Detection and Saliency Features Estimation in Point Cloud Data*. Canadian Computer and Robot Vision, Regina, Canada.

Hollick, J., Belton, D., Moncrieff, S., Woods, A., Hutchison, A., Helmholz, P. (2013). *Creation of 3D models from large unstructured image and video datasets*. IntArchPhRS, No. B6, ISPRS Workshop: High resolution earth imaging for geospatial information.

Iwaszczuk, D., Helmholz, P., Belton, D., Stilla, U. (2013). *Model-to-image registration and automatic texture mapping using a video sequence taken by a mini UAV*. IntArchPhRS, No. B6, ISPRS Workshop: High resolution earth imaging for geospatial information.

Nurunnabi, A., Belton, D., West, G. (2013). *Diagnostics based principal component analysis for robust plane fitting in laser data*. 16th International Conference on Computer and Information Technology (ICCIT 2013, Khulna, Bangladesh)

Borck, M., Palmer, R., Tan, T., West, G. (2014). *Using depth maps to find interesting regions*. IEEE Region 10 Technical Symposium: TENSYP 2014.

Borck, M., R., Tan, T., West, G. (2014) *An image engineering approach to analysing mobile mapping data*. Locate 14, Canberra 7-9 April 2014.

Yu, C., Helmholz, P., Belton, D. & West, G. (2014). *Grammar based Automatic 3D model reconstruction from TLS data*. ISPRS Commission IV symposium, China 2014.

E. Ghanbari Parmehr, C.S. Fraser, C Zhang, J. Leach. (2013). *Automatic co-registration of satellite imagery and LiDAR data using local mutual information*. IGARSS 2013

Zhang, C., Fraser, C.S. (2013) *Modelling and correction of interior orientation error for precise georeferencing of satellite imagery*. IGARSS 2013

Zhang, C., Fraser, C.S. (2013) *Estimating planimetric accuracy of airborne LiDAR using high-resolution digital aerial imagery*. IGARSS 2013

Ghanbari Parmehr, E., Fraser, C.S., Zhang, C., Leach, J. (2013) *An effective histogram binning for mutual information based registration of optical imagery and 3D LiDAR data*. IEEE International Conference on Image Processing (ICIP) Sept 15-18 2013 Melbourne.

Ghanbari Parmehr, E., Fraser, C.S., Zhang, C., Leach, J. (2013) *Automatic registration of optical imagery with 3D LiDAR data using local combined mutual information*. ISPRS Laser Scanning 2013 - Antalya, Turkey.

He, Y., Zhang, C., Fraser C.S. (2013) *A line-based spectral clustering method for efficient planar structure extraction from LiDAR data*. ISPRS Laser Scanning 2013 - Antalya, Turkey.

Azadbakht, M., Fraser, C.S., Zhang, C., Leach, J. (2013) *Sparsity based regularization approaches in reconstructing the range and cross section in full-waveform LiDAR*. ISPRS Laser Scanning 2013 - Antalya, Turkey.

Azadbakht, M., Fraser, C.S., Zhang, C., Leach, J. (2013) *A signal denoising method for full-waveform LiDAR data*. ISPRS Laser Scanning 2013 - Antalya, Turkey.

Siddiqui, f., Teng, S., Awrangjeb, M., Lu, G. (2013) *An improved building detection in complex sites using the LiDAR height variation and point density*. Int. Conference on Image and Vision Computing, New Zealand.

Awrangjeb, M., Lu, G. (2013) *Building roof plane extraction from LiDAR data*. DICTA 2013, Hobart, Tasmania.

Awrangjeb, M., Lu, G. (2013) *A performance review of recent corner detectors*. DICTA 2013, Hobart, Tasmania.

Awrangjeb, M., Fraser, C. (2013) *Rule-based segmentation of LiDAR point cloud for automatic extraction of building roof planes*. ISPRS Laser Scanning 2013 - Antalya, Turkey.

Will Woodgate. (2013). *An Intercomparison of Passive Terrestrial Remote Sensing Technologies to Derive LAI and Canopy Cover Metrics*. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXII ISPRS Congress.

Soto-Berelov, M., Jones, S., Mellor, A., Culvenor, A., Haywood, A., Suarez, L., Wilkes, P. (2013) *A collaborative framework for vegetated systems research: A prospective from Victoria*. IGARSS 2013 Melbourne.

Rasaiah, B., Bellman, C., Chisholm, L., Gamon, J., Hueni, A., Huete, A., Jones, S., Malthus, T., Ong, C., Phinn, S., Roelfsema, C., Suarez, L., Townsend, P., Trevithick, R., Wyatt, M. (2013) *Approaches to establishing a metadata standard for field spectroscopy datasets*. IGARSS 2013 Melbourne.

Suarez, L., Jones, S., Haywood, A., Wilkes, P., Woodgate, W., Soto-Berelov, M., Meller, A. *Woody vegetation landscape feature generation from hyperspectral and LiDAR data (a CRCSI 2.07 Woody Attribution Paper)*. IGARSS 2013 Melbourne.

Woodgate, W., Armston, J., Disney, M., Jones, S., Suarez, L., Hill, M., Wilkes, P., Soto-Berelov, M. (2013) *The impact of sensor characteristics for obtaining accurate ground-based measurements of LAI*. IGARSS 2013 Melbourne.

Wilkes, P., Jones, S., Suarez, L., Haywood, A., Mellor, A., Soto-Berelov, M., Woodgate, W. (2013) *MAUP and LiDAR derived canopy structure (s CRCSE 2.07 Woody Attribution paper)*. IGARSS 2013 Melbourne.

Stamatopoulos, C. & Fraser, C. (2014) *Automated Target-Free Network orientation and Camera Calibration*. ASPRS 2014 - Louisville USA.

Fraser, C. & Stamatopoulos, C. (2014) *Automated Target-Free Camera Calibration*. Digital Rural Futures Conf. USQ, QLD.

Program 3: Spatial Data infrastructures

Refereed Conference Proceedings

Goodhue, P., Reitsma, F., Trotter, M. (2014) *Crowd sourcing biomass estimation in pastures*. Digital Rural Futures Conf. USQ, QLD

Program 4.1: Agriculture, Natural Resources

Refereed Journal Articles

Stanley, J.N., Lamb, D.W., Irvine, S.E. And Schneider, D.A. (2014) *The effect of aluminium neutron probe access tubes on the apparent electrical conductivity recorded by an electromagnetic soil survey sensor*. IEEE Geoscience and Remote Sensing Letters. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6525344&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxppls%2Fabs_all.jsp%3Farnumber%3D6525344

Verma, N.K., Lamb, D.W., Reid, N. And Wilson, B. (2014) *A comparative study of land cover classification techniques for 'farmscapes' using very high-resolution remotely sensed data*. Photogrammetric Engineering and Remote Sensing. 80 (5): 461-470. (DOI 10.14358/PERS.80.5.461)

Stanley, J., Lamb, D., Falzon, G., Scheider, D. (2014) *Apparent electrical conductivity (Eca) as a surrogate for neutron probe counts to measure soil moisture content in heavy clay soils (Vertosols)*. Soil Research. 52: 373-378 <http://www.publish.csiro.au/?paper=SR13142>

Stanley, J., Lamb, D., Irvine, S. & Schneider, D. (2014) *Combination active optical and passive thermal infrared sensor for low-level airborne crop sensing*. Precision Agriculture. <http://link.springer.com/article/10.1007/s11119-014-9350-0>

Verma, N., Lamb, D., Reid, N., Wilson, B. (2014) *An allometric model for estimating DBH of isolated and clustered Eucalyptus trees from measurements of crown projection area*. Forest Ecology and Management. 326:125-132 (DOI 10.1016/j.foreco.2014.04.003)

Tanase, M., Panciera, R., Lowell, K., Aponte, C., Hacker, J., Walker, J. (2013) *Forest Biomass Estimation at High Spatial Resolution: Radar vs Lidar sensors*. IEEE Geoscience and Remote Sensing Letters.

Tanase, M., Santoro, M., Aponte, C., De la Riva, J. (2013) *Polarimetric properties of burned forest areas at C- and L- band*. IEEE JSTARS

Tanase, M., Panciera, R., Lowell, K., Tian, S. Garcia-Martin, A., Walker, J.P. (2013) *Sensitivity of L-band Radar Backscatter to Forest Biomass in Semi-arid Environments: A comparative analysis of parametric and non-parametric models*. IEEE Geoscience and Remote Sensing Letters.

Panciera, R., Tanase, M., Lowell, K., Walker, J. (2013) *Evaluation of IEM, Dubois and Oh Radar Backscatter Models using Airborne L-band SAR*. IEEE Geoscience and Remote Sensing Letters.

Refereed Conference Proceedings

Mundava, C., Schut, A.G.T., Stovold, R., Donald, G., Lamb, D.W., Helmholz, P. (2013) *Grounding truthing protocols for biomass estimation in rangelands environments*. IGARSS 2013 Melbourne.

Verma, N.K., Lamb, D.W., Reid, N. And Wilson, B. (2013) *Tree cover extraction from 50 cm worldview imagery: A comparison of image processing techniques*. IGARSS 2013 Melbourne.

Schaefer, M., Lamb, D., Bradbury, R. (2014) *A comparison of two ranging approaches in an active, optical plant canopy sensor*. IEEE Sensors Applications Symposium.

Program 4.3: Energy Utilities

Refereed Conference Proceedings

Bruggeman, T., Ford J. (2013) *Automated Aerial Inspection Guidance with improved Turn Planning*. Australian Control Conference, Perth.

Techakesari, O., Bruggeman, T., Ford, J (2013) *Control of Infrastructure Inspection Aircraft Vertical Dynamics in the Presence of Thermal Disturbances*. Australian Control Conference, Perth.

Program 4.4: Health

Refereed Journal Articles

Jardine, A., Mullan, N., Gudes, O., Moncrieff, S., West, G., Cosford, J., Xiao, J., Yun, G., Somerford, P. (2014) *Web-based geovisualisation of spatial information to support evidence based health policy*. Health Information Management Journal. <http://www.ncbi.nlm.nih.gov/pubmed/24948661>

Goldberg, D., Ballard, M., Boyd, J., Mullan, N., Garfield, C., Rosman, D., Ferrante, A.M., Semmens, J. (2013) *An evaluation framework for comparing geocoding systems*. International Journal of Health Geographics.

Kang, SY., McGree, J., Mengersen, K. (2013) *The impact of spatial scales and spatial smoothing on the outcome of Bayesian spatial model*. PLOS One DOI: 10.1371/journal.pone.0075957

Hsieh, J., Cramb, S., McGree, J., Baade, P., Dunn, N., Mengersen, K. (2014) *Bayesian spatial analysis for the evaluation of breast cancer detection methods*. Australian and New Zealand Journal of Statistics.

Kang, S., McGree, J., Baade, P. & Mengersen, K. (2014) *An investigation of the impact of various geographical scales for the specification of spatial dependence*. Journal of Applied Statistics, DOI:10.1080/02664763.2014.920779

Kang, S., McGree, J. & Mengersen, K. (2014) *The choice of spatial scales and spatial smoothness priors for various spatial patterns*. Spatial and Temporal Epidemiology Vol 10 July 2014 (pp11-26, DOI: 10.1016/j.sste.2014.05.003)

Refereed Conference Proceedings

Moncrieff, S., West, G. (2013) *Dynamic Linkage and Visualisation of Multivariate Spatiotemporal Information*. Proceedings ACM SIG Spatial Workshop on Health GIS, Orlando USA.

Program 4.5: Urban Planning

Book Chapter

Newman P. (2014) *Rediscovering compact cities for sustainability*. Elgar Companion to Sustainable Cities: Strategies, Methods and Outlook.

Refereed Journal Articles

Glackin, S., Trubka, R. (2014) *Creating a Spatial Decision Support System for Sustainable Housing Regeneration in Australian Greyfields*. Journal of Sustainable Cities and Society.

Newton, P., Glackin, S. (2014) *Understanding Infill: Towards new policy and practice for urban regeneration in the established suburbs of Australian Cities*. Urban Policy and Research, Volume 32, Issue 2.

Newton, P., Glackin, S. (2013) *Using Geo-spatial Techniques as Stakeholder Engagement Tools in Urban Planning and Development*. Built Environment 39(4) 473-501

Glackin, S. (2013) *Redeveloping the Greyfields with ENVISION: Using Participatory Support Systems to Reduce Urban Sprawl in Australia*. European Journal of Geography 3(1) 6-22

Newton, P., Newman, P., Glackin, S., Trubka, R. (2013) *Greening the Greyfields: Unlocking the Redevelopment Potential of the Middle Suburbs in Australian Cities*. World Academy of Science Engineering and Technology no. 71. 658-67

Refereed Conference Proceedings

Glackin, S., Trubka, R., Newton, P., Newman, P., Mouritz, M. (2013) *Greening the Greyfields: Trials, tools and tribulations of redevelopment in the middle suburbs*. Planning Institute of Australia Annual Conference, 24-27 March, Canberra.

Lee, G, Dunser, A., Nassani, A., Billinghamurst, M. (2013) *AntarticAR: An Outdoor AR Experience of a Virtual Tour to Antarctica*. Proc. Of iSMAR2013-AMHMH, Adelaide, Oct 2013 pp29-38

Lee, G., Billingham, M. (2013) *A Component based Framework for Mobile Outdoor AR Applications*. Proc. Of VRACAI 2013, Hong Kong, China, Nov 2013, pp 207-210

Lindeman, R., Lee, G., Beattie, L., Gamper, H., Krishnan, P.R., Akhilesh, A. (2013) *GeoBoids: A Mobile AR Application for Exergaming*. In 11th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2012) - Arts, Media and Humanities Proceedings, PP93-94, Atlanta, Georgia, USA

Lee, G., Billingham, M. *CityView AR outdoor AR visualisation*. (2013) Proceedings of the 13th International Conference of the NZ Chapter of the ACM's Special Interest Group on Human-Computer Interaction (CHINZ 2012). ACM, New York, USA PP 97-97

Lee, G., Duenser, A., Kim, S., Billingham, M. (2013) *CityView AR Mobile Outdoor AR Applications for City Visualisation*. In 11th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2012) - Arts, Media and Humanities Proceedings, PP57-64, Atlanta, Georgia, USA

Technical Reports

McIntosh, J., Newman, P., Glackin, S. *Value Capture: Integrating Land Based Public Transport Funding Mechanisms*.

Hendrikan, *Redevelopment Around Rail: Calculating the trade-off between TODs and greenfields development - A case study of Perth*.

UDEM

Refereed Journal Articles

Keyers, J. (2014) *Vertical datum transformation across Australia's coasts*. Position magazine (Dec/Jan 2014 - No. 68, pp 22-24)

Quadros, N. (2013) *Unlocking the characteristics of bathymetric LiDAR sensors*. LiDAR News Volume 3/ issue 6

GENERAL

Refereed Journal Articles

Ehlers, M., Woodgate, P., Annoni, A., Schade S. *Advancing digital earth: Beyond the next generation*. International Journal of Digital Earth, Vol. 7, No. 1.

Refereed Conference Proceedings

Ehlers, M., Woodgate, P., Annoni, A., Schade S. *Digital Earth reloaded – Beyond the next generation*. IOP Conference Series Earth and Environmental Science 02/2014; 18(1):012005

Barrett, P., Berrill A., Gale G., Jones K., Léger N., Lonergan, D., Warner J., Woodgate P., Ziobrowski M. *Location data privacy: Guidelines, assessment and recommendations*. The Location Forum.

8. Appendix 2 – Phd List

Name	Research Program	Project Title	Research Organisation	Country	Start Date	Completion Date
PhD Completions						
Anna Donets	1	Using Single Receiver GPS Observations to Analyze the Dynamic Motion of Large Engineering Structures.	Melbourne	Australia	February 2007	2011-12
Jun Wang	1	RTK Integrity.	QUT	Australia	August 2008	2011-12
Michael Filmer	1	An Examination of the Australian Height Datum.	Curtin	Australia	April 2009	2011-12
Kui Zhang	2	Advanced InSAR Technologies.	UNSW	Australia	2008	2010-11
Eric Zhengrong Li	2	Aerial Image Analysis Using Spiking Neural Networks with Application to Power Line Corridor Monitoring.	QUT	Australia	2010	2011-12
Alex Ng	2	PsinSAR Radar Interferometry.	UNSW	Australia	March 2006	2010-11
Matthew Hutchison	3	Developing an Agent-Based Framework for Intelligent Geocoding.	Curtin	Australia	May 2004	2010-11
Marco Marinelli	3	Assessing Error Effects in Critical Application Areas.	Curtin	Australia	April 2005	2011-12
Jiang Li	4	Intelligent Object Placement and Scaling in Virtual Decision Environments.	Melbourne	Australia	January 2008	2010-11
Marcos Nino-Ruiz	4	Application of Rural Landscape visualisation for Decision Making and Policy Development.	Melbourne	Australia	September 2008	2012-13
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
Pan Peter Wang	4	Real-Time Data Visualisation in Collaborative Virtual Environments for Emergency Management.	Melbourne	Australia	February 2008	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
Michael Schaefer	4	Advanced Biomass Sensing Using Active Optical Sensors	UNE	Australia	March 2011	2012-13
Xin Lui	2	Determination of the High Water Mark and its Location along a Coastline	Curtin	Australia	March 2012	2013-14
Eldar Rubinov	1	Stochastic Modelling for Real-Time GNSS Positioning.	Melbourne	Australia	January 2010	2013-14
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	Anticipated Completion Date
Current PhD Students						
Grant Hausler	1	National Positioning Infrastructure: Technical, Organisational and Economic Requirements	UNSW	Australia	January 2011	Submitted March 2014
Jonathan Kok	4	Robust and Efficient Hardware-based Evolutionary Technique for Multi-objective Optimisation in Aerospace	QUT	Australia	June 2010	Submitted August 2014
Xiaoying Wu	3	Schema Evolution in a Federated Database Environment	Curtin	Australia	July 2012	Submitted November 2013
Mark Broomhall	4	A Method For the Remote Sensing of Aerosols Based on MODIS Time Series Data Within an Operational System for Near-Real Time Atmospheric Correction	Curtin	Australia	October 2004	March 2015
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 2016
Premalatha Varadharajulu	3	Spatial Data Supply Chain Modelling in Australia and New Zealand	Curtin	Australia	January 2014	September 2016
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	July 2014
Nic Donnelly	1	Integration of Interferometric Synthetic Aperture Radar into a National Geodetic Datum	UNSW	Australia	February 2013	July 2015
Mohsen Azadbakht	2	Processing LiDAR Waveforms to Extract Features Accurately	Melbourne	Australia	January 2012	June 2015
Jannah Baker	4	Spatial Interactions Between Chronic Diseases, Risk Factor Exploration and Effects of Health Screening	QUT	Australia	January 2012	December 2015
Michael Borck	2	Feature Extraction from Multi-modal Mobile Mapping Data	Curtin	Australia	February 2011	July 2014
Ben Fitzpatrick	4	Experimental Designs and Bayesian Spatiotemporal Models for Carbon in Farmscapes	QUT	Australia	October 2011	May 2015
Yuxiang He	2	Automated Building Reconstruction from Aerial and LiDAR Data	Melbourne	Australia	June 2011	November 2014
Daniel Hogg	4	Modelling Spatial Variations in Natural Disaster Impact	Canterbury	New Zealand	February 2013	January 2016
Su Yun Kang	4	Comparison of Spatial Modelling Using Point-process Data and Aerial Data	QUT	Australia	February 2011	Submitted April 2014
James McIntosh	4	Funding Sustainable Transport Through an Integrated Land Use and Transport Planning Framework Utilising Value Capture	Curtin	Australia	July 2011	Submitted July 2014

Name	Research Program	Project Title	Research Organisation	Country	Start Date	Anticipated Completion Date
Charity Mundava	4	Biomass Assessment Tools to Assist Grazing Management in the Kimberley Region of Western Australia	Curtin	Australia	October 2011	October 2014
Abdul Nurunnabi	2	Mobile Mapping of Transport Corridors and the Extraction of Assets from Video and Range Data	Curtin	Australia	March 2011	Submitted October 2014
Robert Odolinski	1	GPS and Galileo Integer Ambiguity Resolution Enabled PPP (PPP - RTK)	Curtin	Australia	February 2011	Submitted October 2014
Richard Palmer	2	Automated Generalised Methods for the Extraction and Analysis of High Level Information From Mobile Mapping Data	Curtin	Australia	March 2011	August 2014
Ebadat Ghanbari Parmehr	2	Automated Registration of Multi-source, Multi-sensor Data	Melbourne	Australia	July 2011	December 2014
Tristan Reed	3	Semantic Search and Discovery of Web-Based Services	Curtin	Australia	February 2014	December 2017
Jessica Roberts	4	Spatially Enabled Livestock Management: Improving Biomass Utilisation in Rotational Systems	UNE	Australia	March 2010	Submitted September 2014
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	June 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	May 2015
Niva Kiran Verma	4	Above-ground Biomass and Carbon Determination in Farmscapes Using High Resolution Remote Sensing	UNE	Australia	September 2011	September 2014
Lei Wang	1	Generalised Ambiguity Resolution Approaches to Processing Multiple GNSS Signals	QUT	Australia	April 2012	April 2015
Yongchao Wang	1	QZSS/BDS Precise Orbit Determination Using Triple Frequency Code and Phase Measurements	QUT	Australia	July 2012	August 2015
Phil Wilkes	2	Scale Variance as Applied to Woody Attribution of Eucalypt Forests	RMIT	Australia/The Netherlands	February 2012	August 2015
William Woodgate	2	Derivation of Leaf Area Index and Associated Metrics from Remotely Sensed and In Situ Data Sources	RMIT	Australia	July 2011	March 2015
Peiyuan Zhou	1	Ionospheric Delay Variance Modelling	UNSW	Australia	February 2013	February 2016
Azeem Sadiq	3	Investigating governance along supply chains and concentrating on provenance	Curtin	Australia	May 2014	May 2017

Name	Research Program	Project Title	Research Organisation	Country	Start Date	Anticipated Completion Date
Masters Students						
Paul Goodhue	4	Crowd sourcing validation for the Biomass Business 2 Project	Canterbury	New Zealand	February 2014	January 2015
James Head-Meares	4	Human Interface Technology: Accurate Wide Area Tracking	Canterbury	New Zealand	April 2013	Completed June 2014
Joel Haasdyk	1	Coordinate Dynamics and Deformation in Large Scale Geodetic Adjustments	UNSW	Australia	February 2013	Deferred
Josh Neville	4	Meeting Housing Demand in Christchurch within the Existing Urban Footprint	Canterbury	New Zealand	January 2014	January 2015
Student Withdrawals						
Name	Research Program	Research Organisation		Commencement Date		
Reza Kalbasi Khoramdashti	3	Canterbury		2013-14		
Christopher Axelsson	2	RMIT		2011-12		
Maria Angelica Lopez Aldana	4	QUT		2011-12		
Kanishka Luthra	3	Canterbury		2013-14		

