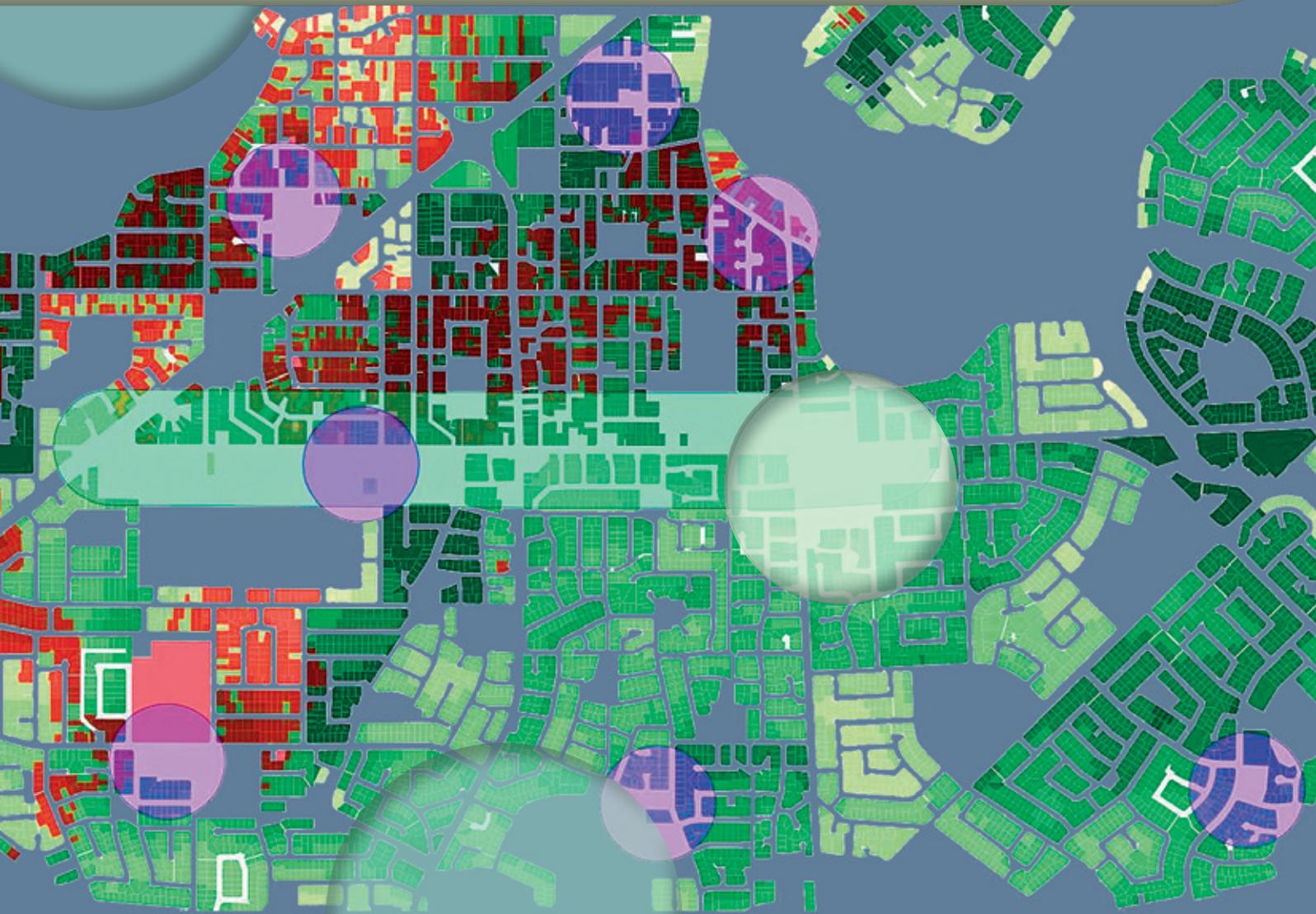


ANNUAL REPORT 2012-13



■ 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

Ergon Energy Corporation Limited

Geoscience Australia

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

Landgate, WA

Queensland University of Technology

The University of New England

University of Canterbury



An Australian Government Initiative



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■ 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. Our purpose 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 remote sensing technologies. The CRCSI brings powerful collaboration on all critical research and education issues that involve a spatial aspect. In doing so, the CRCSI seeks to accelerate the take-up of spatial science by key end users, spawning major innovation and productivity advances in the 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 2012-13 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 2012-13:

- A world-first in integrating GPS and Chinese BeiDou satellite signals to demonstrate the benefits in Australia of precise, real-time positioning in obstructed environments. The research proved that the hybrid solution integrating the high elevation BeiDou satellites allows instantaneous precise positioning to be achieved in challenging areas such as open-pit mines, urban canyons and high multipath environments where a single constellation solution (e.g. GPS only) would normally fail.
- A further world-first in demonstrating the use of the Japanese QZSS LEX signal in delivering real-time, centimetre accurate precise point positioning (PPP) in Australia. This research involves a collaboration between the CRCSI research team and colleagues at the Japanese Aerospace Exploration Agency (JAXA) and will ultimately lead to an “Australian-made” LEX message for testing. The use of a satellite based delivery system points towards a strategy for providing a truly national positioning infrastructure, not limited by the vagaries of mobile phone coverage.
- CRCSI researchers first began working on 3D-imaging in 2010. The research involves the integration of co-registered imagery and range (LiDAR) data to facilitate new automated feature extraction techniques to deliver enhanced operational performance and efficiency. This year, CRCSI implemented the theory of Mutual Information drawn from health imaging, and new algorithms for automated building extraction and roof modelling have been developed and shown to perform to high levels of accuracy.
- Previously CRCSI researchers reported efficiency gains through improved cornering control of aircraft during power line inspection operations. This year, the same team has delivered a further productivity improvement of up to 20% reduction in flight times through the implementation of intelligent 3D dynamic flight path planning routines. Not only has this ground breaking research delivered multi million dollar operational savings for the project partners, it has importantly secured higher levels of operational safety for the pilots involved.
- Research in conjunction with Cancer Council Queensland has demonstrated that where a person lives has a measurable impact on whether they will survive a diagnosed cancer. In fact approximately 8% of breast and colorectal cancer deaths within five years of diagnosis in Queensland can be attributed to spatial variation, otherwise known as “spatial inequalities”. The research considered the influence of factors such as proximity to treatment services and cancer stage at diagnosis, and found that greater access to breast screening and diagnostic facilities in remote areas can decrease spatial inequalities in cancer survival. This is the first time that such information has been produced in an Australian context. The research findings will equip health agencies to identify and address spatial inequality.
- Researchers have assessed a combination of optical and thermal sensors on low flying aircraft to map canopy temperature in cotton and thereby infer available soil water for plants. When these data are used in combination with biomass data, also acquired aerially, they show the potential to generate on-the-fly variable rate fertiliser predictions. The combination of airborne sensors and the associated analysis tools potentially offer the ability to more precisely manage broad acre crops for yield improvement.
- Continued urban sprawl threatens the long term sustainability of Australian cities and feeds highly undesirable economic, environmental

and social outcomes. A preferred alternative is well managed, and strategic re-development of the ageing middle suburbs. CRCSI researchers have developed a spatial decision support system (known as ENVISION) to optimise the identification and selection of suburban precincts ripe for re-development. The new software tools, to be made available initially through the AURIN portal, promise to deliver optimal community outcomes as population pressures and environmental and societal imperatives demand housing solutions

that cannot be served by perpetual urban expansion.

- This year, the CRCSI's research has produced one book, 15 book chapters, 26 refereed journal articles and 50 papers in refereed conference proceedings. In addition, two of our postgraduate students completed their studies.

Awards

CRCSI researchers received a number of awards during the year, including:

Name	Organisation	Award
Dr Joanne Poon	Sinclair Knight Merz, CRCSI Alumni	Sept 2012 - Young Spatial Professional of the Year – Victorian Spatial Excellence Awards April 2013 - Young Professional of the Year Award - Asia-Pacific Spatial Excellence Awards
Professor Clive Fraser	CRCSI	American Society for Photogrammetry and Remote Sensing Foundation Outstanding Technical Achievement Award for his development and production of the digital camera calibration system "Australis"
Professor Mark Billingham	University of Canterbury	10 Year Lasting Impact Award at the 11th IEEE International Symposium on Mixed and Augmented Reality, Atlanta GA USA for 'Marker tracking and HMD Calibration for a Video-Based Augmented Reality Conferencing System'.
Professor Peter Teunissen	Curtin University	Honorary Professorship for esteemed contributions to geodetic science by Institute of Geodesy and Geophysics of Chinese Academy of Sciences
Dr Marco Nino-Ruiz	AURIN, CRCSI Alumni	SSSI Postgraduate Student Award – Victorian Spatial Excellence Awards
Dr Nathan Quadros	CRCSI	Cooperative Research Centres Association Awards Finalist - 'Early Career Researcher'
Professor Ian Bishop	University of Melbourne, CRCSI Alumni	IGI Global winner in the Fifth Annual Excellence in Research Journal Awards for a publication based on previous CRCSI work "'On-Line Approaches to Data Delivery and Visualisation in Landscape Planning and Management", International Journal of E-Planning Research
Emeritus Professor John Trinder	University of New South Wales	Em Prof John Trinder was made an Honorary Fellow of the University of NSW in recognition of his conspicuous and continued involvement in support of the interests and welfare of the UNSW, and of the photogrammetric and remote sensing community, in Australia and abroad.
Dr Jun Wang	Queensland University of Technology, CRCSI Alumni	Siganto Foundation Medal award - The Siganto Foundation Medal is awarded to a distinguished PhD graduate from the QUT Science and Engineering Faculty for knowledge dissemination, global recognition and career progression in the field of Engineering."

Table 1: Awards received by CRCSI Researchers in 2012-13

Commercialisation / Utilisation

The CRCSI met 7 of its 12 utilisation milestones for 2012-13 and an additional four milestones were achieved ahead of schedule. Delays in the deployment of both the Geovisualisation HealthTracks software and Envision planning software in Government state departments were the primary reason for the outstanding four milestones. There were a number of notable achievements in utilisation including further use of the Flight Assist System by Ergon Energy across Queensland; continued use of the Barista feature extraction software in Geoscience Australia and other state land departments; increased rollout 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. Further pleasing results were the finalisation of the development of Australia's National Positioning Infrastructure Plan and Australia's Satellite Utilisation policy, within which CRCSI staff played major roles.

Education/training

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

Nine post-graduate students commenced in 2012-13 with either full or top-up Scholarships, bringing the total cohort of continuing and commencing students to 41 at 30 June 2013. During the year two students completed their studies, thus we have in total 43 current or completed post-graduates and are on track to meet and exceed our Commonwealth target of having invested in (enrolled

or graduated) at least 50 PhDs and Masters with our university partners by 30 June 2018.

Students are involved in all major projects. Each student is required to have an external end user supervisor. Students attend the annual CRCSI conference which has a specific day for 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 2013 43pl had 47 full member companies, with several other companies were 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. An update on strategies to mitigate risks with a high residual impact rating is reported to the Board at each Board meeting. The high impact risks monitored by the Board include:

Risk	Mitigation Strategies
Intellectual property not protected/commercialised	Regular review of IP register.
Ensuring that partner investment is justified by 2018 and beyond and acknowledged as a sound investment	Strategic Plan and annual Business Plans in place Quarterly milestones monitoring through projects Programs 1, 2 and 4 on track against targets and work in Program 3 was initiated.
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	Investment Committee and Program Board provide a regular due diligence and review. Quarterly reports from each project leader to be reviewed by the Project Board, Management & Board. No major points of failure evident.
Failure to meet the key Commonwealth targets	Regular monitoring of commitments through Board reporting One Essential participant is below its commitments (Queensland NRM) The shortfall is still significant and was not met in 2012/13.
Quality and quantity of inkind commitment from participants insufficient	CRCSI 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

2012-13 continued to be a tough environment for end users, in particular the government partners. Several state government departments continued to implement staff cutbacks following on from the introduction of austerity measures. The growing impact of 2011-12 cuts was realised through 2012-13 particularly via the capacity of the government agencies to resource their inkind commitments to projects as staff were either not replaced or assigned other duties. 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 as challenging in future years as was the case in 2012-13, although where projects deliver outputs there are expected to be increased contributions through development efforts. CRCSI monitors its inkind quarterly and consults with project teams on any potential issues through its quarterly project management group meetings.

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

The CRCSI prepares individual partner engagement plans with its Essential and Other Participants. These set out the requirements for each company, government agency and university. They are reviewed annually. The collective knowledge from these plans makes an important contribution to the annual review of the CRCSI's Strategic Plan. A detailed database 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. Implementation of a customer relations management system is likely in 2013-14 to track all meaningful contact with participants and to allow for early identification of potential 'red flag' issues, thus ensuring prompt action.

Opportunities for the CRCSI and strategies adopted to exploit these opportunities

The Program Boards meet regularly to review the

strategic development within each research and application program. 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 CRCSI's strategic direction aligns with its end user environment

CRCSI participants are grouped 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 CRCSI in 2012-13.

1.4 Impacts

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

The CRCSI reviewed its outputs, usages and impacts in 2012-13 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. Changes in outputs were:

Program 1: when the original milestones were developed the program leaders were not able to forecast the timing of research outputs with the same accuracy as is now possible based on input from partners, researchers and current knowledge regarding the implementation timetable of new Global Navigation Satellite Systems. As such for Output 1.1, we sought to delay one project and the two resultant milestones for a five year period. The network design tool is no longer considered a priority by partners. Under the present resource constraints, higher priority tasks are to be conducted, and the network design work will commence at a later stage.

Program 2: The major change from the application has been the removal of Output 2.5 as the principal partner (Department of Defence) no longer wishes to pursue this line of research. We have instead concentrated our efforts in the vegetative landscape management area in response to partner demand. This has resulted in the addition of a new project which has the backing of all of the natural agencies in Australia, and focuses on woody vegetation classification and seeks to develop tools and procedures to auto-generate landscape level woody vegetation features (i.e. spatial layers) from field.

Program 3: Outputs 3.1 – 3.3 have revised milestones. It has been more challenging for the end users to initiate and create the Australia and New Zealand Spatial Marketplace than they first envisaged. We have developed a complementary research plan and re-scoped milestones to best match the estimated timing of the new implementation plan. We anticipate there may be further amendments to milestones in due course, should there be any substantial shift in the Marketplace Strategy.

Program 4: 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 have determined that the resources required to implement Output 4.1 are significantly greater than earlier anticipated and the efforts of our partners to assist will be critical to the delivery of this output. In addition, we have removed milestones relating to the climate change adaptation program. These were related to objectives of two of our state agencies (NSW and Victoria), however the original mandate is no longer a high priority for either agency. It must be noted that this does not detract from any emphasis on climate change. Indeed climate change adaptation strategies are either embedded in or implicit in the milestones relating to biomass and natural resource management.

A summary of noted changes to outputs and usage is given in Table 3.

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Usage	Milestone Changes	Probability of output delivery			Probability of usage given output			NPV (\$M)		
Usage Reference	none / rephased / moderate / significant / new	2009	2013	% change	2009	2013	% change	2009	2013	\$ change
1.1 Analysis Centre Software toolkit and GNSS test track	rephased	50%	50%	0%	60%	60%	0%	\$3.87	\$1.64	-\$2.23
1.2 Program 1 PhD's	rephased	90%	90%	0%	90%	90%	0%	\$0.00	\$0.00	\$0.00
2.1 Biomass estimation and vegetation mapping tools	significant	75%	75%	0%	75%	25%	-50%	\$0.58	\$0.15	-\$0.43
2.2 Data capture and extraction tools for powerline infrastructure	significant (accelerated)	30%	45%	15%	70%	85%	15%	\$13.82	\$13.78	-\$0.04
2.3 Feature extraction tools for environmental management	none	75%	75%	0%	75%	75%	0%	\$4.52	\$2.32	-\$2.20
2.4 Software for private company use	none	75%	75%	0%	50%	50%	0%	\$1.05	\$1.05	\$0.00
2.5 Program 2 PhD's	none	90%	90%	0%	90%	90%	0%	\$0.00	\$0.00	\$0.00
2.6 Urban Digital Elevation Modelling tools	new	0%	100%	100%	0%	90%	90%	\$0.00	\$22.69	\$22.69
3.1 Federated data model	none	75%	75%	0%	75%	75%	0%	\$0.68	\$0.68	\$0.00
3.2 Standards for web enabled spatial infrastructure	none	60%	60%	0%	70%	70%	0%	\$2.25	\$9.53	\$7.28
3.3 - Program 3 PhDs	none	90%	90%	0%	90%	90%	0%	\$0.00	\$0.00	\$0.00
3.4 Real time information access	new	0%	100%	100%	0%	90%	90%	\$0.00	\$12.03	\$12.03
4.1 Environmental management tools	significant	70%	70%	0%	75%	75%	0%	\$1.02	\$1.17	\$0.15
4.2 Farm management tools	moderate	75%	60%	-15%	50%	50%	0%	\$17.25	\$9.03	-\$8.22
4.3 Health visualistaion tools	moderate	20%	30%	10%	40%	50%	10%	\$1.77	\$1.92	\$0.15
4.4 Urban planning tools	moderate	20%	25%	5%	40%	40%	0%	\$2.00	\$1.24	-\$0.76
4.5 Program 4 PhDs	none	90%	90%	0%	90%	90%	0%	\$0.00	\$0.00	\$0.00

Table 3: Summary of changes to outputs and usage in the Evaluation Impact Performance Tool

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

The CRCSI reviewed the monetary impacts and expected benefits with programs due to the recent amendment of output and utilisation milestones as at July 2012. The overall expected program costs have increased from \$186.79M (2010) to \$230.72M (2012). The expected benefits have also increased by a slightly higher ratio from \$305.31M (2010) to \$412.21M (2012) resulting in an overall increase in the CRC cost benefit ratio by approximately 10% to 1.79 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 decreased from 2.52 (2010) to 1.67 (2012). This is due to a 30% decrease in expected benefits from \$73.99M (2010) to \$56.59M (2012) resulting from the delayed start and rephasing of impact 1.2 and the increase in Program 1 expected usage costs. This impact value is expected to increase in the future as economic data becomes available to reflect the impact of program outputs on additional market segments.

Expected Benefit: Cost Ratio of Program 2 – the cost benefit ratio has increased by 103% from 0.95 (2010) to 1.98 (2012). This is due to an increase in all Program 2 impacts, including the identification of new benefits from impact 2.3 National Elevation Data Framework and commercialisation receipts (\$79.3M), accelerated uptake

of impact 2.2 Energy activity (\$16.76M) and avoided labour costs for impact 2.1 – NRM management (\$840K).

Expected Benefit: Cost Ratio of Program 3 – the cost benefit ratio has marginally increased from 2.15 (2010) to 2.20 (2012). This reflects the net change between the decrease in expected benefits of impact 3.1 and 3.2 (-\$7.86M) and the identification of new benefits that have resulted from implementation of impact 3.3 (+58.23M).

Expected Benefit: Cost Ratio of Program 4 – the cost benefit ratio has decreased from 1.65 (2010) to 1.44 (2012). This reflects the change in ratio between the decrease usage costs and the net impact of changes to impact 4.1 Tools for farm profitability (-\$41.65M) and impact 4.2 Health visualisation (+\$6.39M) and 4.3 Urban planning (+\$9.97M).

The changes are summarised in Table 4 (over page).

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

The CRCSI is now three 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.

2 Governance and Management

2.1 Structure and governance

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.

Impact Reference	Impact	Milestone Changes	Probability of usage to enable impact			Probability of impact occurring			NPV (\$M)		
			none / rephased / moderate / significant / new	2009	2013	% change	2009	2013	% change	2009	2013
1.1	Avoided cost of Network infrastructure	rephased	30%	30%	0%	60%	60%	0%	\$0.10	\$0.06	-\$0.04
1.2	Accerated uptake of National Positioning Infrastructure	rephased	30%	30%	0%	30%	30%	0%	\$73.89	\$50.71	-\$23.18
1.3	Postgraduate completions	new	0%	81%	81%	0%	100%	100%	\$0.00	\$5.82	\$5.82
2.1	Avoided costs of labour (resource management)	moderate	50%	60%	10%	60%	70%	10%	\$25.00	\$25.84	\$0.84
2.2	Avoided costs of (Energy) / business process improvement	rephased	21%	38%	17%	70%	70%	0%	\$25.82	\$42.58	\$16.76
2.3	National Elevation Data Framework Portal and commercialisation Portal receipts	significant	90%	90%	0%	25%	75%	50%	\$0.68	\$80.01	\$79.33
3.1	Cost reduction - policy adoption and online technologies	rephased	49%	49%	0%	20%	20%	0%	\$39.28	\$31.92	-\$7.36
3.2	Spatial industry growth	none	40%	40%	0%	15%	15%	0%	\$2.86	\$2.35	-\$0.51
3.3	ABS Implementation of Creative Commons license	new	0%	90%	90%	0%	75%	75%	\$0.00	\$58.23	\$58.23
4.1	Impact of tools on farm probability	significant	38%	30%	-8%	50%	50%	0%	\$101.24	\$59.69	-\$41.55
4.2	Impact of tools on health	moderate	8%	15%	7%	40%	60%	20%	\$9.86	\$16.25	\$6.39
4.3	Impact of tools on urban planning	moderate	8%	10%	2%	60%	60%	0%	\$28.76	\$38.73	\$9.97

Table 4: Summary of monetary impacts and expected benefits within programs due to amendment of output and utilisation milestones as at July 2012

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

- 43pl (43 Pty Ltd, version 2)
- 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 97 formal participants in the CRCSI from the government, private and research (university) sectors,

with a further 10 organisations committed through letters of agreement. They have been formed into three Colleges, one representing each of these three sectors; 43pl (with 47 SMEs), the Research and Education College (primarily universities), and the Government Agencies College managed by ANZLIC (the Australia New Zealand Land Information Council made up of government agencies at Federal, State and Territory levels). The Colleges 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.

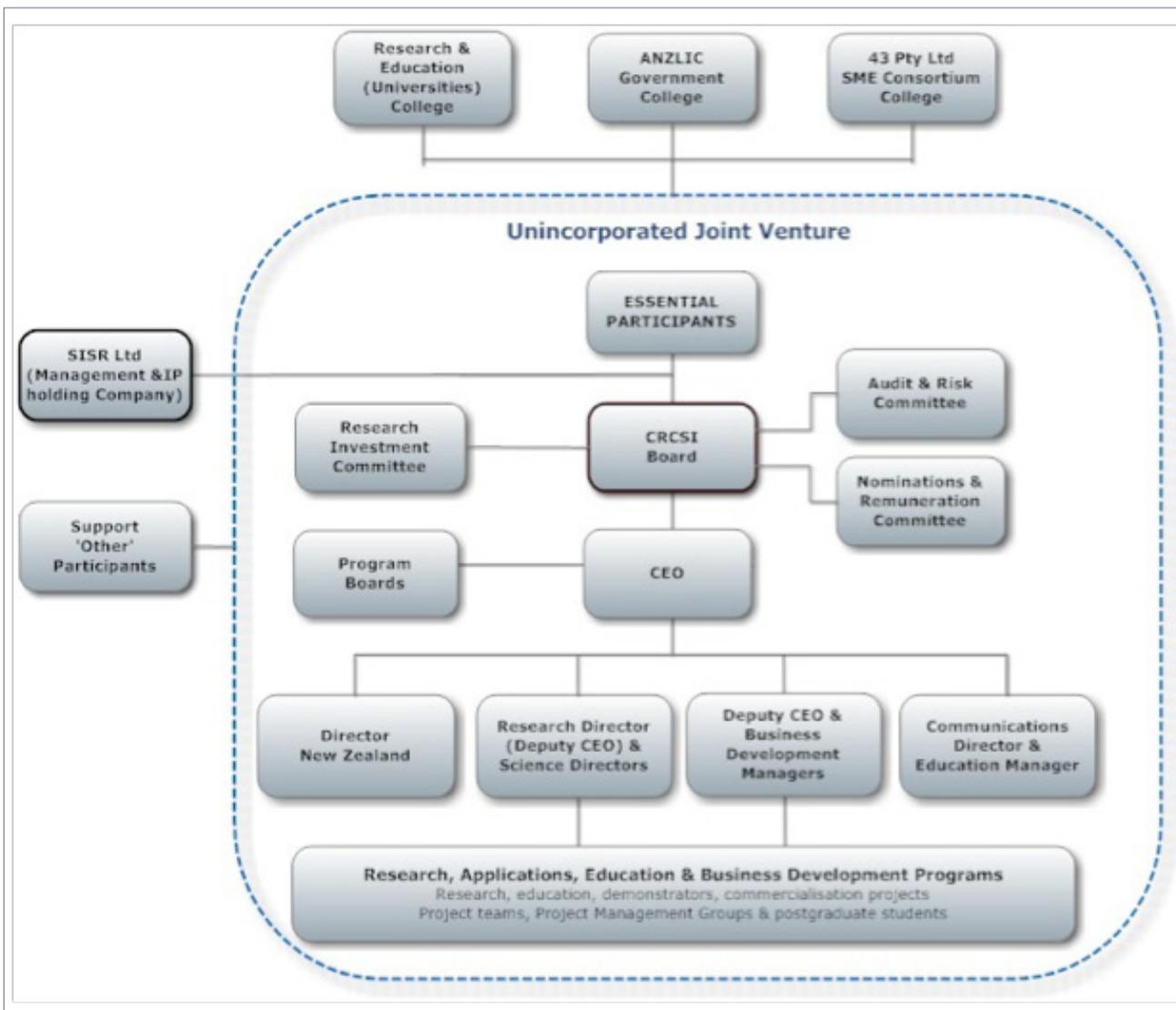


Figure 1: The governance and management structure of the CRC for Spatial Information (CRCSI)

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.

2.2 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 five times in 2012-13. A new, independent Board member joined the Board at the start of the period, Mr Colin MacDonald, the Secretary of the New Zealand Department of Internal Affairs and New Zealand's Chief Information Officer. 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

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 5: Roles and Accountabilities within the CRCSI Governance Structure

Directors

Mary O’Kane (Chair)



Mary O’Kane is a consultant and company director. She is Executive Chairman of Mary O’Kane & Associates Pty Ltd, 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. Professor O’Kane was Vice-Chancellor and President of the University of Adelaide from 1996-2001 and Deputy Vice-Chancellor (Research) from 1994-96. She was also Professor of Electrical and Electronic Engineering within the University and now holds the title of Professor Emeritus.

Mary has served on several boards and committees in the public and private sectors including being a director of PSMA Ltd, ITC Ltd, National ICT Australia Ltd, Business Events Sydney Ltd, the Australian Business Foundation, 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 (CSIRO). She is a Fellow and Vice-President of the 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 and a Degree in Forest Science from the University of Melbourne.

Drew Clarke



Drew Clarke is Secretary of the Commonwealth Department of Broadband, Communications and the Digital Economy. The portfolio includes the ABC; SBS; Australia Post, TUSMA 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.

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.

Malcolm McCoy



Malcolm McCoy is a Business Development Consultant with AAM Pty Ltd one of the largest geospatial companies in Australia. He has 25 years' experience as a director of survey and spatial companies and nearly 40 years

in the industry. He was previously Managing Director of Vekta Pty Ltd prior to its merger with AAM.

Malcolm has a comprehensive understanding of survey and spatial disciplines in both the private and public sectors. He has a degree in Applied Science (Surveying) from RMIT, was a Licensed Surveyor for 30 years and has contributed to the profession at local, national and international levels in senior executive positions.

His areas of expertise are land and engineering surveying but also corporate governance, strategic planning, business development and project management.

Tina McMeckan



Tina has 20 years of 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 SP Ausnet Limited. 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 and a Member of the Victorian EPA Hazwaste Fund Advisory Panel. She recently retired as Chairman of the Centre for Eye Research Australia. She is a past Director of the Vision CRC and a past Member of the Funds Management Committee of the AusIndustry Research and Development Board.

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 the initial bid preparation in 2003 then as a member of REAC and the CRCSI Board, and until recently as Chair of the Research and Education College. Graeme also Chairs The Research and Investment Committee, which is a CRCSI Board Committee. As Head of the Curtin University School of Spatial Sciences he led the engagement of Curtin with the CRCSI during its inception and his research background is in remote sensing.

Board meeting dates and attendance

Table 6 sets out the number of Board and Board Committee meetings held and the number of meetings attended by each Director and/or Board Committee member.

Changes to board membership

Mr Colin MacDonald, Chief Executive and Secretary for Internal Affairs and Government Chief Information was appointed to the CRCSI Board in July 2012 and attended his first meeting in September 2012.

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 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.

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.

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Directors/ Committee Members	Board of Directors		Audit & Risk Committee		Research Investment Committee		Nominations & Remuneration Committee	
Number of meetings held	5		3		3		2	
Directors	Eligible	Attended	Eligible	Attended	Eligible	Attended	Eligible	Attended
A. Clarke	5	5					2	2
C. MacDonald	4	3						
G. Wright	5	5			3	3		
M. OKane	5	5					2	2
M.McCoy	5	5	3	2				
P.Woodgate	5	5			3	3		
T. McMeckan	5	5	3	3				
Committee Members	Eligible	Attended	Eligible	Attended	Eligible	Attended	Eligible	Attended
J. Bangay					3	0		
A. Berrill					3	3		
S. Ramage					3	2		
M Goodchild					3	1		
G. Perkins					4	2		
J Trinder					3	3		
W.Pooler			3	3				

Table 6: CRCSI Board and Committee attendance in 2012-13.

Notes:

1. Board meetings were held on 16 July 2012, 11 Sept 2012, 18 Dec 2012, 26 Feb 2013 and 24 May 2013.
2. S Jacoby resigned from the Research and Investment Committee at the end of 2011-12, and G Perkins resigned in March 2013
3. C MacDonald appointed to the Board in July 2012.

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	CRCSI Affiliation	
Graeme Wright	Chair	Board Director, Curtin University, Essential Participant – Perth, WA	
James Bangay	Member	Ergon Energy, Other Participant - Brisbane Qld	
Arthur Berrill	Member	Independent, DMTI Spatial – Toronto, Canada	
Mike Goodchild	Member	Independent, University of California, Santa Barbara	
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 7: Board Committee Membership 2012-13

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)	67%
John Dawson	Geoscience Australia	Program Manager, Research Program 1	31%
Clive Fraser	CRCSI	Professor and Science Director (Research Program 2: Automated Feature Extraction)	80%
Geoff West	Curtin University	Professor and Science Director (Research Program 3: Spatial Infrastructure)	50%
Kylie Armstrong	Landgate	Program Manager (Research Program 3: Spatial Infrastructure) (from April 2013)	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) (from December 2012)	8%
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)	33%

Table 8: Time Commitments of key staff

Note: Dr Geoff Jacquez from the University of New York, was appointed to the position of Science Director of Program 4.4: Health in December 2012. Applications Program 4.2: Defence and Program 4.3: Energy Utilities are yet to demonstrate a need for a Science Director.

2.3 CRCSI Strategic Plan

The CRCSI strategic plan is updated annually by the Board.

The Vision

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.

Context within which we operate and our resources

The CRCSI is an unincorporated joint venture set up under the Cooperative Research Centre Program of the Australian Commonwealth Government. The purpose is to build critical mass in research ventures between end-users and researchers tackling clearly articulated, major challenges for the end users. The term of the CRCSI runs from January 2010 to June 2018. The partners from the government, private and research sectors have agreed to provide \$160 million (cash and inkind). The spatial information industry is one of the fastest growing in the world.

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.

What success will look like

By 2018 the CRCSI will be recognised world-wide for the high impact of our research, especially in the enabling role we played in creating a single, multi-GNSS network in Australia, and adding value to the development of the Australia-New Zealand Spatial Marketplace. A thriving spatial industry will acknowledge the central role of the CRCSI. We will be considered an essential partner for complex research collaborations both locally and internationally. Spatial education will be improved as a result of the CRCSI's activities, significantly enhanced by 50 or more new CRCSI PhDs. The transition of the CRCSI from the CRC Program to a permanent and sustainable entity will be implemented on or before June 2018.

Our Strategic Objectives

National precise positioning (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.

Automated generation of spatial information products (Program 2)

Objective 2

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

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

Objective 3

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

Applications (Program 4)

Objective 4

To include but not be limited to the realisation of high impact use of the CRCSI's research in the following areas: Agriculture and Natural Resources affected by Climate Change (4.1) through the creation of a biomass and carbon monitoring system for high resolution and high frequency application on farms and through improved environmental monitoring; Defence (4.2) by adapting the emerging 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, paradigms and

theories including agglomeration economy and greyfield regeneration to support sustainable urban development.

Education (Program 5)

Objective 5

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

Industry development and sustainability (Program 6)

Objective 6

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

Objective 7

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

Collaboration

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

Risks

The strategic risks are: that other research developments

domestically and internationally render the CRCSI's research programs obsolete; we fail to retain and nurture a cadre of eminent researchers; we fail to attract an adequate cohort of postgraduate candidates; we lose our reputation as the leading spatial research institution in Australia and New Zealand; we fail to generate sufficient independent funding and support to transition to a self-sustaining entity; we fail to continue to meet the expectations of our partners.

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 feature extraction and data-to-information generation processes, that lead to productivity gains in the spatial information industry.
3. Wide recognition by our partners of the CRCSI's role in helping establish and value-add to the Australia and New Zealand Spatial Marketplace.
4. An Educational Program that is judged to be transformational by our partners.
5. Establishment of a self sustaining entity by mid 2018.

2.4 Participants

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

A total of 97 CRCSI contributors, including Essential, Other and Third Parties have provided either cash or inkind contributions to support the CRC's activities for the period. Of these, 58 Participants are equity holding partners in the CRCSI holding beneficial ownership rights in Centre IP based in proportional to their aggregate cash contributions to CRCSI. For a full list of Participants see Table 10.

Not all partners have been able to sign off on the Essential Participant Agreements or the Other Participant agreements. Instead they are engaging in the collaboration through an exchange of letters or MOUs. The reasons for not being able to enter into a formal agreement include reluctance to enter into the legal cost of reviewing such a large agreement (applies to some companies), reluctance to enter into an Australian agreement (applies to some overseas partners), and reluctance to commit to all of the obligations in the agreements.

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.

Changes to Participants

Other Participants who signed during the period were Open Geospatial Consortium Inc, and Melbourne University who retired as an Essential Participant in June 2012.

Participants Name	Retiring, withdrawing or new	Departmental Approval Y/N
University of Melbourne	Retiring	Yes

Table 9: Changes to Essential Participant in 2012-13

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	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
Land and Property Information (LPI) of the Department of Finance and Services, NSW	Essential	33 537 762 019	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
Defence Imagery and Geospatial Organisation	Other	68 706 814 312	Australian Government
Department of Health, WA	Other	13 993 250 709	State Government
GEOIDE (Inc), Canada	Other	n/a	International
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

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Participant's Name	Participant Type	ABN or ACN	Organisation Type
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
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
CTG Consulting Pty Ltd	43pl	24 100 876 015	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
FBA - Fitzroy Basin Association	43pl	30 802 469 401	Industry / Private Sector
Fugro Spatial Solutions Pty Ltd	43pl	52 008 673 916	Industry / Private Sector
GeoSmart Maps Ltd	43pl	N/A	Industry / Private Sector
Geoimage Pty Ltd	43pl	75 010 840 294	Industry / Private Sector
Geometry Pty Ltd	43pl	35 094 569 507	Industry / Private Sector
GPSat Systems Australia Pty Ltd	43pl	47 056 077 902	Industry / Private Sector
iintegrate Systems	43pl	48 111 015 297	Industry / Private Sector
Insight GIS	43pl	80 059 212 798	Industry / Private Sector
Land Equity International Pty Ltd	43pl	42 097 054 165	Industry / Private Sector
Lester Franks Survey & Geographic Pty Ltd	43pl	25 098 991 210	Industry / Private Sector
Mercury Project Solutions Pty Ltd	43pl	57 141 118 194	Industry / Private Sector
Milne Agricultural Group	43pl	92 008 919 579	Industry / Private Sector
Nearmap Pty Ltd	43pl	16 120 677 250	Industry / Private Sector
NGIS Australia Pty Ltd	43pl	56 061 264 793	Industry / Private Sector
Omnilink Pty Ltd	43pl	80 056 793 723	Industry / Private Sector
Fugro Satellite Positioning Pty Ltd	43pl	50 009 300 761	Industry / Private Sector
FARMpos Pty Ltd (Precision Agriculture)	43pl	61 567 291 569	Industry / Private Sector
Photomapping Services	43pl	30 005 552 876	Industry / Private Sector
PSMA Australia Ltd	43pl	23 089 912 710	Industry / Private Sector
RPS Mapping	43pl	52 113 485 475	Industry / Private Sector
Scanalyse Pty Ltd	43pl	63 117 523 369	Industry / Private Sector
Septentrio Satellite Navigation	43pl	n/a	Industry / Private Sector

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Participant's Name	Participant Type	ABN or ACN	Organisation Type
Sinclair Knight Merz Pty Ltd	43pl	37 001 024 095	Industry / Private Sector
Spatial Information Technology Enterprises Ltd	43pl	49 085 230 173	Industry / Private Sector
Spatial Vision Innovations Pty Ltd	43pl	28 092 695 951	Industry / Private Sector
Sundown Pastoral Company	43pl	86 000 334 190	Industry / Private Sector
Superair	43pl	25 990 899 338	Industry / Private Sector
ThinkSpatial	43pl	65 711 887 042	Industry / Private Sector
Trimble Navigation Australia Pty Ltd	43pl	23 057 599 881	Industry / Private Sector
True 3D	43pl	96 486 268 410	Industry / Private Sector
Twynam Investments	43pl	12 000 573 213	Industry / Private Sector
Vekta Pty Ltd	43pl	41 138 024 754	Industry / Private Sector
VPAC Ltd	43pl	59 093 732 426	Industry / Private Sector
we-do-IT Pty Ltd	43pl	26 071 972 891	Industry / Private Sector
Whelans (WA) Pty Ltd	43pl	68 074 363 741	Industry / Private Sector
ACIL Tasman Pty Ltd	Third Party	68 102 652 148	Industry / Private Sector
ANZLIC	Third Party	31 722 153 579	Australian Government
BECA	Third Party	n/a	Industry / Private Sector
Biosphere Reserve Foundation Ltd	Third Party	15 107 484 408	Industry / Private Sector
Cancer Council (QLD)	Third Party	48 321 126 727	State Government
Canterbury Health Board	Third Party	n/a	NZ Government
City of Canning	Third Party	80 227 965 466	State Government
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Third Party	41 687 119 230	Australian Government
Department of Broadband, Communications and the Digital Economy	Third Party	51 491 646 726	Australian Government
Department of Climate Change and Energy Efficiency	Third Party	50 182 626 845	Australian Government
Department of Energy Resources and Tourism - Office of Spatial Policy	Third Party	46 252 861 927	Australian Government
Department of Environment and Conservation PNG	Third Party	N/A	International
Department of Planning and Community Development (VIC)	Third Party	30 485 673 497	State Government
Department of Primary Industries (NSW)	Third Party	42 860 678 701	State Government
Flinders University	Third Party	65 542 596 200	University
GHD	Third Party	39 008 488 373	Industry / Private Sector
Japan Aerospace Exploration Agency	Third Party	n/a	International
Ministry of Business Innovation and Employment (NZ)	Third Party	n/a	NZ Government
Manningham City Council	Third Party	61 498 471 081	State Government
Monash University	Third Party	12 377 614 012	University
University of Exeter	Third Party	n/a	University
University of Sydney	Third Party	15 211 513 464	University
What If?	Third Party	n/a	International

Table 10: CRCSI Participants 2012-13

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

2.5 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 2012-13 year. CRCSI ended the year with an operating deficit of \$1.0M against a budgeted deficit of \$4.5M. This is a favourable movement to budget, due to the sale of the Scanalyse investment, higher interest and licensing income, and also due to budget under spend in all departments, particularly research. Total cash and inkind contributions were \$28.1M for the period, unfavourable to budget by \$1.0M, but favourable year on year by \$0.4M. CRCSI remains in a healthy cash position, with \$12.2M 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 9, CRCSI received total cash funding for 2012-13 of \$11.6M, including additional funding for contract research (\$1.5M) and Commercialisation proceeds from the sale of Scanalyse and license fees from Ergon (\$1.2M). Payments in advance, delayed expenditure and the resultant high bank balances have also impacted on contribution levels, with bank interest of \$468k received for the period.

Essential Participant contributions were behind budget by \$0.5M overall, at \$2.5M, with additional project funds received from Land and Property Information NSW (+\$110k), Curtin University (+\$34k) and DEPI Vic (+\$83k), offset against deferred contribution receipts from Ergon Energy (-\$500k), and Queensland Department of Natural Resources and Mines (-\$179k). 43pl receipts were also under budget by \$29k, reflecting some partner withdrawals caused by tougher economic conditions faced during the period.

Despite the delayed payment from Ergon Energy, their contributions remain positive to budget cumulatively (+\$275k) and Ergon have paid their 2012-13 contribution in August 2013. Contributions from The University of Canterbury have also been deferred, with the \$150k contribution paid in 2012-13 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 2012-13 contribution by the end of 2013. The Queensland Department of Natural Resources and Mines payment deferral of cumulative \$864k is being addressed through the arrangement of several meetings between QDNRM and the CRCSI and several projects have been identified to reduce this gap. QDNRM has committed to covering the shortfall in future years, however with the substantial budget implications caused by the Queensland floods, has experienced some cashflow issues.

The sources of CRCSI cash funding were evenly spread between Participant contributions, Commonwealth Program funds and contract research during 2012-13, a trend which replicates the prior year.

The full year expenditure of \$10.7M was under budget by \$2.1M. The variance was driven by the delays in research expenditure of \$2.46M, as well as savings in other cost centres including Directorate, Business Development and Communications.

Almost four out of every five cash dollars spent by CRCSI went into the Research Program in 2012-13, an increase from the three out of every four dollars in 2011-12.

Financial Statement (\$'000s)

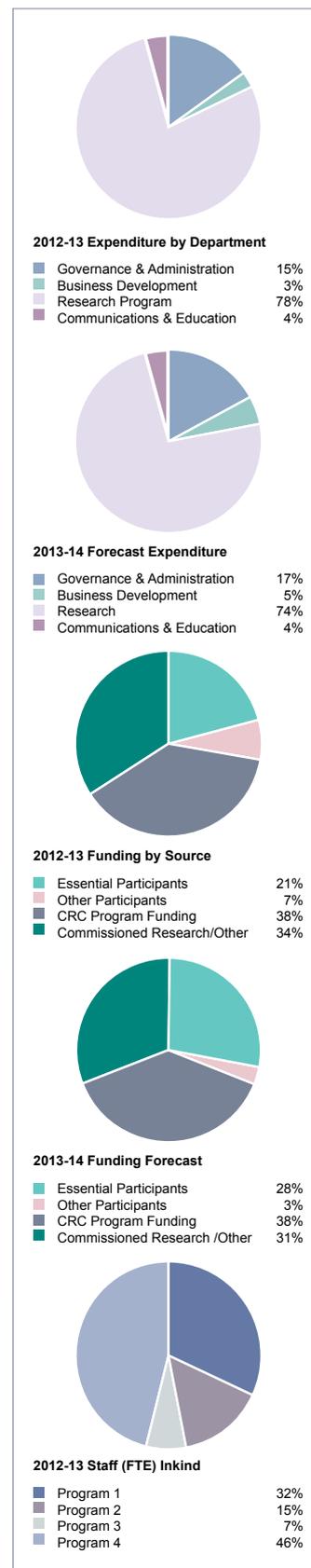
Funding (Cash)	2011-12 Actual	2012-13 Actual	2012-13 Budget	2013-14 Budget
Essential Participants	3,039	2,472	3,239	2,841
Other Participants	1,121	807	852	335
CRC Program	4,002	4,452	4,452	3,925
Commissioned Research/Other	3,607	3,913	3,311	3,241
Total Funds	11,769	11,644	11,854	10,342

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

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

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

Table 11: Financial Statement



This trend reflects the continued progress toward having a full suite of projects in all Program areas in progress. The remaining expenditure was attributed to Business Development (3%), Education and Communications (4%) and Administration (15%). When in-kind contributions are taken into account the cost of administration is 8% of the total investment of the CRCSI.

Participant FTE in-kind contributions although higher than the previous year (+ FTE 7.9) also reflect slower progress than anticipated within the Research Program at 46.1 FTE against a budget of 49.4 FTE. Non staff in-kind was higher than budgeted (\$6.0M versus \$4.8M) mainly due to higher than expected data contributions from partners for research projects, particularly in Program 4.

For the financial year ending 30 June 2013 SISR had a positive cash flow, and had sufficient funding to meet its debts. Of the \$12.2M cash at Bank at the end of the period, 83% are committed funds.

2.6 Communications

Internal communications activities undertaken during the period

With 97 key stakeholders the CRCSI places a great deal of emphasis on good communications. The CRCSI has a dedicated Communications Director. It uses the network of its 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 ANZLIC has a Council and Executive operated by the federal Government with support from the States and Territories and the New Zealand Government.

The CRCSI produces regular communiqués to update members and interested stakeholders (1000 subscribers) on CRCSI activities. It conducts regular road shows 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. Attendance at our conferences is limited to members

only as requested by members. The annual conference runs over three days and involves presentations on most 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 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 Communications Director has a role 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). The WA office houses the CRCSI Communications Director, the Program Managers for Health and Spatial Infrastructure, 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, with blogs available for each project to encourage

debate and enquiry. Project video presentations are made available regularly through the website. Discussion groups on LinkedIn (550 members) and Facebook are maintained along with blog and Twitter (250 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. These were all significant events on the calendar for Australia and most attracted between 500 and 800 delegates.

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.

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

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 Program which is maintained by the Communications Director.

2.7 Intellectual property management

Intellectual Property 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 (10) working days of receipt of the notice advise SISR whether it desires to utilise or participate in the utilisation of the IP. If no Participant desires to commercialise then SISR is free to utilise the CRCSI IP.

No CRCSI Participant can commercialise, dispose of or encumber any interests which it might hold in 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 intellectual property registers are a vital element in

ensuring that information and methods generated by the CRCSI are recorded and where appropriate developed for commercial benefit. The CEO is responsible for maintaining a register of CRCSI IP.

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.

The CRCSI IP Management Policy provides a framework for the CRCSI Participants and researchers to permit the utilisation of research outcomes of the CRCSI. The policy sets out ownership rights and the responsibilities of researchers and participants. It provides guidance on the identification, protection and commercialisation of CRCSI IP. The policy is based upon the IP ownership and management principles outlined in the CRCSI Essential Participants Agreement and Commonwealth Agreement.

Current items being actively pursued and held on the register are listed in Table 12.

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.

Description	Pathway
Real Time Quality Control Software for Positioning	Under licence to Project Participants
Software and techniques for improved accuracy and range of RTK Positioning Systems	Invention disclosure under review and evaluation
Photogrammetric software for the generation of spatial information products from satellite imagery (Barista)	Continuing project and under licence to Project Participants
Software for the detection and measurement of ground surface movement using radar based remote sensing	Licensed to UNSW (New South Innovations) for commercialisation
Aircraft guidance and path planning software	Under licence option to CRCSI Participant
National Nested Grid Standard, Workflow Management System Software Platform and data model based on a grid cell (raster) approach for management of spatial information	Continuing project and under licence to CRCSI Participants
Health Software Spatial Augmentation Module for increased analytical and GIS capability	Continuing project and under licence to CRCSI Participants
Laser Scanning Segmentation Software (NN Clean)	Under licence to CRCSI Participants
Terrestrial Laser Scanning Calibration Software	Under licence to CRCSI Participants

Table 12: Overview of current IP items held by CRCSI which are being actively pursued

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 has no active patents.

3 Performance Against Activities

3.1 Progress against the key challenge/outcomes

The CRCSI research program is designed to meet the strategic objectives for spatially enabling Australia and New Zealand that have been developed for the Australia and New Zealand Land Information Council (ANZLIC) representing federal, state and territory government agencies, and endorsed by industry.

Objective 1: To facilitate the research to enable the creation of a coordinated national network of satellite system reference stations to permit real-time positioning to 2cm accuracy

The CRCSI, through its partners is conducting research to facilitate the creation of a coordinated national network of satellite system reference stations (to be known as the National Positioning Infrastructure) with real-time positioning accuracy of 2cm (in planimetry and 6cm accuracy in height). This infrastructure and its services

will provide precise positional information on people, vehicles, built infrastructure and natural assets across the nation. Realising such a network requires substantial research (through CRCSI Program 1 Positioning) to optimise the use of existing and new reference stations, and the 75 new positioning satellites being launched by Europe, Russia, China, Japan, South Korea and India over the next five years.

Program 1 projects are underway (listed in detail under Research) under the leadership of Science Director Professor Peter Teunissen and the management of the CRCSI Research Director, Dr Phil Collier. The efforts of the Program 1 Board have also ensured progress is on track to achieving Program objectives.

Objective 2: To establish a fully functioning market place for spatial information.

The development of the ‘Australia and New Zealand Spatial Marketplace’ will enable government agencies to lift the licensing, governance and technical restrictions on providing the vast stores of government-held spatial data to the open market and to encourage other users to trade and value-add their data as well. The National Innovation Systems Review documents the huge benefits to Australia in unlocking access to these data. Industry strongly supports this objective and CRCSI research (through CRCSI Program 3 “Spatial Infrastructures”) is required for its realisation.

Progress against this objective has been delayed due to the slower than expected development of the plan to develop the Marketplace. This plan is beyond the control of the CRCSI.

Following on from the approved Program 3 Research Strategy, the flagship project commenced in January 2013 and a second project has been approved to commence in October 2013. A companion project is expected to commence in 2013-14 to address remaining elements of the strategy. These three projects will address the key challenge research imperatives.

3.2 Research

Summary of Research Activities by Program

A total of eight new CRCSI funded projects were approved by the Board during 2012-13 and two projects were successfully completed. Table 11 shows the full research portfolio of active projects, with the eight new projects highlighted by an asterisk (*). A number of new project proposals are presently being developed, with a primary focus on building up research activity in the Spatial Infrastructures Program (Program 3). The CRCSI also undertakes a number of commissioned research projects. These are not discussed here.

The structure of the CRCSI’s research program is shown in Figure 2, which highlights the three foundation research activities (in the centre) and the five application areas (in the outer ring).



Figure 2: Structure of the CRCSI Research Program.

Program-by-program review

Program 1 (Positioning) comprises six active projects (see Figure 3). A core deliverable for the Program is the Analysis Centre Software (ACS). The ACS will facilitate the integration of a range of research outputs from the Program (in the form of 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 RTK-PPP (Real-time Kinematic Precise Point Positioning) which offers the prospect of ± 2 cm 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 geodetic datum for Australia and New Zealand, a project that falls at the cutting edge of geodetic science. This project is strongly supported by Geoscience Australia and Land Information New Zealand as the agencies responsible for building and operating national geodetic infrastructure.

Full realisation of Program 1 research goals is partially dependent upon the availability of new global and regional satellite navigation systems becoming available in the near future. These dependencies are being monitored and risks are being mitigated through alternative strategies such as simulation so delays in the launch of new satellites will not detrimentally impact the research activities.

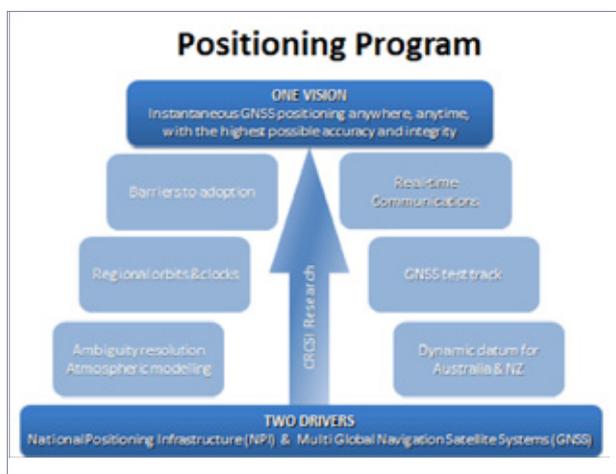


Figure 3 – Positioning Program outline

From a science perspective, the profile of the Program continues to grow both nationally and internationally 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. Visiting researchers from China (Wuhan University) and Europe (Technical University of Delft) have been hosted by the Program and have and continue to

make substantive contributions to the research activities. No need for a major change in research direction has been identified to date though the Program Board is watchful that this is a rapidly changing space and is paying close attention to external activities that may demand a response, such as the emergence of new competitive and/or complementary technologies and the growing interest in indoor positioning systems. The Program produced two book chapters, eight refereed journal papers and eight refereed conference papers in 2012-13. The Science Director for the Program is Professor Peter Teunissen, an ARC Federation Fellow at Curtin University and one of the world's most highly regarded researchers in this area of science. The Chair of the Program Board is Dr Chris Pigram, CEO of Geoscience Australia.

Program 2 (Automated Spatial Information Generation)

comprises six projects focussing on different aspects of the general research problem of automated feature extraction and 3D object/scene reconstruction and modelling from remote sensing systems, especially space-borne, aerial and terrestrial imagery, and airborne and terrestrial laser scanners. Functional models, algorithms and computational processes and procedures for the detection, identification and measurement of natural and man-made features in the imagery and laser scanner data are being developed. Moreover, research attention is focussed on enhanced feature extraction prospects 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 – proposed by CRC SI researchers – yields a single unified, georegistered data source and thereby enhances the reliability and efficiency of the complex and computer-intensive feature extraction process. Two projects in the Program (2.02 and 2.11) 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 and a fifth project, funded by the ARC, aims



Figure 4: Automated building detection from aerial imagery and building reconstruction from LiDAR data and aerial imagery – Project 2.02

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.

New developments in feature extraction produced in Program 2 research are implemented in software such that they can be tested and evaluated by both industry partners and collaborating research teams. The CRC SI-developed Barista software, which has attracted international commercial usage, provides a useful operational platform for implementing and testing research outputs, thus allowing end users to engage directly and in a timely fashion with the research activity. Whereas progress is being made in feature extraction for automated object and scene reconstruction, i.e. essentially 3D mapping, the problem is not one that lends itself to deterministic solutions. Instead, feature extraction is ultimately about the ability of computers to replicate human understanding and interpretation, and while the research being conducted advances the present state of the art via geometric and radiometric modelling tools, the achievement of a truly comprehensive solution to the extraction and modelling of the full range of cartographic features of interest is tied to the rate of progress in research into computer-based interpretation, image understanding and machine learning. Figure 4 images highlight the

research in building detection and reconstruction from aerial imagery and airborne laser scanning data.

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, within the reporting period, the three project teams produced 7 book chapters, 6 refereed journal papers and 28 refereed conference papers, and won international awards. The Science Director for this Program is Professor Clive Fraser, a Professorial Fellow at the University of Melbourne and one of Australia's most senior researchers in this area of science, with a highly regarded research reputation internationally.

Program 3 (Spatial infrastructures) Following the release of the Program 3 Research Strategy in 2012, the Program 3 team travelled extensively and continued to workshop with stakeholders to develop a common understanding of the required research. The research strategy sets out to improve the organisation, access and use of spatial data in Australia and New Zealand. Feedback on the strategy, both locally and internationally, has been encouraging.

The main research activities will include Semantic Web (Web 3.0), Artificial Intelligence and Supply Chains as these areas will allow the capabilities of spatial

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CRCSI Projects: Current as at June 30, 2013				
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
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	19 Apr 14	1
2.09*	Development of a Standard Software Procedure and Tool to Quality Assure Elevation Data	1 Jul 12	30 Jun 13	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
3.05	Unlocking the LANDSAT archive for future challenges	1 Jan 11	31 Dec 12	5
4.12	Biomass business	1 Jul 10	30 Jun 14	11
4.15	Towards operational monitoring of key climate parameters from synthetic aperture radar	1 Jan 11	31 Dec 13	8
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
4.43	Evaluation and Identification of Health Geocoding Research Priorities	1 June 12	30 Nov 12	4
4.44	Urban Planning Geovisualisation eResearch Tools	1-Apr-12	30-Mar 13	1
4.45*	Geographic variations in natural disaster impact and spatial links to non-injury related health outcomes	1 Sept 12	31 Aug 15	4
4.51	Greening the Greyfields – A spatial information platform for 21st century sustainable urban planning	1 Jul 10	30 June 14	6
4.52	Using Augmented Reality as an urban design tool	1 Apr 12	30 Sept 12	2
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
5.01*	Spatial Innovation & R&D - Baseline and Benchmark Study	1 Oct 11	31 Mar 14	2
5.02*	Surveying and geospatial skills gaps	1 Jul 12	30 Jun 13	2
9.07	Flight Assist System (FAS) Demonstrator	17 Jan 11	30 Apr 12	2

Table 13: CRCSI projects. * Newly funded CRCSI projects in 2012-13

infrastructures to be taken beyond existing manual methods for providing data, apps and services to more automated methods for dealing with data and processes.

Recently approved Project 3.01 “Semantic Web Technologies for Next Generation Spatial Infrastructures” is underway and will cover search and discovery and federated data integration as demanded by end users. The main aim is to enhance current Spatial Infrastructures by improving the user experience, making many of the operations more seamless and improving access to spatial resources (data, applications and services).

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 identify and target the strategic information technology challenges for managing Big Data, while preparing for the near future when Australia can expect to receive huge volumes of Earth observation data each day from government sources such as Sentinel-2 and Himawari-8, from commercial suppliers, and from new satellites. The challenge for Program 3 in this context is identifying and exploring methods for automating and optimising data management, querying, analysis and visualisation of these very large, geographically extensive time-series (geo-temporal) datasets to allow them to be exploited by end users.

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

Program 4.1 (Agriculture, Natural Resources and Climate Change) has two multi-year research projects. Considerable effort has been made to define a program strategy such that new projects are oriented to evolving program needs. This means having future projects

whose focus is the practical delivery of user-ready spatial information delivered via appropriate media to achieve increased uptake by agricultural, natural resource, and environmental professionals. The result has been the approval of two new projects that will commence in the latter half of 2013. One 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. The second, in collaboration with Meat and Livestock Australia, will focus on improving the management of farms producing red meat, using hand-held biomass sensors supported by a region-wide spatial data infrastructure. Both projects will benefit through being jointly conducted with Program 3 researchers while also providing case studies that enable contextualisation and scoping of Program 3 activities.

Much of the Program’s on going research, through the “Biomass Business” (4.12) project, is focused on the estimation of biomass in an agricultural context using terrestrial, airborne and satellite-borne remote sensing technologies. The intention is to improve the ability of farmers to determine biomass in the landscape for forage availability for grazing stock and to assist croppers to assess plant requirements for water and nutrients. A third objective is to allow the estimation of standing carbon at farmscape level as an input to a future carbon trading scheme.

A second project, a co-funded ARC Super Science project (Project 4.15), tackles the problem of estimating soil moisture and woody vegetation status from a mix of satellite-borne and airborne Synthetic Aperture Radar (SAR) remote sensing technologies. It complements the activity of Project 2.07 by improving the ability to describe and summarise woody vegetative cover at individual locations and over regions – the essential building block of any landscape monitoring system. The soil moisture component of the project, which is of particular interest to agricultural areas, focuses on developing and testing methods to estimate temporal series of near-surface soil moisture from temporally dense data sets of SAR acquisitions.

Program 4.1 demonstrates high levels of national and international engagement. Collaborations with NASA and the Italian Research Council are a prominent feature of the Super Science project and interest from Europe, the U.S and New Zealand in the Biomass Business project has seen members of the project team attending numerous conferences and giving invited presentations. A total of three refereed journal papers and three papers in refereed conference proceedings were produced in 2012-13. The Project 4.12 team continues to run the ANZ Spatially-enabled Livestock Management Symposium series with last year's 4th Symposium held in New Zealand (and the coming 5th symposium to be held in Sydney). The team also organised and hosted the inaugural Digital Rural Futures Conference (160 delegates) in Armidale NSW in June 2013. Professor Kim Lowell, University of Melbourne, an internationally recognised specialist in biometrics and spatial information is the Program's Science Director.

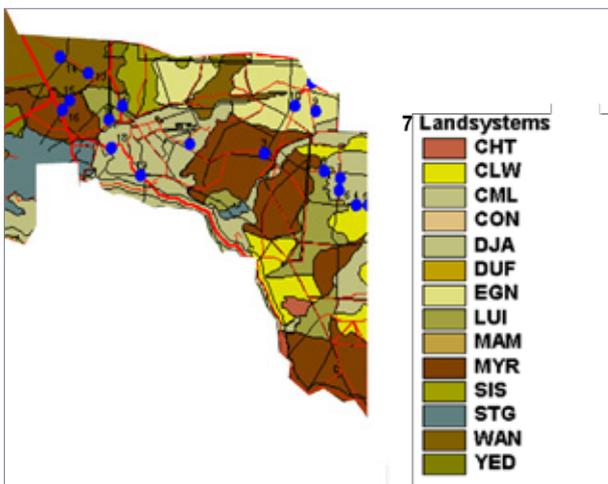


Figure 5: (above) Charity Mundava PhD Curtin University (left) and the team recording influence of buried metallic access tubes (for soil moisture measurement) on the response of an above-ground, electromagnetic induction soil sensor used for inferring soil moisture in Project 4.12. (below) Biomass assessment tools to assist grazing management for the Kimberley region of Western Australia.

Program 4.2 (Defence) is a different type of Program to the others within CRCSI. Suggestions coming from Defence agency partners for research activities at the time of the bid (such as the use of full motion video) were subsequently withdrawn due to changing Defence priorities. During 2012-13, Defence agencies (primarily the Australian Geospatial Organisation) were largely content to keep a watching brief on research activities across the CRCSI without direct engagement in any major projects. They did, however, continue to directly support a commissioned research project in close-range photogrammetry. Areas of interest included Program 2 (around the problem of automated feature extraction), Program 3 (the management and provision of spatial information) and Program 4.3 (low level mapping and monitoring from aerial platforms). Accordingly this Program does not have the usual structure of a Science Director and Program Board. The altered priorities of the Program have given rise to revised milestones in this area.

Program 4.3 (Energy) comprises a single project (Project 4.31) focused on the spatial information priorities of electricity distribution companies, in particular Ergon Energy. Aerial inspection of large powerline networks by low altitude fixed-wing aircraft is a complex and potentially hazardous task. This motivates investigation of new aircraft planning and control technologies to improve the safety and efficiency of powerline inspection. Since 2009, the CRCSI has researched and developed flight-test-proven automated aerial powerline inspection technologies. Currently, a single research project operates under this program, the enhanced Flight Assist System (eFAS) project, which aims to extend the 2D aircraft flight-path planning, data capture and flight assist concepts developed under previous CRCSI projects to an active 3D capability.

The benefits are:

- reduced pilot workload regarding the horizontal and vertical control of the aircraft, maintenance of safe horizontal and vertical separation from terrain/obstacles, and positioning the aircraft at the correct altitude and speed;
- consistent data capture; and



Figure 6: Part of the eFAS team with one of the ROAMES aircraft (left to right: Duncan Greer, Troy Bruggemann, Jason Ford, Ryan Fechney and George Curran)

- reduced flight mission times and improved operational efficiencies.

The research team (see Figure 6) will develop an enhanced flight assist system that will deliver substantial efficiency gains in the aerial acquisition of spatial information covering powerline assets. Overall, eFAS aims to ensure that the costly exercise of acquiring spatial information over hundreds of thousands of kilometres of powerline assets is as efficient and safe as possible.

End user engagement in the Program is very strong and research outputs find direct application in Ergon's ROAMES system. ROAMES is an outcome of Ergon's engagement in CRCSI-1 and is currently operational. To date, the ROAMES aircraft have flown a total of 240,000 km under Flight Assist System (FAS) control, of which 75,000 km



Figure 7: Lead Software Engineer Ryan Fechney with the software in the loop test facility

has been in inspection mode. This equates to surveying approximately 55,000 km of Ergon's 150,000 km of power line network, with the target of surveying the complete network in a 12 month period. Program 4.3 is strongly aligned with the Commonwealth milestones and is on track to meet the associated timelines. Strong end user engagement ensures the continued relevance of the research activities and no need for redirecting the research activities has emerged to date. Efforts to engage other energy companies in the research are ongoing, but managing commercial sensitivities are an important consideration governing the pace of commercialisation. In 2013, Ergon Energy exercised an Australian and Global license on the FAS background IP. The Program produced five refereed conference papers in 2012-13. The Program does not have a Science Director. Its Program Director is Mr James Bangay, the Director of Strategy at Ergon Energy.

Program 4.4 (Health) has an interdisciplinary research team developing new systems and methodologies for spatially analysing health service datasets. The research extends spatial science and complementary activities encourage end user engagement across the health sector.

The long term objective is for health agencies across Australia and New Zealand to adopt spatial technologies and for spatial data to be incorporated into health service planning and research, which will in turn increase health

sector effectiveness and improve quality of life. The program will also expand the spatial health industry and create new skills and services.

The past year has seen a growth in partnerships and collaborative research opportunities, including the joint appointment with Curtin University Department of Spatial Science of a Health Research Fellow, Dr Ori Gudes. New research in the field of geocoding started in 2012 and external infrastructure funds were secured to support the spatial data management of core Western Australian health datasets.

In November 2012 two international spatial health experts were appointed as Science Directors. Professor Clive Sabel (Bristol University) and Professor Geoffrey Jacques (University of New York) strengthen international links and bring valuable perspectives to the program. The Science Directors and CRC SI researchers joined other members of the Global Spatial Network (GSN) to form an international advisory group on spatial health research. The GSN Swedish partner, Future Position X, called on this group when developing a competitive proposal for innovation funding titled Geo Life Region. The proposal was successful and work continues to establish joint research programs under the Geo Life Region program.

Three new PhD students have started spatial health projects at Curtin University (Spatial Science Department), QUT (Mathematics) and University of Canterbury (Geography), a true reflection of the interdisciplinary nature of the program. Ms Narelle Mullan, seconded from the WA Department of Health, is the Program Manager and the Program Board is chaired by Professor Tarun Weeramanthri, WA's Chief Health Officer and Executive Director, Public Health and Clinical Services. The Program produced two book chapters and one refereed journal paper in 2012-13.

Program 4.5 (Urban Planning) is developing spatial tools and strategies to support decision-making processes in urban planning for Australia and New Zealand. The Program aims to facilitate enhanced access to and use of diverse spatial information resources (data and software

tools) to support improved professional and community engagement, decision making and investment decisions in our major cities. The Program Director is Professor Peter Newman from Curtin University in Western Australia.

The largest project in the Program is Project 4.51 – Greening the Greyfields. The project team has been working with case study local governments in Western Australia and Victoria in partnership with Landgate (WA), the Department of Planning (WA), the Department of Planning and Community Development (VIC), and the Department of Sustainability and the Environment (VIC) to deliver a demonstrator decision support system capable of assisting planners and stakeholders in formulating housing redevelopment strategies in the aging middle suburbs. Next stages of the project (Project 4.55) will involve a growing partnership with the Australian Urban Research Infrastructure Network (AURIN) to develop a web-based visualisation and assessment platform enabling planners and community members to engage in the virtual redevelopment of housing precincts, and then subsequently evaluate the performance of redevelopment scenarios according to a variety of key performance indicators (KPIs). The next stages will also 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 for urban growth.

Other projects in Program 4.5 include Project 4.52 – Augmented Reality in Urban Planning and Project 4.53 – Adoption of Spatial Information Tools in Urban Planning, both of which are developing spatial tools for use by planners. The Program produced one book, six book chapters, nine refereed journal articles, and two refereed conference papers in 2012-13.

Summary of Research Program Highlights

3D positioning in obstructed environments enhanced through GPS + BeiDou integration

The new Chinese BeiDou (BDS) satellite navigation system has recently achieved operational status in the

Asia-Pacific region. On the back of this achievement, the Project 1.01 team, based at Curtin University, has investigated for the first time the impact and advantages of simultaneously tracking both BDS and GPS satellites to achieve precise, real-time kinematic positioning for Australian users. The research, set for publication in the Australian Journal of Spatial Science, demonstrates that robust, instantaneous GPS+BDS real-time kinematic positioning with centimetre accuracy is possible even in environments where satellite positioning would normally be possible (e.g. open-pit mines, urban canyons and areas of high signal reflection). From a practical perspective, the research proves that a combined BDS+GPS solution can enhance the usability and reliability of satellite positioning technology, building user confidence when employing satellite positioning technology, particularly in environments not normally suited to such technology.

JAXA and CRCSI demonstrate LEX signal performance in Australia

The Japanese Aerospace Exploration Agency (JAXA) has launched the first satellite in its planned Quasi Zenith Satellite System (QZSS). The satellite, known as Michibiki, transmits the LEX (L-band experimental) signal in addition to the routine positioning signals and



Figure 8: LEX-based positioning from the QZSS satellite

thereby allows real-time precise point positioning (PPP) at the centimetre level, with a suitably equipped receiver. In partnership with JAXA, CRCSI Project 1.11 has successfully performed the first live demonstration of the QZSS LEX signal in Australia. The demonstration took place at the IGNSS Symposium in Surfers Paradise, Queensland in July. Conference attendees witnessed LEX-based positioning via a live video stream and a parallel real-time map display of the receiver trajectory in the symposium auditorium. While capturing the imagination and appreciation of the expert IGNSS audience, the activity caused many Gold Coast tourists to wonder what the fuss was all about. (Figure 8)

This first time demonstration was significant in that it showed how the QZSS LEX signal could potentially be used as a satellite based augmentation system to support of the National Positioning Infrastructure (NPI) vision of instantaneous, high accuracy positioning, anywhere, anytime.

Realisation of a 3D-image enhances automated feature extraction

Project 2.02 researchers have developed and implemented a new method for automated, multi-modal data registration. This innovative approach, based on Mutual Information Theory, allows fully automatic, high accuracy registration of aerial imagery and LiDAR point clouds, to both practically realise a 3D image and greatly enhance robust feature extraction and object reconstruction. This research has contributed to more robust automated building extraction from aerial imagery and LiDAR, and has improved segmentation within LiDAR point clouds to provide better automated roof modelling. The operational impacts of this research will be enhanced production processes for feature extraction for mapping in general, and 3D building extraction and modelling in particular (Figure 9). The new approach will also potentially facilitate more comprehensive change detection for urban mapping, GIS and environmental monitoring when employed to provide higher-accuracy multi-temporal image registration.



Figure 9: (top to bottom) Overlay of the registered point clouds and image; Close view of the details; and LiDAR point clouds colored by the corresponding pixels of the RGB imagery

Further efficiency gains in airborne power line inspection

The project research team at Australian Research Centre for Aerospace Automation (QUT) has developed 3D flight path planning software (with sensor footprint modelling) suitable for challenging situations such as infrastructure inspection near mountains, cliff faces, valleys and coastline. These enhancements are estimated to offer flight length savings up to 20% in some situations (in addition to previous savings offered by earlier developments in the project) along with notable improvements in pilot safety. The new approach also offers a greater degree of flexibility in flight planning, leading to dynamic re-planning and associated efficiency gains. Further, the developed Enhanced Flight Assist System (eFAS) has improved the performance of airborne inspection systems in windy conditions which can affect the height and speed control of the aircraft. Overall, the outcomes achieved through this project are delivering tangible productivity and efficiency gains to the system operators.

Spatial awareness can deliver higher rates of cancer survival

The recent Atlas of Cancer in Queensland report demonstrated that the survival outcomes for people diagnosed with cancer depends on where they live. While the extent of this variation across geographical areas (otherwise known as “spatial inequalities”) was clear, the causes and impacts were not well understood. CRC SI affiliated researchers from the Queensland University of Technology and Cancer Council Queensland were able to separate the impacts of random geographical variation and early diagnosis to determine the proportion of breast and colorectal cancer deaths that could be attributed to spatial inequalities. They found differences in cancer stage at diagnosis explained a substantial portion of the spatial inequalities in breast cancer survival, but there was a greater amount of unexplained spatial variation for colorectal cancer survival. This research quantified the impact of spatial inequalities on cancer survival, showing that 640 (7.6%) breast and colorectal cancer deaths in Queensland could be attributed to the impact of spatial

inequalities. It also identified that greater access to breast cancer screening and diagnostic facilities in many remote areas could decrease spatial inequalities in cancer survival. Governments and policy makers require this type of quantitative evidence to effectively address health inequities. Detailed estimates for cancer survival have not previously been available in Australia. Results of this research were published “Health and Place”.

Spatial support for better urban re-development decisions

Cities in Australia are growing at an unprecedented rate and the pressure to identify areas to accommodate new housing is increasing. Conventions have seen urban growth boundaries being pushed outward with a consequent proliferation of urban sprawl. The economic, social and environmental costs of this form of urban expansion make it unsustainable in the long term. New state planning policies and strategies are therefore beginning to require a greater focus on in-fill development

through the middle suburbs. To support this new paradigm, this research aims to develop new spatially intelligent tools and techniques for identifying “greyfield” precincts for priority redevelopment.

In the past year, the project team has completed a prototype spatially based decision support system for assisting planners, developers and other stakeholders in creating plans and strategies for optimal greyfield redevelopment. The software, trialled by State agencies and local government authorities in Victoria and Western Australia, has shown the value of accessing spatial information and applying spatial logic to evaluate redevelopment scenarios. To drive utilisation, the CRCSI is collaborating with the Australian Urban Research Infrastructure Network (AURIN) to convert the developed tools into a web service accessible through the AURIN portal. The new software will include Multi-Criteria Evaluation (MCE) capabilities, a tool for identifying properties with a high redevelopment probability, a

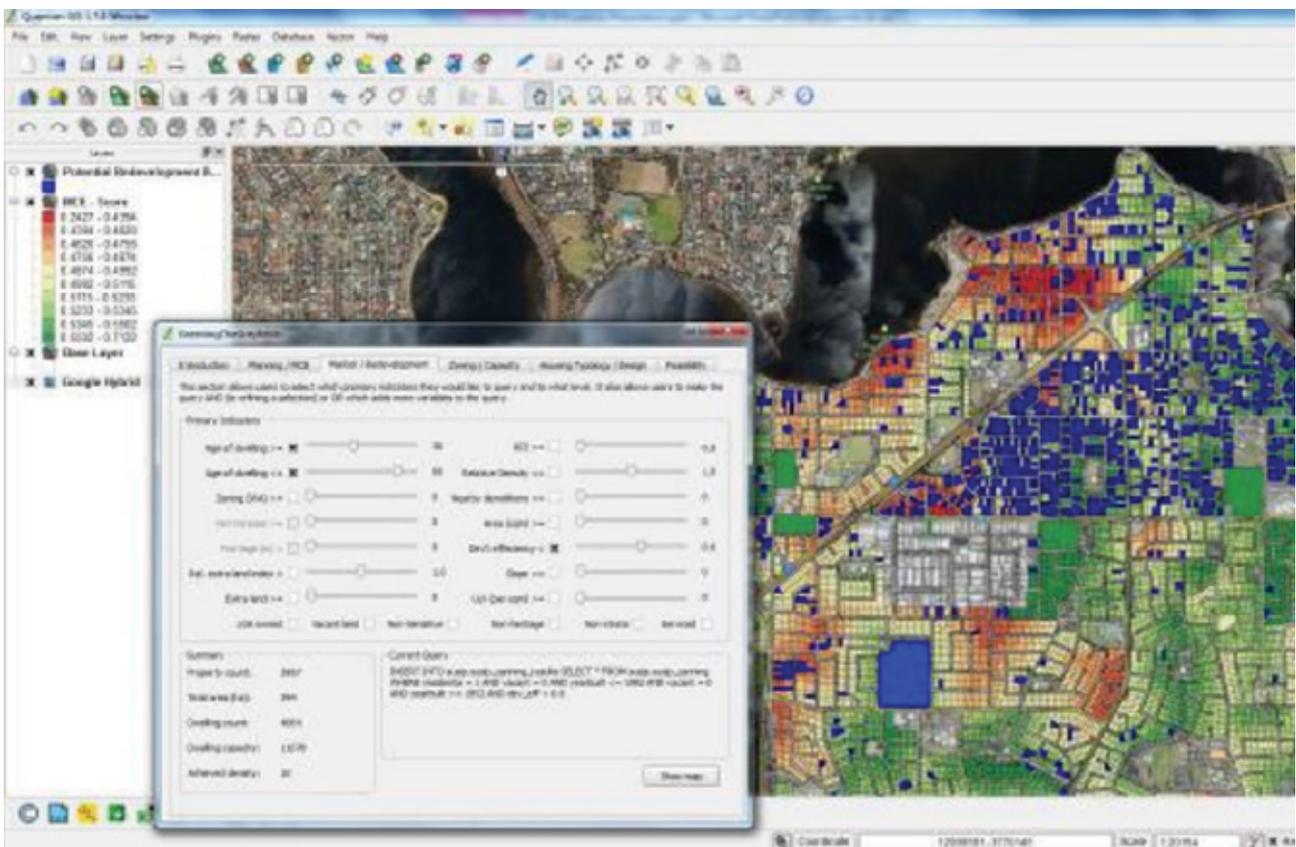


Figure 10: An example output from the ENVISION demonstrator system. The thematic map displays strategic redevelopment suitability with properties characterised by having a high redevelopment potential shown in blue.

rezoning tool, and a tool for analysing dwelling yields if lot amalgamation could be achieved. The online version of ENVISION will connect to AURIN's data hub and utilise datasets via web services, reducing the need for users to source their own data.

Extent to which the CRC SI is on target to achieve its research outputs

For 2012-13 the CRC SI met 20 of its 27 Research Milestones and seven of 12 Utilisation Milestones. With regard to the research milestones, R3.1.3 will be delivered by ANZLIC and so will be re-categorised as a Utilisation Milestone. R3.4.3 will not be met, but the shortfall will be made up by above quota students in other areas and by the work of a part-time Research Fellow. Milestones R4.3.5; R4.4.4 and R4.5.8 will be met but will be delayed by up to twelve months. In relation to the Utilisation Milestones, U3.2.2 will not be met and the continuing relevance of this milestone needs to be assessed. U4.3.4, U4.3.5 and U4.4.4 will be met but will be delayed by up to twelve months. 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 the research outputs is partially evidenced by the number of refereed journal articles and globally notable refereed conference publications through the period. A list is provided separately in this report. In addition the emerging uptake of a number of research outputs (noted mainly under the Utilisation section of this report) further acts as an indicator of quality and achievement.

Any issues, including technical or scientific impediments

The 2012-13 year has seen the major issue impacting on the performance of the CRC SI overcome – namely the definition and initiation of the research activities in Program 3. This Program now has a clearly articulated and fully supported research strategy, with one major project

underway, two joint projects approved for an early start in 2013-14 and a number of proposals for new research at the drafting stage. With this notable achievement, and early signs of good progress, the overall research portfolio is reaching capacity and functioning productively. There are no substantive impediments impacting on research progress.

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

All CRC SI projects have end user involvement either as direct project participants or via a rigorous consultative process. These participants are drawn from the academic, government and private sectors, supported by the increasing uptake of research outputs amongst 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 dominated by end user members, ensures that the research is designed to meet their needs.

Any changes proposed to future research directions

At present there is no evidence to suggest that substantial changes in the research directions of the CRC SI will be required. The potential for future change is acknowledged, however, either based on research results and their end user implementation or from developments from the external environment. The CRC SI will continue to be vigilant in evaluating the ongoing viability and relevance of current research directions and in the early identification of new research directions as these emerge.

Publications

As shown in Appendix 1, over 100 separate publications were produced in 2012-13, including one book, 15 book chapters, 26 refereed journal articles and 50 papers in refereed conference proceedings.

3.3 Utilisation and commercialisation

Extent to which the CRCSI is on target to achieve its utilisation/commercialisation outputs

The CRCSI accomplished seven of its 12 utilisation output milestones for 2012-13 and completed a further four ahead of plan. It is expected that the outstanding utilisation milestones will be met in 12-13. The current outlook for the 2013-14 year is that two will be completed by late calendar year 2013, with a further three milestones on track for completion by June 2015.

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

Milestones that require concentrated effort in 2012-13:

- 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 CRCSI anticipated the utilisation milestones of U4.3.4: roll-out to two further Health agencies, and U4.3.6 Health researchers from universities use results of geocoding positional error sensitivity research would be complete by 2012-13. 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 2013-14 by securing commercial partners to assist with achieving the CRCSI milestones.
- Utilisation 4.4: Usage for Output 4.6 (Data,

metrics, visualisations, scenario projections and communication tools) will be used by policy makers, planners and regulators across the three tiers of government and key user communities (developers, professional advisers, financiers, business, industry and community). The take-up pathway will commence with trial and demonstration initiatives conducted with large project partners (User Group B consists of large organisations eg Victorian Department of Planning and Community Development). Large users are characterised by annual throughput of 25 or more projects and the size and diversity spread of such projects. User Group A consists of SME scale planning groups, developers and Local Governments. The CRCSI anticipated the utilisation milestones U4.4.3: two further Group B deployments and U4.4.4: Status Implementation Report completed on initial trial projects covering first three end user Group B deployments would be completed by 2012-3, however this uptake will be completed in 2013-14 with the assistance of commercial partners and a follow-on project.

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 CRCSI proposals before the Board will approve CRCSI 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.

During 2012-13 licence income was received from Ergon Energy. Ergon is now rolling out flight planning software to multiple aircraft to enable timely, effective capture over their entire powerline distribution network.

If no participant desires to utilise the IP then SISR is free to utilise the CIP in the manner it sees fit.

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 2012-13 activities included:

Project National Data Grid Project - Enhanced Platform for Environmental Modelling was adopted by both Geoscience Australia and Victorian Department of Sustainability and Environment. In addition CRCSI is a consortium member to the project titled 'Unlocking the LANDSAT archive for future challenges' (ULA) led by Lockheed Martin Australia. The project is funded by the Australian Space Research Program and the \$3.4M initiative aims to build earth observation infrastructure to enable ongoing processing of the national LANDSAT imagery archive currently housed at Geoscience Australia.

The ULA project represents a fundamental shift away from on-demand processing of raw scene-based Landsat data to produce bespoke data products to the automated generation and use of standardised, well calibrated, products at the national scale. This data was populated in the National Nested Grid (NNG).

The infrastructure outcome from this initiative is continuing to be developed by the consortium partners and it will be operationalised by Geoscience Australia. This initiative will utilise CRCSI-1 Centre Intellectual Property created under the National Data Grid project. Both of these CRCSI-1 projects have resulted in successful prototype installations in government partners and implementation of further instances of NDG is the next phase of development. Note that this is a successful implementation of Research Output 3.6. During 2012-13 the decision was made to also release accompanying IP relating to enabling software, the Rastor Storage Archive as open source to encourage broader adoption of the overall solution amongst government.

Project 2.02 Topographic Mapping Feature Extraction (Barista) The CRCSI Barista software system was more widely adopted in 2012-13 being used by additional 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 two companies 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. The Project Leader was from the end user organisation Landgate, and subsequently moved to the start-up company.

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. The IndjiWatch online service currently watches hundreds of thousands of kilometres of the interconnected electricity network through most of eastern Australia from Queensland to Tasmania. It also operates in the USA and Canada. IndjiWatch assesses the impact of over twenty million natural phenomenon events, such as lightning strikes, per month on this network. iintegrate Systems continues to maintain its product with Australian and US energy customers.

Scanalyse Pty Ltd (www.scanalyse.com.au), a spin out company of CRCSI funded research employing over 20 people was sold in March 2013 to Outotec, a Finnish minerals and metals processing technology and services supplier. This resulted in CRCSI selling its stake in Scanalyse. The Scanalyse CEO commented that ‘It is a great move from a Scanalyse point of view as we can now tap into Outotec’s global network and rapidly

expand our reach. This is precisely what the business needs to do’. Outotec’s global centre of excellence in grinding is in Perth, and the Scanalyse operations will remain. MillMapper™, Scanalyse’s first commercial product release was a world first and has international patent protection. MillMapper™ is a three-dimensional laser scanning and modelling technology and service for monitoring rates of wear in milling and other mining operations. It reduces maintenance costs, increases productivity, improves safety and offers greenhouse savings in the energy-intensive operations. It represents a quantum leap in the in-situ measurement, modelling and management of grinding mill liners and grinding media previously based on visual inspection or manual measurement inside dangerous grinding mills. Now established and operating on mine sites around the world, this technology has become standard operating practice in all progressive mine site milling applications. Operators are now able to make decisions based on solid measurement data and robust analyses. Based in Perth, Western Australia, Scanalyse has operations in Australia, and North and South America and has worked in over 60 different mine sites around the world.

3.4 Education and Training

The CRCSI made good progress towards ‘improving the skilled capability of the Australian and New Zealand workforce’ working with the key stakeholders through the National Spatial Education Leadership Group. The Group comprises senior representatives of all of the lead bodies in the spatial industry from government, the private sector and the university and vocational training sectors. The CRCSI led the development of the Terms of Reference for the Group. With the full endorsement of the Group, the CRCSI funded a project to assess the skilled capacity shortage, supply and demand, using Queensland as an initial test case. Following development of a nationwide scaling-up of findings, a recommended suite of measures to improve the national skills shortage will be prepared.

Nine post-graduate students commenced in 2012-13 with either full or top-up Scholarships, bringing the total cohort of continuing and commencing students to 41 at 30

June 2013. During the year, two students completed their studies, thus we have in total 43 current or completed post-graduates and are on track to meet and exceed our Commonwealth target of having invested in (enrolled or graduated) at least 50 PhDs and Masters with our university partners by 30 June 2018. A full list of CRCSI PhD completions for 2010-13 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

The CRCSI has an unmet milestone relating to the recruitment of postgraduate students in Program 3.



Figure 11: Nathan Quadros CRCA Awards 2013 - Early Career Finalist

Milestone 3.4.1: One Masters and three PhDs commenced). The role of PhDs in developing Program 3 outputs has diminished relative to initial expectations and has been overtaken by a requirement to use established researchers and software developers. While the achievement of the set Program 3 milestones for PhD enrolments will continue to be challenging, overall, other programs are exceeding the CRCSI postgraduate targets.

Details of the education / training activities conducted during the reporting period, including postgraduate, undergraduate, vocational education and training (VET) and professional development

Postgraduate: CRCSI-supported students are all invited to the Annual Conference which includes a workshop specifically for students with the workshop program set by the students in consultation with senior management. A mentor scheme has been put in place to offer general support and advice and awareness of CRCSI issues and opportunities.

Undergraduate and VET: While the CRCSI is not active in this field, we do support overall skills provision to the industry through participation in national fora and planning, such as the National Spatial Education Leadership Group.

Professional Development: 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. Continuing Professional Development courses are offered within the CRCSI programs as required, and during 2012-13 the CRCSI ran focussed training courses in remote sensing and Python scripting for its PhD students. In addition introductory courses for health professionals have been actively supported by the CRCSI through 43pl.

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.

Evidence of the level of involvement of end users in developing and conducting education / training activities, including the supervision of postgraduate students

Each student is required to have an external end user adjunct supervisor. End user supervisors are present at student events and at the annual conference and workshops. Guest lectures are sometimes given by 43pl members in CRCSI university courses.

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. The CRCSI's current student population is drawn from 13 different nations representing a diverse range of cultures and prior experiences. 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 member company
- one is working in a non-member company
- eight are in academia or other research institutions
- one is a Research Fellow on a CRCSI project
- three 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 2012 Conference showed that 100% of respondents either agreed or strongly agreed that the conference was useful. Of all respondents, not just students, 96% agreed or strongly agreed that the conference 'met or exceeded expectations', and 73% 'identified potential applications of new technology or innovation'.

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

3.5 SME Engagement

CRCSI strategy for engaging with SMEs

SMEs are deeply integrated into CRCSI's activities. CRCSI has a unique structure for its international 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 Communications Director. 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

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 2013 the 43pl Directors were Tony Wheeler (Independent Chair), Jack de Lange (Queensland), Jim Curnow (SA and NT), Chris Earls (WA), Ed Garvin (NSW & ACT), Rob Rowell (Tasmania and Victoria) and Simon Jellie (New Zealand & International).

The current membership of 43pl is 47. The number fluctuates as companies merge, leave the industry, spin off new companies or choose to leave the CRCSI. An additional number of companies are partners by exchange of letters but are not members. New applications for membership of 43pl are encouraged.

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.



Figure 12: CRCSI Program 3 Science Director, Professor Geoff West and CRCSI Health Program Manager Ms Narelle Mullan present at the West Australian Roadshow in Perth in May 2013.

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

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
- Access to R&D initiatives and IP for commercialisation, eg Scanalyse: a spin off company based on the CRC SI 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.

3.6 Collaboration

The CRC SI has a detailed database of all participants and key stakeholders. It monitors about 130 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 CRC SI, and Management's view of how well the CRC SI is performing in relation to meeting those expectations. This analysis is quantified and reviewed at least annually.

The CRC SI has many participants across Australia and in New Zealand. Most 43pl companies and some external companies had formal collaborative arrangements with the CRC SI 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 CRC SI when judged by the number of organisations prepared to participate. Fostering a CRC SI culture of excellence in cooperation is important to the Board and Management. The CRC SI is a collaborative enterprise and this is practiced in various ways.

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

The CRC SI 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 CRC SI'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 CRC SI. 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 Institute for Child Health Research 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 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.

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 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 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



Figure 13: Perth roadshow 2013.

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); 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 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 which “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.
- GEOIDE Network - based at the University of Laval in Quebec, Canada (analogous to the CRCSI), funded as a Canadian ‘Network of Centres of Excellence’ (<http://www.geoide.ulaval.ca>)
- Chinese Academy of Sciences (CAS) - A collaborative research agreement underpins joint activities that are being developed, in particular through CAS's Centre for Earth Observation and Digital Earth (CEODE).
- 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: Canada (GEOIDE), South Korea (Korean Land Spatialization Group), Mexico (Centro-Geo),

Sweden (Future Position X) and two affiliate partners; European Union (AGILE) and the US (UCGIS). Iran and Ireland are also expressing interest in joining. CRC SI supported a successful Future Position X bid to establish a major funding stream in the health area with a view to expanding the CRC SI Health Program’s reach and impact.

3.7 Other activities

This section covers the more significant activities that have occurred complementary to the research activities specified and funded under the Commonwealth Agreement.

The Urban Digital Elevation Model Project and Development of a 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.

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.

In recent years 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 Climate Change and Energy Efficiency (DCCEE), Geoscience Australia (GA), and the CRC SI.

The Urban Digital Elevation Modelling in High Priority Regions (UDEM) project has implemented a model of



Figure 14: A digital surface model (DSM) generated by airborne LiDAR showing the port area in of Nuku'alofa, Tonga. The aerial imagery captured as part of this project is shown over the water.



Figure 15: An airborne LiDAR point cloud captured in an area of Vanimo, PNG for the Pacific Island project with DIICCS RTE.

improved management and governance of a fundamental, national elevation dataset. During 2012-13 outcomes included:

- 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. 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?”
 - Consistent technical requirements for contracting bathymetric LiDAR surveys in Australia have been developed. The bathymetric LiDAR specifications are currently under review by the Intergovernmental Committee for Surveying and Mapping (ICSM) Bathymetry Working Group.
 - A report titled ‘Vertical datum harmonisation across the littoral zone has been completed. It addressed questions such as “What is the best method to integrate land-based DEMs with near-shore bathymetric DEMs?” The project produced a Demonstration Tool as proof of the coastal vertical datum transformation concept which is available for download. A more comprehensive tool is under development and will be made available in 2013-14.
 - Work was completed on the the usability of Hydro-DEMs for modelling coastal and floodplain inundations. The work summarises three research reports provided by Sinclair Knight Merz (SKM) and Cardno and it addressed “When is additional processing such as Hydro-enforcement and Hydro-conditioning necessary for DEMs used to model floodplain and coastal inundations?”
 - Reports finalising research into the integration of Multi-Resolution DEMs produced Demonstration software (available for download) which addressed user needs for differing resolution DEMs and “What is the optimal process for developing DEMs of differing resolutions?”
 - A sea level rise communication products has been developed and will be made available in 2013-14.
- The UDEM project has demonstrated world best practice

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

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

Kokoda Project

In 2008, Australia and Papua and New Guinea committed to cooperate and work together for the protection and sustainable use of the natural and cultural resources of the 40,000 square kilometers that make up the Owen Stanley Ranges region including the Kokoda Track. The Australian Department of the Environment, Water,



Figure 16: The Kokoda Trail

Heritage and the Arts (DEWHA) has assisted PNG Department of Environment and Conservation (DEC), to develop spatial systems and databases to support the land use planning requirements of the Kokoda Initiative and development of a Sustainable Development Masterplan for the Brown River Catchment, Kokoda Track and Owen Stanley Ranges region. The CRC SI assisted in the development of the following key datasets through the provision of high spatial resolution, digital elevation data for slope analysis, drainage delineation and flood modelling using Earthdata aerial GeoSAR and Japanese satellite PALSAR radar data:

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

These datasets were required to assess the suitability of the Owen-Stanley Ranges and adjacent high-relief hills and foothills for logging, susceptibility of the cleared landscape to erosion, line of site visualisation and to assess the suitability of these areas for different land uses. Activities in 2012-13 finalised the project and handover and training of local staff to use the tools and data developed.

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

The CRC SI 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. Updated versions are being regularly delivered to the AGO. Specific



Figure 17: Nathan Eaton (NGIS), Matthew Hammond (NGIS), Laura Gerstenberg (DIICCSRTE) and Nathan Quadros (CRCSI) in Nuku'alofa, Tonga for the training and capacity building scoping mission.

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

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

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 recently captured high resolution elevation data will improve the accuracy of inundation modelling and subsequently the estimation of risk to coastal infrastructure and communities. All of the airborne LiDAR and imagery surveys used as a basis for this project were conducted and delivered by another 43pl partner, AAM Group. During this earlier stage of the project the CRCSI provided technical specifications, area selections and technical assistance to the airborne capture. The NGIS component of the project seeks 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.

4.0 Performance Review

The CRCSI Performance Review was completed in May 2013 with the formal response provided by the CRCSI in July 2013. The CRCSI will address CRC Review recommendations during the 2013-14 year in accordance

with the Review Implementation Plan below and report details relating to the proportion of recommendations implemented, strategies for implementing any remaining recommendations and any difficulties anticipated by the Board in relation to any of the recommendations in the subsequent Annual Report.

2013-14 IMPLEMENTATION PLAN		
Rec	Description	Time Frame
Recommendation 1. The Panel recommends the CRC clearly defines, articulates and promulgates the economic benefits of its research programs. This includes the financial, social and environmental value that is being returned to participants as well as the prospective benefits to the wider community.		
A	Formulate plain English descriptions of the nature and benefits of each research output to partners and research teams.	From Sept 2013
B	Bring up-to-date our Impact Tool. Disseminate and communicate key Impact Tool analyses and forecasts in conjunction with a new CRCSI communication strategy.	Sept 2013
C	Brief our researchers, students, 43pl members, other partners and wider stakeholders through a variety of means, to equip them to articulate the benefits to others.	Dec 2013
D	Provide our annual Highlights Report to all partners accompanied by clear impact and benefits statements.	Dec 2013
E	Review website content to ensure it is up to date with the latest activity and impacts.	Sept 2013
F	Maintaining our public profile at conferences and in the media as part of the new Communications Strategy.	Dec 2013
Recommendation 2. The Panel recommends the CRC implements a more rigorous process to determine the commercial value of its IP, and options for maximising return on investment, before placing IP under Creative Commons licencing arrangements.		
A	Review process for commercialising IP and maximising return on investment to see where it can be improved, in particular to provide greater support to our plans to become a stand-alone entity post CRC Program in mid 2018	Aug 2013
Recommendation 3. The Panel recommends the CRC considers potential alternative business and delivery models to those that are currently being used. For example, 'freemium' vs. premium models for uptake of the CRC's outputs. This includes assessing the cost / benefit to determine when the CRC should provide consulting and contract services.		
A	Review suggested literature and practices and its application to CRCSI current and future commercial activities	Aug 2013
Recommendation 4. The Panel recommends the CRC develops and implements a strategy to 'socialise' the work and objectives of the CRC to participants, potential end-users, and the wider community. This should occur at the same time as further development of the research activities to improve awareness and prepare for uptake and utilisation of the CRC's outputs.		
A	Redevelop Communications Strategy to incorporate development of (1) a strong network of domain specific champions; (2) increased media communications (traditional and social media); and (3) increased speaking in fora that raise awareness of CRCSI benefits (outside presenting technical and research outcomes)	Dec 2013
B	Work with the domain champions to develop a strategy for broader communications in the applications areas of the CRCSI	Dec 2013
C	Generate through traditional and social media greater awareness of our activities and achievements	Dec 2013
D	Emphasise conference speaking in fora that raise awareness and indicate CRCSI benefits, rather than simply presenting technical and research outcomes	Dec 2013
E	Re-evaluate the opening up of our Annual Conference to attendees from non-partner organisations through a managed process.	Nov 2013
F	Placing an increasing emphasis on the CRCSI conference and roadshows	July 2013

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2013-14 IMPLEMENTATION PLAN		
Rec	Description	Time Frame
<p>Recommendation 5. The panel recommends the CRC considers the feasibility of establishing additional regional nodes and/or improves or expands existing regional office activities in order to foster broader regional promotion and engagement.</p>		
A	Audit CRCSI presence in all relevant locations and develop an appropriate action plan to raise each node's profile and engagement	Oct 2013
B	Use Annual Conference, roadshows and allied workshops to explore further node development and promote regional promotion and engagement	Nov 2013
<p>Recommendation 6. The panel recommends that CRC management takes appropriate steps to improve linkages and awareness at the lower levels of the organisation, for example between research projects as well as within and across the different research programs.</p>		
A	Provide Project Engagement Plans and Utilisation Plans to a wider group of our stakeholders.	Sept 2013
B	Using conferences, roadshows, project workshops, and allied activities to attract a wider group of stakeholders in our partnering organisations.	July 2013
C	Develop and implement student conference days and colloquia series.	Dec 2013
<p>Recommendation 7. The panel recommends the CRC appoints a dedicated education and training manager to provide coordinated support and ensure ongoing professional development for graduate students. And</p> <p>Recommendation 8. The panel recommends the education and training manager develops a more robust induction package to fully inform students of the scope and objectives of the CRC, and enable them to gain early benefit from the CRC's networks. The role would also involve the recruitment of future cohorts of students and extending recognition of the CRC and the CRC program into educational communities.</p>		
A	Appoint an education and training manager.	Nov 2013
B	Implement a new student induction package and extend recognition of the CRCSI.	From Jan 2014
<p>Recommendation 9. The panel recommends the CRC engages with universities beyond the current participant universities, within both Australia and New Zealand, to improve its branding and to attract potential students, including from disciplines beyond those traditionally associated with the spatial information industry.</p>		
A	Implement measures to grow our brand awareness and widen our recruiting catchments in relevant universities, from government and industry.	Dec 2013 (and then ongoing)
<p>Recommendation 10. The panel recommends the CRC seeks additional funding for their scholarships and educational programs from a wider variety of sources, including industry and Government sources (e.g. AusAid, NHMRC, ARC and other funding agencies).</p>		
A	Implement appropriate management processes to review alternate sources of funding which complement CRCSI funding at each opportunity.	Oct 2013
<p>Recommendation 11. The panel recommends the CRC seeks additional funding for their scholarships and educational programs from a wider variety of sources, including industry and Government sources (e.g. AusAid, NHMRC, ARC and other funding agencies).</p>		
A	Redevelop the Communications Strategy to address all recommendations that have a communications component including 1, 4, 5, 6, 7, 8, and 9.	Dec 2013
<p>Monitoring the Implementation of this Plan.</p>		
A	The Board will monitor at each of its quarterly meetings the implementation of this Plan.	Quarterly
B	An annual report on progress with respect to the implementation will be provided to the CRC Program. Related issues will also be reported on.	Annually

Table 14: 2013-14 Implementation Plan

5 Glossary and Acronyms

43pl	43 Pty Ltd, a company representing the CRCSI's SME consortium
AGRI	Australian Geographic Reference Image
ALOS	Advanced Land Observation Satellite
ANZLIC	ANZLIC - the Spatial Information Council formerly known as the Australia and New Zealand Land Information Council
ASC	Australian Spatial Consortium
AURIN	Australian Urban Research Infrastructure Network
ASPRS	The American Society for Photogrammetry & Remote Sensing
CAS	Chinese Academy of Sciences
CEO	Chief Executive Officer
CEODE	Centre for Earth Observation and Digital Earth, Chinese Academy of Science
COAG	Council of Australian Governments
CORS	Continuously Operating Reference Station
CRC	Cooperative Research Centre
CRC Program	Secretariat of the DIISRTE 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
EIPT	Economic Impact Performance Tool
DCCEE	Australian Department of Climate Change and Energy Efficiency
DEC	PNG Department of Environment and Conservation
DEM	Digital Elevation Model
DEPI VIC	Department of Environment and Primary Industries Victoria
DEWHA	Australian Government Department of Sustainability, Environment, Water, Population and Communities.
DIGO	Defence Imagery & Geospatial Organisation Australia
DIICCSRTE	Commonwealth Department of Industry, Innovation, Climate Change, Science, Research, and Tertiary Education
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
GEO	Intergovernmental Group on Earth Observations
GEOIDE	Geomatics for Informed Decisions (Canada)
GeoSAR	Geographic Synthetic Aperture Radar
GIS	Geographic Information Systems
GITA	Geospatial Information & Technology Association
G-NAF	Geocoded National Address File
GNSS	Global Navigation Satellite Systems

GCPs	Ground Control Points
GPS	Global Positioning System
GSN	Global Spatial Network
InSar	Interferometric Synthetic Aperture Radar
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
MOU	Memorandum of Understanding
MRV	Monitoring, Reporting & Verifying
NASA	National Aeronautics & Space Administration (USA)
NCRIS	National Collaborative Research Infrastructure Strategy
NEDF	National Elevation Data Framework
NNG	National Nested Grid
PALSAR	Phased Array type L-band Synthetic Aperture Radar
PERS	Photogrammetric Engineering & Remote Sensing
PNG	Papua New Guinea
PNT	Position, Navigation and Timing
PSInSAR	Permanent Scatter Interferometric Synthetic Aperture Radar
PSM	Public Service Medal
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

6 Appendix 1 - Publications

Program 1: Positioning

Book Chapters

Gu, S., Shi, C., Lou, Y., Feng, Y. & Ge, M. (2013). Generalization-positioning for mixed-frequency of mixed-GNSS and its preliminary applications. Lecture notes in Electrical Engineering 244, J Sun et al (eds), China Satellite Navigation Conference 2013 Proceedings, pp: 399-428

Wang, J. (2013). *A satellite selection algorithm for achieving high reliability of ambiguity resolutions with GPS and Beidou constellations*. Lecture notes in Electrical Engineering 245, J Sun et al (eds), China Satellite Navigation Conference 2013 Proceedings, pp: 3-20

Refereed Journal Articles

Feng, Y. (2012). *Regression and hypothesis tests for multivariate GNSS state time series*. Journal of GPS, Vol 11, 2012. DOI:10.5081/jgps.11.1.33

Rubinov, E., Collier, P., Fuller, S. & Seager, J. (2012). *Review of GNSS format for Real-Time Positioning*. Position IT Journal of GISSA and SAGI, South Africa), September 2012, pp.20-27

Rubinov, E., Wonnacott, R., Fuller, S. & Collier, P. (2012). *Integrity Monitoring of CORS Networks – TrigNet Case Study*. South African Journal of Geomatics Vol. 1, No. 1 (2012) pp.1-13. Online version available from <http://www.sajg.org.za/index.php/sajg>

Teunissen, P., & de Bakker, P. (2012) *Single-receiver single-channel multi-frequency GNSS integrity: outliers, slips and ionospheric disturbances*. Journal of Geodesy DOI 10.1007/s00190-012-058-x

Verhagen, S., Li, B. & Teunissen, P. (2013). *Ps-LAMBDA: Ambiguity Success Rate Evaluation Software for Interferometric Applications*. Computers and Geosciences 54:361-376

Verhagen, S., & Teunissen, P. (2012) *The ratio test for future GNSS ambiguity resolution*. GPS Solutions DOI 10.1007/s10291-012-0299-z

Verhagen, S. & Teunissen, P. (2013) *Ambiguity resolution performance with GPS and Compass for LEO formation flying*. Advances in Space Research. Vol. Online pp. 1-24. DOI: 10.1016/j.asr.2013.03

Wang, C., Gu, S., Chuang, C. & Feng, Y. (2012). *Analysis of regionally enhanced GPS orbit and clock solutions and contribution to improvement of real-time precise point positioning*. Journal of GPS Vol 11

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Choy, S., Harima, K., Li, Y., Wakabayashi, Y., Tateshita, H., Kogure, S. & Rizos, C. (2013) *Real-Time Precise Point Positioning Utilising the Japanese Quasi-Zenith Satellite System (QZSS)*. Proceedings of the IGSS Symposium 2013, Paper 93

Donnelly, N., Fraser, R., Haasdyk, J. & Tarbit S. (2013). *GeodesyML – A GML application schema for geodetic data transfer in Australia and New Zealand*. Proceedings of Surveying and Spatial Sciences Conference (SSSC2013), 15-19 April, Canberra, Australia, 15pp

Gua, S., Shi, C., Lou, Y., Feng, Y. & Liu, M. (2013). *Generalization-positioning for Mixed-frequency of Mixed-GNSS and its preliminary applications*. China Satellite Navigation Conference (CSNC) 2013 Proceedings, Lecture Notes in Electrical Engineering, Vol. 244, Springer-Verlag Berlin Heidelberg.

Li, W., Teunissen, P., Zhang, B. & Verhagen, S. (2013). *Precise Point Positioning Using GPS and Compass Observation*. China Satellite Navigation Conference (CSNC) 2013 Proceedings, Lecture Notes in Electrical Engineering, Vol. 244, Springer-Verlag Berlin Heidelberg, pp. 367-378

Li, W., Verhagen, S. & Teunissen, P. (2013). *GNSS integer ambiguity estimation and evaluation: LAMBDA and Ps-LAMBDA*. China Satellite Navigation Conference (CSNC) 2013 Proceedings, Lecture Notes in Electrical Engineering, Vol. 244, Springer-Verlag Berlin Heidelberg, pp. 291-301

Odolinski, R., Teunissen, P. & Odijk, D. (2013). *An Analysis of Combined COMPASS/BeiDou-2 and GPS Single- and Multiple frequency RTK positioning*. In Proceedings on ION Pacific PNT Conference, 2013 Hawaii

Teunissen, P. (2013). *GNSS integer Ambiguity Validation: Overview of Theory and Methods*. Invited in Proceedings on ION Pacific PNT Conference, 2013 Hawaii

Wang, L. & Feng, Y. (2013). *Fixed failure rate ambiguity validation methods for GPS and Compass*. China Satellite Navigation Conference (CSNC) 2013 Proceedings, Lecture Notes in Electrical Engineering, Vol. 244, Springer-Verlag Berlin Heidelberg, Ch 34

Program 2: Feature Extraction

Book Chapters

Fraser, C. (2013). *The Concept of Self Calibration*. Ch. 10.2.10 of Manual Photogrammetry, 6th ed. (Ed. J. Chris McGlone), American Society of Photogrammetry & Remote Sensing, Bethesda, Maryland, ISBN 1-57083-099-1, 1318 pages, pp. 876-885

Fraser, C. (2013). *Free Network Adjustment*. Ch. 10.2.9 of Manual Photogrammetry, 6th ed. (Ed. J. Chris McGlone), American Society of Photogrammetry & Remote Sensing, Bethesda, Maryland, ISBN 1-57083-099-1, 1318 pages, pp. 885-888

Fraser, C. (2013). *Industrial and Engineering Measurement*. Ch. 13.3 of Manual Photogrammetry, 6th ed. (Ed. J. Chris McGlone), American Society of Photogrammetry & Remote Sensing, Bethesda, Maryland, ISBN 1-57083-099-1, 1318 pages, pp. 1075-1082

Jones, S., Farmer, E., Soto-Berelov, M. & Woodgate, W. (2013). *Validation of remote sensing biophysical products*. Ch 2. AusCover Good Practice Guidelines (A technical handbook supporting calibration and validation activities of remotely sensed data products)

Quadros, N & Keyzers, J (2013). *Airborne LiDAR Acquisition and Validation*. AusCover Good Practice Guidelines (A technical handbook supporting calibration and validation activities of remotely sensed data products)

Schaefer, M., Farmer, E., Soto-Berelov, M., Woodgate, W. & Jones, S. (2013). *Validation of LAI and FPAR products*. Ch. 6. AusCover Good Practice Guidelines (A technical handbook supporting calibration and validation activities of remotely sensed data products)

Suarez, L., Restrepo-Coupe, N., Hueni, A. & Chisholm, L. (2013). *Vegetation spectroscopy*. Ch. 9. AusCover Good Practice Guidelines (A technical handbook supporting calibration and validation activities of remotely sensed data products)

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Awrangjeb, M., Lu, G. & Fraser, C. (2012). *Performance Comparisons of Contour-Based Corner Detectors*. IEEE Transactions on Image Processing, 21(9): 4167-4179

Fraser, C. (2013). *Automatic Camera Calibration in Close Range Photogrammetry*. PE&RS - Vol 79 No. 4 - April 2013

Keyzers, J., Quadros, N. & Collier, P. (2013). *Vertical Datum Transformations across the Australian Littoral Zone*. Journal of Coastal Research. DOI: <http://dx.doi.org/10.2112/JCOASTRES-D-12-00228.1>

Pablo J, Zarcho-Tejada, P., Suarez, L. & Gonzalez-Dugo, V (2013). *Spatial resolution effects on chlorophyll fluorescence retrievals in a heterogeneous canopy using hyperspectral imagery and radiative transfer simulation*. Geoscience and Remote Sensing Letters, IEEE Volume:10, Issue: 4

Quadros, N. (2012). *What Users Want in Their Bathymetry: Bathymetry User Needs and Challenges in Australia and New Zealand*. Hydro International September 2012, Volume 16, Number 6 pp 18:23

Thulin, S., Hill, M., Held, A., Jones, S., & Woodgate, P (2012). *Hyperspectral determination of feed quality constituents in temperate pastures: effect of processing methods on predictive relationships from partial least squares regression*. International Journal of Applied Earth Observation and Geoinformation, Vol. 19 (October 2012), pp. 322-334, DOI:10.1016/j.jag.2012.06.006 Key: citeulike:10959683

Refereed Conference Proceedings

Awrangjeb, M., Zhang, C. & C.S. Fraser (2012). *Automatic Reconstruction of Building Roofs through Effective Integration of LiDAR and Multispectral Imagery*. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume I-3, 2012 XXII ISPRS Congress, 25 August – 01 September 2012, Melbourne, Australia

Awrangjeb, M., Zhang, C. & C.S. Fraser (2012). *An Improved Building Detection Technique for Complex Scenes*. Proceedings of the 2012 IEEE International Conference on Multimedia and Expo Workshops pp 516 - 521 ISBN: 978-1-4673-2027-6 DOI : 10.1109/ICMEW.2012.96

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7 Appendix 2 – PhD Completions 2010-13

Name	Title of Thesis	Graduating University	CRCSI Program
Anna Donets	Using Single Receiver GPS Observations to Analyze the Dynamic Motion of Large Engineering Structures.	Melbourne	1
Jun Wang	RTK Integrity.	QUT	1
Michael Filmer	An Examination of the Australian Height Datum.	Curtin	1
Kui Zhang	Advanced InSAR Technologies.	UNSW	2
Eric Zhengrong Li	Aerial Image Analysis Using Spiking Neural Networks with Application to Power Line Corridor Monitoring.	QUT	2
Alex Ng	PsinSAR Radar Interferometry.	UNSW	2
Matthew Hutchison	Developing an Agent-Based Framework for Intelligent Geocoding.	Curtin	3
Marco Marinelli	Assessing Error Effects in Critical Application Areas.	Curtin	3
Jiang Li	Intelligent Object Placement and Scaling in Virtual Decision Environments.	Melbourne	4
Marcos Nino-Ruiz	Application of Rural Landscape Visualisation for Decision Making and Policy Development.	Melbourne	4
Roman Trubka	Agglomeration Economies in Australian Cities: Productivity benefits of increasing density and accessibility by way of urban transport infrastructure planning.	Curtin	4
Pan Peter Wang	Real-Time Data Visualisation in Collaborative Virtual Environments for Emergency Management.	Melbourne	4
Tao Chen	Augmented Reality Integration and Live Communication between GIS and SIEVE.	Melbourne	4
Haohui Chen	Collaborative Virtual Environment for Knowledge Management - A New Paradigm for Distributed Communications.	Melbourne	4
Michael Schaefer	Advanced Biomass Sensing Using Active Optical Sensors	UNE	4
Marcos Nino-Ruiz	Spatial Model Steering: An Exploratory Approach to Land Use Allocation Under Future Climate Change Projections	Melbourne	4
Adam Roff	Hyperspectral Imagery for Vegetation Management.	UNSW	2
Michael Day	Hyperspectral Remote Sensing for Land Management Applications.	UNSW	2

