Cooperative Research Centre for Spatial Information

The business case for incorporating an agricultural theme into a CRC rebid

Prepared by:

KIRI-GANAI RESEARCH PTY LTD

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Kiri-ganai research

Authors:

Dr Richard Price
Prof Geoff Taylor
Prof David lamb
Dr Isabel Coppa
Mr David Wright
Dr Don Yule

The brief

To provide the CRC SI with a business and scientific case for the inclusion or otherwise of an agricultural theme in a rebid into the next round of Commonwealth CRC Programme support.

The conclusion

- ⇒ There is a compelling case for agricultural industries to invest in the products and services of an innovative spatial information technology sector.
- ⇒ While there are alternative avenues for agricultural industries to direct such investment, a restructured CRC-SI could provide the basis for significantly greater benefits through a focus on breakthrough, rather than incremental, technologies;
  - spatial information technologies would qualify as 'breakthrough' for most Australian agricultural industries
  - the CRC-SI can potentially contribute to the transformation of agricultural industries beyond the capacity of commodity specific approaches to agricultural investment in R&D.
- ⇒ These breakthrough technologies apply to agriculture both on-farm and along the post-farm supply chain.
- ⇒ The incorporation of agriculture as a core theme in a new CRC will provide economic, environmental and social benefits to individual businesses, industries and the nation.

The potential investment portfolio

This business case recommends that a portfolio of agricultural investment needs to take the form of a core program embedded into the CRC rebid structure. This is an advance on current CRC investment across an assortment of unconnected agricultural projects.

By taking a 'program' approach, the intention is to share the strengths of all partners and collaborators, project leaders, researchers, and extension, service and product deliverers so that each activity has the opportunity to extract from and add value to each other activity.

The program structure outlined for the rebid includes four thematic sub-programs plus a cross-thematic sub-program that deals with social, economic, ethical and management issues relevant to agriculture as well as with the overlapping interests shared with non-agricultural programs of the CRC. These sub-programs, outlined in detail in this business case, include:

Sub-program 1	Rapid and cost effective monitoring
Sub-program 2	Next generation precision agriculture
Sub-program 3	Remote and networked farm management systems
Sub-program 4	Market intelligence and supply chain systems
Sub-program 5	Unifying spatial technologies across agriculture and between other sectors and agriculture

The business case

Overview

Agriculture is not one but many industries, each of which represents a different land-use but also involves very different markets and supply chains. The current $31 billion value of farm and fish production is the basis of a $65 billion food processing sector and a $92 billion food retail sector (Ag & Food Reference Group 2006). Both the horizontal and vertical diversity of agriculture provides opportunities for an astoundingly diverse range of spatial information products and services.

Agriculture is the basis of a $188 billion supply chain in Australia

Recent studies of the application of spatial information to agriculture show that there is enormous untapped potential for the production and related transport and processing sectors to markedly increase their efficiency and profitability through strategic and tactical use of the range of existing technologies available. For example, the uptake of precision guidance systems technology in the grain industry has lead to between 10 and 20 percent increases in profitability for the 10 percent of farmers that have thus far adopted it. To date this represents a 1 percent reduction in overall industry costs (10 percent x 10 percent) (Acil Tasman 2007). CSIRO estimates that benefits can range from $14 to $30 per hectare across the grains industry (CSIRO 2007). In Victoria alone, the industry can expect to grow farm income by $418 million through the extension of existing GPS network technology (Allen Consulting 2007).

Exponential growth of the agricultural sector can be expected from next generation spatial information technologies as well as by adapting current technologies to new industries and markets in innovative ways. While the grain, cotton and sugar industries have been the main beneficiaries of terrestrial-based spatial information technologies, higher value production systems such as horticulture provide fertile ground that offer even larger returns. With a value of around $4.5 billion, horticulture is one of the fastest growing agricultural industries with an enormous propensity to use high technology to drive down production costs and increase product quality and monitoring from plant to plate. Taking technologies applicable to farms and paddocks and adapting them to plots, greenhouses and even individual plants takes precision agriculture to another level altogether.

Spatial information technologies can bring benefits to a range of industries

Even in the broadacre industries, the cattle industry in northern Australia can improve pasture utilisation by as much as 300% given the use of better spatial information and forecasts. It is in this region and industry that some of the largest investments in agricultural activity are occurring, with corporate investment from business conglomerates, banks and superannuation funds alike taking advantage of a beef export market growing in response to improvements in the living standards and consumption choices of developing countries such as China and India.

The drivers for adoption of spatial information technologies are converging in favour of such technologies resulting not simply in incremental change to the bottom line of agricultural businesses, but on essentially transforming them. These drivers include the pressure to produce more with less: less water, less labour, less fuel, less chemicals, less fertilizers, less impact on natural resources, less certainty about climate and weather, and less time. At the same time we are seeing more corporate agriculture, more family farms acting corporate businesses, more interactions between disparately located properties, more decisions being made from a distance, more enterprise diversity within and across properties, and more opportunities in the green land use sector (including carbon sequestration and water harvesting).

Spatial information means more than precision agriculture to the agricultural sector. Accurate crop forecasts matching and exceeding the intelligence our competitors' posses will be vital to the marketing and insurance sectors alike. In an increasingly deregulatory environment, knowledge means market power, and spatial technologies can act not only to increase the accuracy of commodity forecasts, but also strengthen the relationships between supply, marketing and demand in export supply chains. Pressure for continuity of supply will require spatial analysis technologies working at different scales for the supply chain: at the marketing level it may require improved knowledge to underpin contracts across Australia, while at the farm scale, it will require improved utilisation of the space available to maximise production under different climatic and cost variables.

With Australian agricultural exports currently valued at around $30 billion, and more than a doubling of food demand estimated by 2050 (Griffon 2006), the prospects for export growth appear excellent, but cannot be taken for granted. Land suitable for agricultural production in South America and sub-Saharan Africa is massively underutilised (22 and 19 percent respectively – see table below), and these continents can adversely affect Australia's export prospects unless Australian agriculture maintains its competitiveness through either massive productivity gains or supplying to niche markets. Spatial information can support both aspirations.

Without innovation, Australian agriculture will struggle to remain competitive

To meet domestic and export demands, Australian grain productivity needs to approximately triple in the next 20 years, hence current market intelligence and supply chain systems will be challenged by expanding production. Real-time access to crop condition and forecasts through remote sensing needs to become common place. It is here that Australia lags behind the world despite the world class capacity we have to exceed international benchmarks.

Sensor technology provides a particularly exciting opportunity for agriculture. Already ear-tagging and monitoring systems are common place in the livestock industries. However, creating sensors that can applied to monitor the health of individual animals on live-export containers or in batteries, the attributes of individual plants and fruits (one sensor per apple for example) in the horticultural and organics industries, or the movement of produce from gate to plate are just some examples of how spatial technology can transform the health, wealth, integrity and respectability of Australian agriculture.

Land available for agriculture in 2000 (10^6ha)

	World	Asia	Latin Amer.	WANA	SS Africa	OECD	Russia
Area cultivated 2000 (a)	1600	439	203	86	228	387	265
Area fitted for agriculture (b)	4400 (IIASA) 4153 (FAO)	586	1066	99	1031	874	497
a/b	39%	75%	19%	87%	22%	44%	53%

Drivers for spatial technology in agriculture

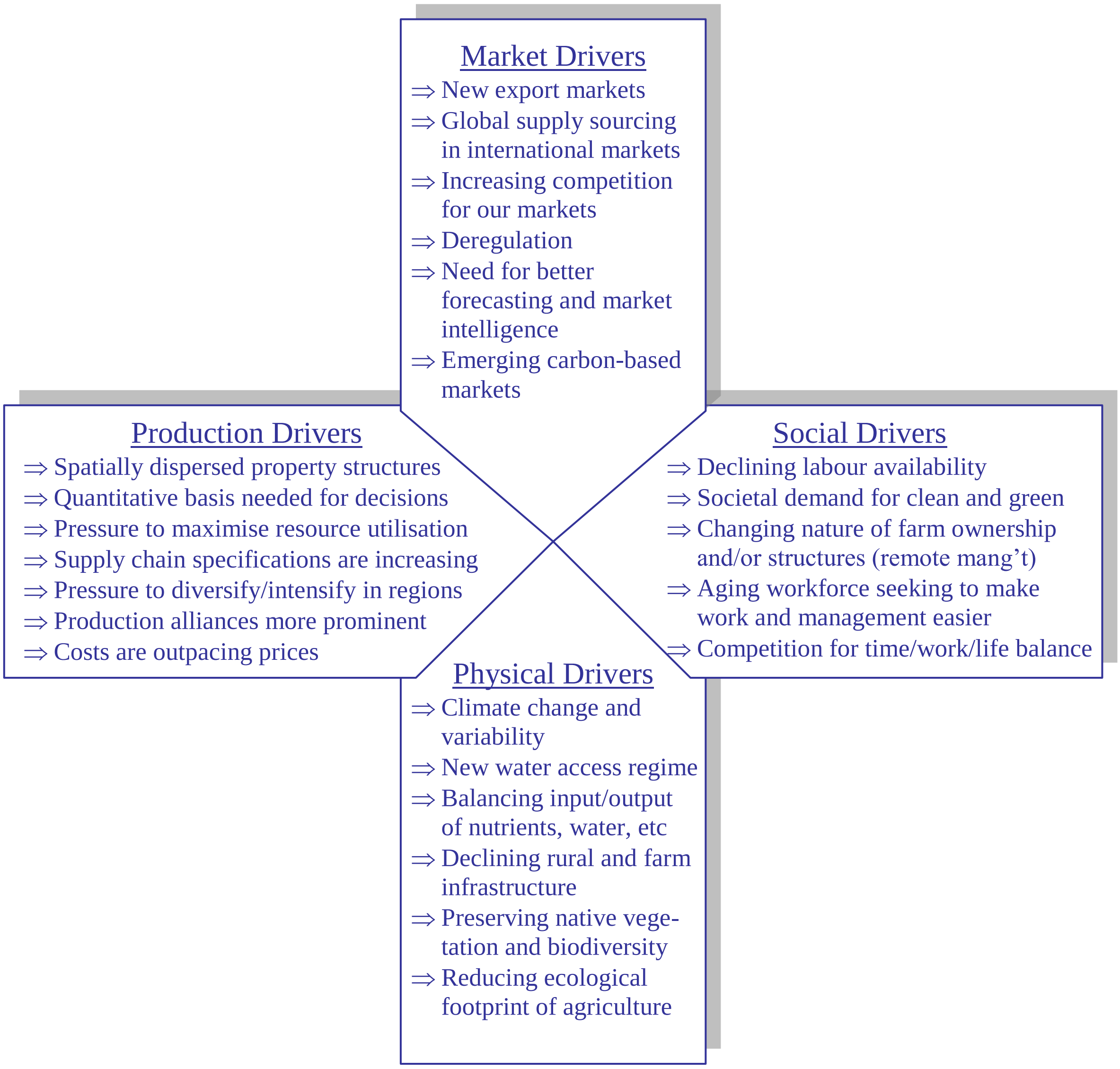
The nature of spatial technology applications is such that they can meet a diversity of management demands associated with agriculture, both on-farm and along the supply chain. However, to this point in time, few agricultural industries have utilised spatial technologies to their full potential, and indeed, many have yet to embrace them to any meaningful extent at all.

While this is an adoption challenge of significant concern, addressing the challenge will lead to inevitable failure without taking into account the shifting operating environment within with agricultural production and related supply chain transactions take place. Indeed, the opportunities arising from these shifts are significant and will result in an inevitable reliance on spatial information technologies for wont of alternative responses.

Drivers of change are shifting in favour of spatial technologies

Innovative farm businesses are already demonstrating a tangible demand for any application that will reduce costs, inputs and reliance on labour and increase efficiency, performance and timely continuity of quality assured supply.

The shifts in the operating environment that will see an increasing call upon spatial information products and services can be summarised as in the following diagram.



Implicit in many of the drivers addressed above is a rapidly changing policy and regulatory environment. Drought and climate change have had an enormous impact on the water debate, which had always been vigorous in an agricultural context in any case. Access to water, and the various regulatory and market-based policy approaches affecting this will have a profound influence on the future of agriculture at the farm and regional scales, but also at the commodity-specific scale. Changing decision variables will change the outcome of what is grown where, when and how.

Likewise, the catchment and regional approach to natural resource management is increasingly narrowing the physical distance between societal expectation, social responsibility and business practice. Expectations that agriculture will reduce its ecological footprint no longer come from faceless, bureaucratic or urban sources, but from neighbours, associates and local communities. Devolved regional approaches to government investment are enhancing collaborative initiatives between industries and catchment authorities to meet triple bottom line aspirations.

Agriculture has always invested in innovation to overcome adversity

Agriculture is one industry that can be relied upon to invest in innovation. Without its significant support for R&D, resulting in productivity gains averaging 2.3 percent per annum for the past thirty years, the declining terms of trade would have seen the annihilation of the sector from Australia's rural landscape. Presently growers invest close to $300 million of their own funds per annum into innovation through a range of R&D corporations. This culture of investment has been a strong driver behind a range of commodity-specific CRCs and, more increasingly, cross-commodity collaborations that seek a greater return on the investment by breaking out of traditional agricultural paradigms.

Challenges presented by agriculture

There is no one agricultural industry or stakeholder base. Its many components can be big and ugly, highly political, diverse, confronting, contradictory, demanding and in many cases frustratingly conservative. It is heterogenous in its essence, with the same diversity of values, perspectives, risk profiles, foibles, energy, intransigencies and behavioural traits across its individuals and institutions as any other sector of society or industry.

The industry's diversity is the CRC's window of opportunity

This makes it difficult to form a relationship with the 'agricultural industry' *per se*, although it does open possibilities for the CRC to interact with individuals and sub-sectors in ways that many traditional agricultural institutions, often tied to particular vested interests, cannot.

This issue is addressed under the target market section of this report. Suffice to say here that the CRC has the freedom to pick and choose to work with the specific agricultural stakeholders it sees as providing the best return on investment, including investment in time, energy and relationship building as much as in financial resources.

Perhaps the single biggest challenge to working with the various sectors of agriculture will be in achieving the levels of adoption that justify the investment made. The uptake of spatial technology across the totality of agriculture has been undeniably poor to this point in time, although it can be argued that a concerted effort has not been mounted. Some of the views expressed by farmers about spatial technology indicate that many individuals:

- ⇒ cannot see the benefits clearly stated in terms of their specific system or aspirations

- ⇒ consider themselves as too old or content to adopt new or high-tech systems
- ⇒ maintain caution about adopting technologies that tie them to ongoing reliance on service provision
- ⇒ remain under the apprehension spatial technologies give governments and/or companies access to data about their business

These concerns need to be taken into account when considering which elements of the industry the CRC would seek to work with. Irrespective of which elements the CRC may work with, they provide important clues as to how the CRC should undertake, extend and communicate its research activities.

The Investment Rationale

The total agricultural area in the world amounts to 5.0 billion ha. Of this, about 1.5 billion ha (30.4%) is arable land and land under permanent crops and 69% is under permanent pastures[1]. By contrast nearly 4 billion hectares of forest cover the earth's surface, equating to roughly 30 percent of total land area. In the past five years as native forests are cleared for agricultural production, total forest area has reduced by a net loss of some 37 million hectares (91 million acres) or 7.3 million hectares, having slowed slightly from 8.9 million hectares lost annually in the 1990s[2].

It's all about how we produce more from less, and with less impact

With world population growth, competing land use and environmental concerns, three key global imperatives, drawn from the drivers outlined previously, are expected to confront agriculture the most over coming decades:

Climate Change Views about agriculture are impacted by deforestation and reduction in carbon sequestration levels, especially in developing countries where conversion of forests to agricultural land is taking place at about 13 million hectares per year. This accounts for between 18 and 25 % of annual green house gas emissions[3].

Global demand for food Today, more than 850 million people are chronically undernourished and unable to obtain sufficient food to meet even minimum energy needs4. Despite clearing of land in developing countries, the "food gap"- the difference between production and demand for food, could more than double in the developing world in the next 25 years where demand for food, largely from animal derived products, is set to double by 2020[5]. United Nations estimates by 2030 more than 8 Billion people will inhabit the earth straining the world's ability to feed itself[6].

Demand for water Analysts forecast that over the coming century water shortages will become an even more critical geopolitical issue than climate change[7].

Given the above, agriculture needs to 'produce more from less' and do so sustainably and profitably. It needs to increase production while achieving net improvements in environmental outcomes (carbon missions and sequestration, water use, soil, biodiversity etc.)

[1] The 2007 Millennium Development Goals Report
[2] http://www.earth-policy.org/Indicators/Forest/2006.htm
[3] The 2007 Millennium Development Goals Report
[4] FAO and FMFH Partners http://www.feedingminds.org/info/info_level.htm
[5] International Food Policy Research Institute, http://www.ifpri.org/PUBS/fps/fps26.htm
[6] www.voanews.com/english/2007-10-16-voa54.cfm
[7] http://www.timesonline.co.uk/tol/news/world/asia/article2689961.ece

Despite agricultural production in Australia representing only a small proportion of GDP (3.1% in 2006), as a major world exporter of food and the world's largest exporter of beef, the key issues raised above establishes agriculture in Australia as a vitally important secor that is ignored at Australia's economic and environmental peril:

⇒ considering the total value of the agricultural supply chain accounts for $188 billion per annum (or nearly 20% of GDP), substantially increased agricultural production from existing land use will result in a significant flow on effect to the Australian economy.

⇒ in the event optimal land use and production of biomass (pasture, crops, livestock, trees) across both intensive and extensive land areas are sustainably increased, agriculture could be largely responsible for a net improvement in environmental outcomes.

From this, three key questions arise:

Question 1 **Does the potential exist to substantially and sustainably increase agricultural production while delivering a net improvement in environmental outcomes?**

Question 2 **Can spatial information and technologies be used to understand and reduce variability and increase biomass production and sustainability?**

Question 3 **Can spatial information and technologies be used to extract similar multiplier benefits along the supply chain?**

Opportunity for Increasing Production: Responding to Question 1

The answer to the first question is unequivocally and resoundingly "Yes".

In support of this statement, given permanent pasture represents 69% of total agricultural land world wide, the following examples in pasture production alone are provided :

i. The Meat and Livestock Australia (MLA) / Heytesbury Pigeon Holes Project demonstrated it is possible to sustainably increase pasture utilisation in the Victoria River Downs in Northern Australia from 10% to 20-30%, potentially a 200-300% increase in production.

ii. In the New England Tablelands, MLA studies assessed average pasture utilisation in the region to be about 30%, yet some producers in the New England are sustainably achieving 70% – 80% pasture utilisation, while others have lifted stocking rates from less than 10 DSE per ha to 28 DSE per ha.

iii. Sundown Pastoral have determined that a 10% increase in pasture utilisation equates to $7.9 Million Gross Margin / year for their cattle operations. Increasing pasture utilisation also increases total pasture production while improving plant root structure and soil structure improving plant resilience and soil water retention means later into drought and sooner out.

Uptake of Spatial Information Technologies in Agriculture: Responding to Question 2

The answer to the second question is a resounding "Yes, but".

Unlike government agencies and other major industries such as mining, telecommunication and energy, farmers are not conventional users of spatial technologies. As indicated previously, the uptake of remote sensing and other precision agriculture technologies in broadacre and intensive cropping has been limited to innovators and early adopters and has been minimal in livestock enterprises.

The use of spatial information for farming has often been criticised for its high cost, poor resolution, lack of timeliness, level of errors, difficulties in ground truthing, data transfer and communication problems and a general lack of decision support tools and know-how in use and application. Consequently there has been a general lack of both knowledge and perceived value.

Many examples exist however which demonstrate the outstanding potential, role and importance of spatial technologies in agriculture, especially in remote monitoring and decision making. This is especially important in cost effectively understanding and managing the reasons for variability in crop, pasture and forest production over large areas. This issue is all the more important with the current skills shortage and drain in labour as a consequence of the mineral resources boom. Examples include:

i. Precision guidance systems technology in the grain industry has lead to between 10 and 20 percent increases in profitability for the 10 percent of farmers that have thus far adopted it. To date this represents a 1 percent reduction in overall industry costs (10 percent x 10 percent) (Acil Tasman 2007). CSIRO estimates that benefits can range from $14 to $30 per hectare across the grains industry (CSIRO 2007). In Victoria alone, the industry can expect to grow farm income by $418 million through the extension of existing GPS network technology (Allen Consulting 2007).

ii. The use of spatial information accounts for 12 per cent of the total GDP of the fishing industry. In particular, remote sensing enables monitoring of fish stocks and movement, essentially dictating the activities and responses of fishermen.

The following table, reflecting the challenges previously noted in respect to broadacre agricultural industries, compares the present value of spatial information to a range of industries. At the same time, however, it demonstrates its enormous potential.

Industry	SI contribution to industry GDP
Grains	0.93%
Sheep	1.35%
Sugar	0.10%
Cotton	0.70%
Forestry	1.93%
Fisheries	12.0%

Uptake of Spatial Information Technologies along the Agriculture Supply Chain: Responding to Question 2

The answer to the second question is a qualified “Yes”.

Tracking agricultural produce from paddock to plate is already occuring in many ways across the food production, processing, transport, wholesale and retail supply chain. In more obvious ways, bar-coded processed food products commonplace in retail stores is the visual tip of significant market-based relationships manifested as contracts, orders, specifications and quality assurance monitoring.

In Europe, parts of Asia and specific markets within the US, these relationships often cover means of production as well as product specificity, and tracking systems are used to monitor the compliance of production systems to consumer expectations about food safety and ecological footprint. The same level of compliance systems have failed to become entrenched in Australia, however, they are still seen as a significant market barrier to certain export destinations looming on the horizon.

There are, however, growing examples of paddock to plate monitoring systems, including those taking an environmental monitoring system (EMS) approach:

i. Enviromeat is an EMS based quality assurance program that to date has certified 25 meat producers from the Gippsland region of Victoria. The EMS compliance is certified by an external auditor according to the procedures of the International Standards Organisation ISO14001 Environmental Quality Assurance. Suppliers of Enviromeat monitor progress and improve practice in the areas of grazing management, soil and fertiliser management, weed and pest management, chemical management, biodiversity and water quality.

ii. 2007). The Traprock Wool Association Inc (TWA) was formed in 1991 with over 80 members from the Traprock region of SE QLD through to northern NSW, covering 400 000 hectares. The group came together recognizing that many of the old industry ways were unsustainable, and there was a need for closer links between growers and their customers. In 2006 adopted an industry Management System amalgamating an EMS (ISO 14000 standard) and Quality Assurance system (ISO 9000 standard).

The qualification on the "yes" to the system is the lack of demonstrated examples of post farm-gate organisations using spatial information technologies to support their supply chain monitoring activities.

The Benefits of CRC Investment in Agriculture

The agricultural theme for the new CRC-SI will generate several outcomes for Australia:

- ⇒ total economic benefits to Australia by 2016 are estimated at $1.8 billion
- ⇒ an increase in the profitability and growth of the grains, livestock, cotton and horticultural industries by 5% per year, technology services by 10% per year and associated support industry by 10% per year
- ⇒ the maintenance of high levels of agricultural productivity in areas stressed by adverse climate change and variability
- ⇒ a reduction in soil erosion across all broadacre agricultural regions
- ⇒ a 10% total reduction in chemical and fertiliser across all broadacre industries
- ⇒ improvements in water use to meet revised water entitlements to agriclture
- ⇒ the development and support of an Australian airborne mapping capacity that would generate business worldwide
- ⇒ the transfer of specialised image interpretive skills, currently within the research community to the wider, Australian, airborne mapping community
- ⇒ market intelligence capability second to none enabling Australia to meet and expand export targets and opportunities

- ⇒ recognition of Australian agriculture as meeting the highest standards of resource management, animal health and food quality.

The Value Proposition

With these outcomes in mind, the value proposition for incorporating agriculture into a CRC_SI bid is to:

> **Through the application of spatial information technologies, bring about the transformation of agriculture as Australia's leading innovation sector, demonstrating exponential improvements in productivity, export growth and environmental stewardship.**

The CRC-SI can be an effective facilitator of agricultural transformation on if it

- ⇒ aligns to dynamic businesses, both corporate and family, rather than conservative industries
- ⇒ is prominent on agriculture's radar screens
- ⇒ is not seen as a 'pusher' of high technology, but a facilitator of integrated systems that demonstrate value as defined by individual users
- ⇒ avoids dabbling, and takes agriculture by the throat
- ⇒ clearly articulates and demonstrates benefits.

The Target Market

There are three main markets for the products and services of the CRC-SI:

i. the farm sector;

ii. the agricultural service sector; and

iii. the logistical and supply chain sectors.

Farm sector

The CRC-SI should recognise that as a technology-based CRC rather than a commodity based one, it may be perceived as disconnected to agricultural industry networks. However, by aligning itself to leading farm innovators who seek to differentiate their business from the industry common denominator, the CRC will be directly in touch with individual decision makers who are in the game of exponential growth and not incrementalism or survival. In any case, it is this group of early adopters that ultimately influences wider industry adoption.

The range of CRC collaborators and partners in this sector is outlined against each of the sub-program sections later in this report.

In addition, the CRC_SI will work with leading farmers in the grains, cotton, livestock and horticultural industries.

The CRC-SI will work with these two groups through a network of technical support and proof sites. Support sites will be where cutting edge technologies are developed through collaborations between researchers and farm management teams, whereas proof sites will be where existing and cutting edge technologies will be tested by networks of farm management teams.

Agricultural service sector

This sector includes the network of spatial information companies that sell either products or services to farm businesses and the network of agronomic and other farm advisers than can help facilitate the incorporation of technologies seamlessly into farming systems.

While there is an overlap between the two networks, the former can greatly assist in the process of opening the farm-sector market to new possibilities rather than assist in the improvement of existing systems.

Also, while these two groups may be seen as intermediaries in the process of reaching the farm-sector, they are important target audiences in their own right. In the case of the spatial information companies, these companies can purchase CRC IP then on-sell the products and services as appropriate to their own markets.

Both groups potentially are also important collaborators in CRC activities and each should play an integral role in the establishment and facilitation of the support and proof sites mentioned previously.

Logistical and supply chain sectors

The market intelligence and sensor technology development activities of the CRC-SI will be of direct relevance and benefit to industry marketing authorities (corporatised or fully private), transport and biosecurity organisations and, potentially, retail and consumer groups.

The range of CRC collaborators and partners in this sector is outlined against each of the sub-program sections later in this report.

The Investment Portfolio

The following sub-programs and projects have been derived as the optimal means of addressing the value proposition, attaining the benefits described above and reaching the major target audiences. These are outlined in further detail from page 13.

1. Rapid and cost effective monitoring

1.1 Development of the low-cost, hyperspectral airborne remote sensing system called here the Australian Land Systems Imaging Spectrometer - ALSIS.

1.2 The development of a user-populated, farm-based, spatial data base, called here "Spatial Farmer" for improved farm management.

1.3 The facilitation of a CRC SI Spatial Information Bureau for agriculture offering remotely sensed data, assistance with the establishment of farm spatial data-bases and spatial information consultant services.

2. Precision Agriculture Technologies

Potential Projects

2.1 Quantifying the amount and composition of biomass in entire farming systems comprising crops, pastures, native vegetation and forests by a combination of hi-resolution satellite imagery, aerial (incl UAV)-truthing, LIDAR/Radar and active on-ground sensors (eg optical, yield monitors, EM38).

2.2 Measuring sustainability derived from, or applied to, a whole-farm biomass inventory

2.3 Deriving a carbon footprint from a whole-farm biomass inventory

3. Remote and networked farm management systems

3.1 The development of an open standards framework for data communication, interoperability and integration between different types of agricultural systems

3.2 Development of an embedded software component and system with data linkage libraries, business system integration capabilities, map rendering and spatial services.

3.3 Development of an embedded 3D visualisation and modelling component which can access data from the sources.

3.4 Determining the legal issues and data licensing and rights management issues surrounding the sharing and use of data between systems.

4. Market intelligence and supply chain systems

4.1 Satellite Crops Monitoring System

4.2 Crop Market Intelligence System.

4.3 Cargo Container Surveillance.

4.4 Food Information System.

4.5 Remote Vital Sign Monitoring of Livestock.

5. Unifying spatial technologies across agriculture and between other sectors and agriculture

5.1 Adapting proposed regional development of integrated positioning and telecommunications systems to support agricultural requirements

5.2 Providing social, economic and policy analysis to support directions and strategies for agriculture in the ‘spatial information age’

5.3 Building capacity, engagement and up-skilling in the agriculture service sector to support appropriate and innovative uses of spatial information.

5.4 Facilitating spatial information think tanks to seek innovative solutions to a range of ‘wicked problems’ or issues of complexity.

The sub-programs

1. Rapid and cost effective monitoring

Rationale

In the future, if spatial information is to play a vital role in Australian agriculture, major advances will need to be made in both remote sensing capability and in spatial data base usability.

While many sources of remotely sensed spatial data are useful for particular agricultural applications, only hyperspectral imagery can, by itself, provide quantitative information on all components of agricultural systems vis., soil type, plant species, condition and stress. Future, spaceborne, hyperspectral, sensors will not have the spatial resolution necessary for farm-scale application and current, airborne, hyperspectral remote sensing systems are prohibitively expensive. We therefore need to look toward low-cost, new generation, sensors carried in very light aircraft or UAVs.

Farm-based agricultural data-bases have the potential to facilitate significant improvements in farm productivity by allowing for the more efficient use of water, fertilisers and pesticides. A vital input to such a data-base will be quantitative remotely sensed data such as that which will be collected by the hyperspectral sensor proposed above. However, only a user-generated, "crowd-sourced", farm-based, spatial data base is practical in these times of diminishing government expenditure.

It is therefore proposed that the CRC SI make the development of a low-cost, hyperspectral, airborne remote sensing system and a complimentary, user-generated, spatial data base for farming applications, key planks in a CRC SI re-bid.

The outcome envisaged for these projects is a commercial bureau providing both hyperspectral imagery and spatial information services to CRC SI company members offering consultancy services to the agricultural sector.

Each of the research areas proposed above will stand on its own merits but together they amount to an agricultural spatial information system comprising the following components:

1.1 Development of the low-cost, hyperspectral airborne remote sensing system called here the Australian Land Systems Imaging Spectrometer - ALSIS.

1.2 The development of a user-populated, farm-based, spatial data base, called here "Spatial Farmer" for improved farm management.

1.3 The facilitation of a CRC SI Spatial Information Bureau for agriculture offering remotely sensed data, assistance with the establishment of farm spatial data-bases and spatial information consultant services.

The economic imperatives for this proposal and each of these components, or sub-themes, are addressed separately below.

The potential impact on Australia's future, outcomes for the Australian farming community and collaboration issues are then described from an integrated perspective.

The economic imperatives

Climate change in Australia is resulting in decreasing water resources, increasing water losses through evaporation and increasing heat stress in crops. This will put increasing pressure on Australia's agriculture sector to become more productive. Various spatial information technologies have the potential to improve agricultural productivity in this difficult environment through cost-effective monitoring but these all require further research and development before they can be implemented.

Potential Projects

1.1 Development of the low-cost, hyperspectral airborne remote sensing system, Australian Land Systems Imaging Spectrometer - ALSIS.

Description:

- The ALSIS instrument will utilise proven off-the-shelf equipment.
- The instrument will be compact and lightweight allowing for installation in different light aircraft, such as single engine or ultralights.
- Design will be targeted at achieving overall low flying costs.
- ALSIS will produce calibrated, fully-georeferenced products compatible with industry-standard imaging processing systems.
- Multi-temporal image acquisition opportunities will be maximised by the simultaneous construction of two ALSIS systems.
- Design and construction costs will also be spread across two systems.
- The estimated total cost for construction of the two ALSIS systems is $500,000.

Markets:

- Precision agriculture operations in grains, cotton, biofuels and other commodities
- Orchard and viticulture producers
- Forest management organisations
- Shallow water fisheries
- Rural Fire Service and Country Fire Authorities
- Departments of Natural Resources and Environment
- Coastal management authorities
- Remote sensing providers and consultants
- Aerial survey companies?
- Defence organisations
- Research organizations (DPI, SARDI, CSIRO, universities, etc.)

Key Research Questions

1. Can low-cost, airborne, hyperspectral systems be built and operated within Australia on a cost-effective basis?

2. Can the information on parameters such soil type, crop vigour, weed and pest infestations obtained from the hyperspectral data be used to increase substantially the efficiency of farming systems.

1.2 The development of a user-populated, "crowd sourced", farm-based, spatial data-base for improved farm management.

Description:

- ⇒ Design and implementation of a user-generated agricultural spatial data base, conceptually here referred to as "Spatial Farmer", for the aggregation and subsequent use of farm data such as crop type, yields, soil condition, soil moisture, weeds and pest infestations.
- ⇒ Key aspects of this data base would be the ability to integrate, display, analyse and assist in management decisions using data received in real time from on-farm sensors, near real-time remotely sensed data and machinery-sourced yield information.

Markets:

- ⇒ Intensive and extensive land-use production systems: Large agribusinesses producing commodities such as grains, other bio-fuels, cotton, viticulture etc. and using precision agriculture methods; also smaller farmers who could benefit from spatial information gathered regionally.
- ⇒ Forestry: Forestry managers from commercial and government sectors needing regular measures of forest and woodland diversity, condition and fuel loads.
- ⇒ Marine: Managers of commercial fisheries, aquaculture ventures and the marine environment in general.
- ⇒ Water and Soils: Catchment management and other government authorities needing to monitor soil degradation and its subsequent effect on water availability and quality.

Key Research Questions

- ⇒ Can a predominately user-generated, agricultural, spatial data-base be designed so that it will provide near-real time information for management decision making within Australian agricultural businesses.
- ⇒ Can a spatial data base be designed that will accept the wide variety of data formats and standards that will be encountered.
- ⇒ Can privacy and confidentiality issues be addressed so as to allow the data-base to be used at a variety of scales ranging from the farm, the catchment, the state and the national.

1.3 The facilitation of a CRC SI Spatial Information Bureau for Agriculture offering remotely sensed data, assistance with the establishment of farm spatial data-bases and spatial information consultant services.

Description:

- ⇒ Agriculture has been slow to pick up recent advances in spatial technology. This is most probably due to a combination of poor liaison by the researchers and the current financial stress of most farming operations. Therefore, if the CRC SI is to undertake research into new spatial technologies for agriculture, it must also be prepared to play a role in the transfer of this technology to the consultant groups servicing the farm sector.
- ⇒ The CRC SI Spatial Information Bureau for Agriculture will be a service organisation responsible for transferring the technologies developed within project sub-themes 3.1 and 3.2 to the agricultural community.

Markets

- ⇒ The market for the CRC SI Spatial Information Bureau for Agriculture will primarily be the spatial consultants and spatial data provider company members of the CRC SI. They will provide the technology transferred to them to the various agricultural markets listed above within sections 3.1.2 and 3.2.2.

The contribution to Australia's industrial, commercial and economic growth

The research proposed within sections 1.2 and 1.2 could have very great significance for Australia. Direct benefits would occur in the areas of:

- ⇒ The maintenance of high levels of agricultural productivity in areas stressed by adverse climate change.
- ⇒ Development and support of an Australian airborne mapping capacity that could generate business worldwide.
- ⇒ The transfer of specialised image interpretive skills, currently within the research community to the wider, Australian, airborne mapping community.
- ⇒ The improvement of cropping methods by the exchange of production data between progressive farming operations.

Indirectly this work will play a role in the maintenance of Australian rural communities at a time when farming in marginal regions, on which these communities are dependent, is becoming increasingly less viable. This "public good" aspect of the proposed research may outweigh the apparent commercial advantages of the projects, should it become apparent that the currently financially stressed agricultural sector will find it difficult to provide the financial support necessary to justify the adoption of these projects.

Impact of the outcomes for end-users

Anticipated outcomes of the research proposed within sections 3.1.2 and 3.2.2 and impacts are:

- ⇒ The provision of fundamental information on soil type and properties that will enable farmers to make better choices of crop types and farming methods.

- ⇒ The provision of near-real time information on crop stress will enable farmers to make better decisions with regard to irrigation, fertilizer and pesticide applications.
- ⇒ The construction of remote sensing systems that will allow Australian aerial mapping companies to grow their businesses for a diverse range of applications in resource mapping and monitoring.
- ⇒ The creation of an agricultural spatial data base that would be generated and maintained at very low cost and would be accessible in ways that would be of economic advantage to both farmers and to those government entities responsible for management of an increasingly fragile agricultural environment.

Specific users of the technology to be created will be CRC SI companies providing technical services to the markets described above, individual large agribusinesses and technical groups within the government sectors.

Critical collaborators

For the proposed research to be successful it will be necessary to ensure the participation of individual farmers, agribusinesses, farming consultancy services, state and federal government agencies. Possible collaborators are listed below.

University-based

Adjunct Associate Professor Geoff Taylor, UNSW

Current CRC SI project leader and remote sensing applications expert

Dr. John Triantafilis, UNSW

Senior Lecturer in Soil Science at UNSW and expert in agricultural data base management and geophysical image processing

Dr. Shawn Laffan, UNSW

Senior lecturer specialising in Spatial Data Modelling

Dr. Anthea Mitchell, Post Doctoral Fellow at UNSW

Remote sensing applications specialist working particularly in vegetation mapping with radar and optical remote sensing systems

Dr. Remy Dehaan, Senior Lecturer at CSU

Remote sensing specialist working particularly in agricultural and earth science applications.

Associate Professor David Lamb, UNE

Physics and electronics specialist working in remote sensing applications for viticulture and precision agriculture

Adam Roff, PhD student at UNSW

Specialist areas are hyperspectral imagery and native vegetation mapping

Michael Day, PhD student at UNSW

Specialist areas are hyperspectral imagery and soil mapping

Government-based

Dr. Glen Fitzgerald, DPI Victoria

Agricultural remote sensing expert with particular skills in airborne sensors

Dr. Tim Danaher, Department of Natural Resources and Water, Queensland

Leader on successful vegetation mapping team using remote sensing methods

Industry sectors

Technical experts within CRC SI companies providing imagery and consultancy services to the agriculture and resources sectors

2. Precision Agriculture Technologies

Rationale

Since the early 1990's there has been a virtual explosion in precision agriculture (PA) technologies and methodologies available to producers. Yet, to this day, uptake remains constrained to the innovator and possibly early majority classes of end-user, primarily because of a lack of decision support tools (Dobermann et al. 2004, McBratney et al. 2005, Lamb et al. 2007). Recently the Parliamentary Secretary to the Federal Minister for Agriculture, Fisheries and Forestry stated "..every primary producer has the same goals – to raise productivity, increase profits, reduce overheads and improve environmental management. And that's where PA fills the bill." (Ley, 2007). To date, those who use PA tools have largely confined activities to understanding sub-field-scale constraints to production, but within the context of single fields. There exists an enormous opportunity to use PA tools/technologies to optimize biomass production on a whole farm-scale (or indeed across numerous farms for large agri-businesses). In this context, optimizing biomass production could include mixed cropping and cattle enterprises (eg cattle and crop rotations), biomass composition (eg native vegetation/trees/crop/pasture interactions) and managing soil and water resources (eg WUE, soil health).

Potential Projects

2.1 **Quantifying the amount and composition of biomass in entire farming systems comprising crops, pastures, native vegetation and forests by a combination of hi-resolution satellite imagery, aerial (incl UAV)-truthing, LIDAR/Radar and active on-ground sensors (eg optical, yield monitors, EM38)**.

2.2 **Measuring sustainability derived from, or applied to, a whole-farm biomass inventory**

Research question:

That net carbon sequestration can be quantified according to above-ground production (eg pastures = biomass minus grazing; crops = biomass growth rate), and hence measured on a whole-farm basis using above-ground remote sensing techniques.

2.3 **Deriving a carbon footprint from a whole-farm biomass inventory**

The contribution to Australia's industrial, commercial and economic growth

Optimising whole-farm biomass production automatically deals with issues of environmental and economic sustainability, viz. balancing land-use in the face of competing land-use opportunities, maximizing WUE, and inventorying and tracking carbon.

Impact of the outcomes for end-users

Optimising biomass production using PA technologies will address

⇒ lack of skilled labour (NFF, 2005), by reducing labour requirements associated with managing farm operations through increasing the intelligence-gathering capability of managers,

- ⇒ critical shortages of water in both irrigated and rain-fed agricultural production systems (NAP, 2006), by increasing WUE through strategic design of fields and or management of irrigation,
- ⇒ increasing costs of inputs such as nitrogen, pesticides and herbicides (e.g.O'Connor, 2003), by facilitating strategic design of fields according to intrinsic 'production capacity' of soil

as well as:

- ⇒ technology-enable agricultural practitioners (farm managers, consultants, agronomists), and
- ⇒ introduce to, develop or refine systems-thinking paradigms of, farm-managers, consultants, agronomists (and attendant opportunities for education sector in rural science/agriculture)

Quantifying the amount and composition of biomass, and incorporation of these data into a global biomass/production model will provide a mechanism for farm managers to:

- ⇒ harmonize productivity by designing land-use on the basis of retaining optimal compositional balance of biomass,
- ⇒ maximize productivity by reducing interference between biomass classes (crops, pastures, native vegetation & forests) (eg, loss in crop yield resulting from in-paddock trees estimated at $300/tree p.a.- ie ~60% reduction in yield, cut-and-fill costs ~ $1000/Ha)
- ⇒ model/predict impacts of land-use strategies and re-design options, and
- ⇒ quantify and track on-farm carbon

Key Markets

Biomass inventorying, and even the extension to Carbon tracking, is a big business opportunity at many levels, especially if this ever gets enshrined in legislation. Opportunities exist for Agribusinesses at Twynam/Sundown scale as well as small growers (<2000 Ha), as well as agronomic and spatial information service providers.

Critical collaborators

Twynam Agriculture:

- operator of numerous irrigated and rain-fed cropping, pasture and forestry operations
- committed to long-term & large scale application of PA technologies
- desperate for on-farm carbon tracking methodology
- Can provide large-scale commercial systems for evaluation of methodologies

Sundown Pastoral:

- operator of numerous irrigated and rain-fed cropping, and intensive animal production systems
- committed to long-term & large scale application of PA technologies, related to WUE and pasture utilization
- desperate to optimize production systems and acutely aware of need for setting up carbon tracking methodology
- Can provide large-scale commercial systems for evaluation of methodologies

UNE:

- Experienced developer, user and evaluator of PA technologies. Knowledge and skills in applying satellite, aerial, proximal sensors in PA.
- Can provide sites for research & development of protocols/methodologies; Newholme, Kirby & McMaster Research Stations (eg Newholme = 1500 Ha of which 900 Ha may soon be converted to forest and, adjacent Kirby will remain as high-yield animal production). McMAster is mixed farming (Crop and Cattle production)
- Education provider in Rural Science (incl. Precision Ag units.)

Uni Melbourne:

- Experienced 3-D visualization & modelling (existing CRCSI investment in SIEVE)

CTF Solutions:

- Experienced in working at the interface of PA and 'systems thinking'

V-Tol aerospace:

- Premier UAV developer and service provider in Australia

TBA:

LIDAR & RADAR provider

3. Remote and networked farm management systems

Rationale

Innovative farmers, be they corporate, large family or simply progressive farm businesses, are constantly seeking to place their ever-diversifying assets and resources under more efficient management systems. In many cases, this includes management of a range of properties or holdings, management of strategic farm alliances and managing from a distance. It also entails optimising resource utilisation within and across farms, landscapes and regions, involving the matching of land use to land capbility to meet a range of economic, social and environmental aspirations.

Essentially these farmers are seeking to improve the logistics at every level of their businesses.

The major industrial and economic needs which exists include:

- ⇒ Simplifying and consolidating an ever burgeoning volume of information and types of data
- ⇒ Real time access to data across and between different on-farm systems and a wide range of public and private data sources
- ⇒ A need to combine many types of data to enable the understanding and interaction of the many different parts that explain the reason for variation in vegetation biomass (be it species, utilisation, slope, aspect, drainage, soil type and nutrients, soil moisture, disease, pests, weather and production events etc)
- ⇒ Optimisation, better utilisation and reduction in cost of agricultural inputs

The industrial and commercial opportunities which exist include:

- ⇒ Substantially and sustainably lifting biomass production (yields of pasture, crops, forestry and livestock) while generating net improvements in environmental outcomes.
- ⇒ Development of an open standard framework and data exchange protocol and that allows real time and near real time access, integration and exchange of data from third party data sources and from and between many different agricultural systems.
- ⇒ A data linkage, integration and map rendering software component and system which can be embedded in existing farm management systems to provide business intelligence capabilities. This component will contain extensible updatable, libraries and links to national datasets (ie admin boundaries, tenements, land claims, native vegetation and cadastre, towns, infrastructure, roads, water catchments and underground water systems, weather, drought, soils, seismological, census data etc) that can also integrate and access data from business software systems.
- ⇒ An embeddable 3D visualisation and modelling component (based on the CRCSI SEIVE system) which can make use of relevant data sources (both archived and near real time) to visualise, measure, monitor biomass production, landscape change over time, develop and model the economic and environmental benefits (including carbon emissions and sequestration) of different land use scenarios.
- ⇒ Spatial information (ie geographic or location based information) is the ideal common linkage which will allow the exchange of information between many different systems and data sources, based on the fact that over 80% of all government and organisational data has a geographic context).

Potential Projects

3.1 **The development of an open standards framework for data communication, interoperability and integration between different types of agricultural systems**

3.2 **Development of an embedded software component and system with data linkage libraries, business system integration capabilities, map rendering and spatial services.**

3.3 **Development of an embedded 3D visualisation and modelling component which can access data from the sources.**

3.4 **Determining the legal issues and data licensing and rights management issues surrounding the sharing and use of data between systems.**

The contribution to Australia's industrial, commercial and economic growth

- ⇒ The contribution to the nation that will lead from the adoption of the proposed research falls into two categories – environmental and financial.
- ⇒ Sustainable and optimal increases in production and optimal land use between pasture, crops, forestry and livestock will deliver net improvements in a range of other environmental outcomes and best practice stewardship by land managers and custodians .
- ⇒ The financial benefits in the form of a substantial additional contribution to GDP (to be estimated) will arise not only from increased value of agricultural production from biomass but also from environmental values, specifically in the form of carbon trading on voluntary markets from reduction in carbon emissions and measurable increases in vegetation and carbon sequestration.
- ⇒ New and additional skills and employment opportunities for rural and regional Australia

Impact of the outcomes for end-users

Agricultural system developers will be able to easily and quickly enhance and improve the functionality of their business decision support tools by near and real time access to data from different systems and third party data sources. This will be achieved by being able to embed the data software integration and linkage component described above.

As a consequence, Land managers and custodians will have real time and near real time access to simpler decision support tools, remote monitoring systems, visualisation tools and other labour saving mechanisms that will:

- ⇒ Collapse the amount of information required to make decisions
- ⇒ Provide integration and sharing of data between farm management systems without the need to transfer data on CD, hard disk
- ⇒ Reduce cost arising from delays in access to information
- ⇒ Provide answers when needed
- ⇒ Automate or provide notification of production events, activities and status that require action

- ⇒ Provide a far great understanding at much more granular level (or resolution) for the reasons for variation in vegetation biomass and the management strategies to minimise variability
- ⇒ Substantially increase sustainability and profitability from both agricultural production and improved environmental outcomes
- ⇒ Demonstrate best practice compliance and environmental stewardship

Key Markets

Key markets for the open standard framework and data exchange protocols and the data linkage, integration and map rendering software component and system and 3d visualisation and modelling tool include :

- ⇒ Precision ag and farm machinery implements and systems manufacturers Agricultural software systems developers
- ⇒ Manufacturers of Telemetry and sensor systems
- ⇒ Benchmarking groups
- ⇒ Spatial technologies and service providers
- ⇒ Education and research institutions
- ⇒ Government Agencies
- ⇒ Financial Institutions
- ⇒ Media Organisations
- ⇒ Farmers, Agro Forestry, Viticulture and Horticulture groups, who wish to directly access and integrate data and systems in house
- ⇒ Export markets in other countries with similar needs

How does this build on or extend the current research of CRCSI

The research proposed in this sub theme will draw on extend the following existing research areas and projects within CRCSI Mark I.

Research Project 3.1	This project will draw on lessons learnt and the research outcomes of existing project 6.5 CORS Network High Performance Positioning Study
Research Project 3.2	This project will dramatically extend existing project 6.8 Clever cattle and cropping systems
Research Project 3.3	This project will extend existing Visualisations program 5 and projects 5.1, 5.2 and 5.3 by enabling it to integrate with data and systems arising from new projects 3.1 and 3.2
Research Project 3.4	This project will extend existing project 3.5 Information Access and Digital Rights Management

Critical Partners and Collaborators

End Users (Pastoralists and Farmers) ie

- Sundown Pastoral
- Twynam
- AACo
- Great Southern
- Heytesbury
- Rowan Peel
- Michael Carbury

Software developers and systems integrators

- Geogenx (Maptool) Projects 3.2 and 3.3

Precision Ag Equipment and Manufacturers and Service Providers

- CTF
- Andrew Smart
- Precision Guidanace Systems Ie AgGuide, Beeline, Croplands Outback, Farm Scan, GPS-Ag, John Deere, Case New Holland, Kee, Rinex, Trimble

Farm Software Developers

- Ie PAM, Practical Systems, Livestock Recording Australia, Agrimaster, FarmKeeper, Concepts Rural Solutions, Breedplan, Lambplan, Merino Select, In-Time, Apex, Ag Leader SMS

Telemetry and Sensors

- Ie AgriLink, Observant, John Deere etc

Government Agencies - Projects 3.1 and 3.4

- Geoscience
- ABS
- State Land Departments
- Other State Departments (ie EPA)
- QLD Treasury

Research Institutions

- University of Melbourne / CRCSI (SIEVE - Ian Bishop / Chris Stockton)
- University of New England
- QUT
- NSW University

4. Market intelligence and supply chain systems

Rationale

The greatest economic value derived from agriculture is realised as agricultural outputs are utilised or otherwise converted into value added products or services along the supply chain. Even in its rawer forms, the value of agriculture to the economy is more as an export income earner than for its actual contribution to GDP. In either instance, supply chains are critical to the realisation of the full value from agricultural production.

Potential Projects

4.1 Satellite Crops Monitoring System

Description

Farmers scout their fields to pick up insect, pest and disease damage and other abnormalities. Often they climb in the roof of the tractor to get a bird's eye view of part of the paddock. As fields in south east Australia are large (115ha in average), scouting is a tedious and time consuming activity. Using satellite technology, it is possible to give farmers imagery with a bird's eye view of their paddocks.

Google Earth is the most used tool to display addresses- it operates on a map base and a satellite imagery base. This technology interlinks with mobile phones and location tracking applications. However- the satellite data Google Earth accesses are archived data and can therefore not be used by farmers and land managers for crop monitoring.

Google Earth recently signed with the French satellite company SPOT IMAGE a multi-year contract for use of SPOT data in Google Earth. Modifications to the system from the current archived to near real time access of the SPOT archive via Google Earth would be of great benefit to Australian farmers.

This application could for example let farmers browse the "real color" satellite composite of their paddock for free, while they pay in an easy one-click- transaction ($5-$10?) per paddock for the much more valuable information of false color infrared satellite images/ and value added product (same satellite and acquisition date, just different bands/ processing algorithms that clearly show crop stress- even before the human eye can recognize it in the field). Value added products for Australia have already been developed by CropView and WADA and can be modified for inclusion into this project.

A joint project where the CRC develops applications for Australian farmers that interlink with Google Earth could be a very beneficial and exciting application that significantly improves lives and businesses in rural Australia

Market

Key markets, in the first instance are Australian broad acre grain farmer, farm mangers and agronomists. The application can be extended to pasture, irrigation farming, viticulture, horticulture, etc.

Research Questions

1. Which value-added products are needed and can be developed for different user groups?
2. Are current algorithms valid for all regions in Australia? Will inclusion of radar data benefit the project?

Critical Collaborators

SPOT Imaging Services

- SPOT (Satellite Pour l'Observation de la Terre) is a high-resolution, optical imaging earth observation satellite system operating from space. It is run by Spot Image based in Toulouse, France.

GOOGLE EARTH

- Google Earth is a virtual globe program that was originally called Earth Viewer and was created by Keyhole, Inc.

GeoConsulting Group Inc.

- GeoConsulting developed Crop View in cooperation with RMIT University.

4.2 Crop Market Intelligence System.

Description

To meet domestic and export demands, Australian grain productivity needs to approximately triple in the next 20 years, hence current market intelligence and supply chain systems will be challenged by expanding production. Satellite remote sensing has shown to be able to significantly contribute the Australian Ag-Industry on various levels and in various applications.

Satellite remote sensing of crops has proven to provide useful information for market intelligence and is routinely used i.e. by Europe (http://agrifish.jrc.it/marsstat/) and the United States (http://www.pecad.fas.usda.gov/cropexplorer/). The yield forecasts are obtained from analyzed data (in respect to crop type, planted area sizes, crop performance, etc.) from AVHRR, MODIS and SPOT Vegetation satellite sensors and are coupled with agro-metrological models. Above mentioned satellites cover large areas of land daily, but do not give a clear picture on what is going on within the paddocks (i.e. AVHRR has 2800 km swath width with 1.1 km pixel resolution). In the northern hemisphere crop estimates are “fine-tuned” with selected medium resolution satellite data (such as SPOT 5, with 10 meters multi-spectral pixel resolution, 60km swath width).

While considerable progress has been made within a current CRC-SI program, combining the STIN yield model with AVHRR and MODIS data resulting in more robust algorithms for Western Australia (Schut, A.G.T. et al., ACRS 2007), the “fine-tuning” process on a sub-paddock level is still to be developed for an operational crop monitoring system.

The medium resolution satellite data needed for “fine-tuning” yield estimates can furthermore be used to obtain intelligence for multiple user groups in varied applications. The proposed project benefits the following user groups: grain marketing companies, insurance companies; finance and real estate service companies in the rural sector; and grain storage centers.

Satellite remote sensing applications for the named sectors offer great opportunity to improve potential users’ decision making processes, however often products have not been developed yet, have no critical mass or market penetration and/or users are unaware of the benefits that remote sensing and spatial technologies could bring them.

Over the next decade remote sensing and spatial technologies will be widely accepted by a vast user range, also in the field of market intelligence for agriculture. Analysis of satellite and agro-metrological data give information to grain crop marketers regarding crop type and crop performance –hence intelligence on yield estimates that can also be used for logistical planning of grain receiving centers. Insurance companies can utilize the same dataset to verify damages and process claims more accurately and fairly. Real estate agents are able to access this central system and determine actual potential yield potential on a sub-paddock level and advise their clients better on (rural) land value. The "land productivity index" is quite a complex product, including data on soil type, DEM: frost and water logging risk, historic yields, distance to town, zoning etc. The same land productivity index can be accessed by financial institutions to verify actual land value for borrowing and lending.

The proposed project is a major step towards such a multi-user satellite system for Australia.

Market

⇒ Market intelligence for Grain marketers: the satellite data are processed for yield estimates (area planted & crop performance);

⇒ Insurance services: Claimed damages can readily be verified and areas/ losses measured using satellite data

⇒ Finance services: A productivity/ soil index can assist in land value estimates (Productivity index obtained from satellite data analyzed in respect to spatial historic crop performance, spatial soil maps and DEMs, etc.)

⇒ Real Estate services: Satellite data assist in advising clients on property values (productivity/ soil index)

Intelligence on yield estimates provides logistics advantage; farmers can be prompted in interactive system to advice on likely grain receiving location

Research Questions

1. How does the satellite crop monitoring system need to be designed to be operational for the majority of the cropping regions in Australia in order to produce yield forecasts with accuracies exceeding current methods?
   - Should agro-meteorological model be combined with low resolution satellite data, and "fine-tuned" with high resolution satellite data -or should it be a model based on satellite data only?
   - Which satellites should be included in the system? Radar too?
   - Definition of "majority" of cropping regions- is this 80%?
   - Which crops should be addressed?
   - How much better does the forecasting accuracy need to be compared to current methods in order to be a worthwhile investment?
2. How do systems need to be designed to make these satellite image data beneficial to other users- such as grain growers, insurance, financial and real estate services as well as for logistical purposes?
   - Should the system be a free benefit to growers as part of "membership" to AWB (or the like)?
   - What kind of analyzed data does this system contain?
   - What value added services is to be "sold" by agronomists to growers?
   - What answers would insurance companies like to obtain in crop damage assessment?
   - What "productivity index" is meaningful for financial and real estate industries?

Critical Collaborators

Australian Wheat Board (AWB)

- AWB Limited is Australia's leading agribusiness and one of the world's largest wheat marketing companies.

Landmark (AWB company)

- Landmark is Australia's largest supplier of agribusiness products and services.

AWB Grain Flow

- AWB GrainFlow is a subsidiary company of AWB Services Ltd, which commenced operation in 1999. GrainFlow now operate a network of 22 storage centres along the east coast and into South Australia.

Resource Imaging Australia

- Resource Imaging Australia (RIA) supplies all ACRES Satellite Data Products to all Australian Industries requiring satellite data products, including the Commonwealth, State and Local Governments.

4.3 Cargo Container Surveillance.

Description

This system tracks containers containing fresh food in transit in Australia or during export. Microchips with transponders monitor location, temperature, humidity of container, etc. These data are sent back via mobile phone network/ or communication satellite to the company headquarters; location of container could be visualized on a Google Earth custom build application, with a query tool to show the location of the specific container on a satellite image, and give a tabular report on relevant monitored parameters of the selected container. Furthermore ranges could be selected (i.e. 1degree C to 4 degree C) and if the defined range is compromised an alarm actions headquarters for intervention (i.e. advise truck driver/ board engineer to fix specific container)

Market

⇒ Food exporters can monitor produce in transit (location, current and recorded conditions etc)

⇒ The system is also interesting to transport companies who could guarantee their customer monitored key parameters (defined range of temperature (important to ensure maintance of the cool chain), humidity, etc.

Research Questions

1. How does the system need to be designed to work reliably, using existing sensors and data transfer methods?
2. How does the data management system need to be designed to optimize the application for the user?

Critical Collaborators

Potential partner: Costa Group

- Based in Victoria, with production, trading and logistical operations throughout Australia and internationally, the Costa Group is a full service grower, packer, shipper, marketer, importer and exporter, with annual revenues now exceeding A$ 1 billion.

4.4 Food Information System.

Description

Every precision farming "treatment" (fertilizer, chemicals, etc) for each plant (i.e. bananas) is recorded and stored throughout the growth cycle on a central spatial database (GIS); during harvesting the location-specific information is attached to each individual fruit on a barcode sticker or a mini-chip; this database is accessible via internet to the end-users –he can access the information of his particular food item (i.e. banana). This system can be extended for more complex value-added food processing, i.e. banana juice- data on banana, chemical analysis of the water used, etc. In the future, even supermarkets could offer detailed information on each food item sold; this system ensures highest food quality for the Australian people and will encourage manufacturers to adopt best practice (giving transparency in the import of "polluted" overseas produce, hence strengthening Australian primary production industry).

Market

The project is in first instance of particular interest to the increasing number of people with food allergies, and other diseases; a "mail order" company could be set up providing guaranteed monitored food and monitored food chain processed goods.

Food suppliers and exporters could guarantee their clients monitored foods, produced in a supervised Australian market ("clean" compared to other nations, therefore competitive advantage of Australian food)

Research Questions

1. How does the design of a food monitoring system look like? –what are critical parameters? Where can existing technology be utilized?
2. What are the limitations of such a system and can logistics be managed profitable? –while each individual banana can be tagged, i.e. grain or sugar cannot be tagged by individual plant; - are 3D models needed for treatment on fruit trees?

4.5 Remote Vital Sign Monitoring of Livestock

Description

This project proposal could not be researched properly due to time constraints. However the concept is included and can be researched if found to be interesting.

Animals are fitted with sensors that record temperature, heart rate etc; these data are transferred remotely via i.e. RFID chips to a local receiver and then the information is passed on via internet/ mobile phone network to a central database for analysis.

Market

Possible Applications:

- ⇒ Equarian industries: monitoring of horse flu symptoms and spatial distribution of affected horses to better understand patterns of infection;
- ⇒ Transport companies specializing in the transport of large and zoo animals
- ⇒ Organizations specializing in the rehabilitation of endangered species in the wild (Wildlife organizations)

Research Questions

1. How can an operational a vital sign monitoring system for animal be build using existing technology?

Critical Collaborators

Company with RFID and bio-monitoring experience
Company with spatial data processing experience

5. Unifying spatial technologies across agriculture and between other sectors and agriculture

Rationale

This sub-program aims to unify outputs from the agriculture Program into industry and community outcomes, to create systems solutions from SI in agriculture and to develop generic processes and products with application and attraction to national and international businesses in and beyond agriculture.

The sub-program will establish proof and support demonstrators where SI outputs from the agriculture program and other CRC programs can be tested, developed and commercialised (Project 5.1); provide social, economic, environmental and policy analyses of directions and strategies for agriculture in the SI age (Project 5.2); build SI capacity and skills in the service sectors (Project 5.3); and develop think tank approaches to address complex issues of adoption, scale and change (project 5.4).

The outcomes will be spatial information driving profitable and sustainable agriculture through rapid change and a World acclaimed, Australia wide recognised CRC with systemic and socially unified multi-industry, multi-service, commercial solutions to tyranny of distance, low population density and large area issues by integrated processes, technologies and gadgets.

Potential Projects

5.1 Adapting proposed regional development of integrated positioning and telecommunications systems to support agricultural requirements

Description

One of the key outcomes from CRC SI (Project 1.4) is the development of integrated positioning and telecommunications systems. While these technologies were developed in urban environments, Project 5 recognises that adaptations for agriculture can also revolutionise the opportunities for regional development.

Agriculture is the obvious vehicle to see if the major constraints to adoption of tyranny of distance and low population densities can be addressed. Agriculture is a spatial information industry and integrated positioning and telecommunications systems have immediate applications in terms of machinery guidance in cropping and animal location in grazing, performance measurements (crop growth and yields and animal weights), record keeping of all operations, engagement with end-users (web based, interactive information and advice delivery), and community wide benefits.

Agriculture, with its long history of accepting new technologies and change, and a large and skilled service sector with experienced contacts with end-users, has the potential to provide proof of concept demonstration sites and to fund on-the-farm development and testing. This is tried and tested methodology for adoption of improved farming practices.

This Project will build on the proof of concept demonstrations that establish quality positioning and telecommunications by then making the systems available to the whole community, particularly mining, construction, surveying, local government and emergency services industries. These industries will also be self-funding by diverting other investments planned to do piecemeal approaches to major issues, such as, individual GNSS base stations for each application with duplicated telecommunication services, and the consequential uncoordinated processing of services, data and information.

These whole of community support sites will use the same infrastructure developed for agriculture and spread the benefits across everyone. Whilst distances are large (by urban or other countries' standards) and the population is few, the density of users applying the technologies for highly productive and high priority purposes is high and very capable of financing community wide development. There is no feasible business case for individual industries developing these systems.

The triple bottom line benefits are clearly obvious in each participating industry, for example but the major benefits will come from integrated community responses to district and regional problems through shared technology, problems and rewards. Integration of planning, implementation and use of infrastructure and production developments will mean savings from efficiencies and higher productivities.

These proof and support sites will create an exceptional resource base for innovations in rural and regional Australia to support the essential improvement of traditional agricultural and mining industries but also new industries based on spatial information and good telecommunications. Many city jobs can be moved to rural towns where natural resources, quality of life, impacts on the environment, and social cohesion are available to reduce over-exploitation pressures in our cities.

The Project involves 5 components, each component addresses specific issues while contributing to developing comprehensive, community wide solutions:

5.1.1 Extensive cropping
5.1.2 Intensive cropping
5.1.3 Extensive grazing
5.1.4 Integration of other industries
5.1.5 Integrated solutions and products

Key partners. It is essential that this Project attract partners from the whole spectrum.

These Project sites will also be active umbrella sites for testing and application of outputs from other CRC Projects as they happen, and for identifying practical problems that require solutions. Outputs from other CRC programs will be integrated into business solutions on these sites with active participation among the breadth of CRC partners.

Key processes throughout Project 5.1 will be scaling up (from paddock to farm to district to region or catchment) and crowd sourcing (to access community knowledge and opinion). The basic positioning and telecommunication components must function at the paddock scale and be integrated around the whole farm. The data and information generated will then be scaled up, with built in safe guards, to larger scales.

Three constraints to Project 5.1 will be addressed in Project 5.2 – 5.4. These Projects address questions related to community cooperation, service sector capacities, and community processes.

5.2 Providing social, economic and policy analysis to support directions and strategies for agriculture in the 'spatial information age'

Description

Project 5 achieves broad cooperative solutions to generally intractable issues in an environment where competition is the current norm. Cooperation is now recognised as the fundamental solution to national and international issues such as climate change, terrorism and water. Project 5.2 aims to apply cooperation concepts at the district, catchment and regional scales by addressing the underlying social, economic and policy issues.

Agriculture is a microcosm of our competition ethos where farmers compete with their neighbours, service providers at all levels compete, and internal groups within districts etc. compete. Competition is necessary but has essentially constructed an environment that now constrains best practice and broad scale solutions. Competition builds boundaries that need not exist, just as national borders constrain obvious solutions to climate change. The competition ethic is now part of our culture and our comfort zones. Socially, it is important to have private groups but from the business and environmental perspectives it is very constraining.

Spatial information does not recognise many of these boundaries – a GPS base station services equally a spatial area regardless of farm boundaries, a satellite image covers equally a whole area. These are cooperation driving technologies for business and environmental applications. The CRC outputs offer non-threatening, high impact spatial information that is equitably available to all – a painless way to break agriculture out of its comfort zones.

Because agriculture has strong, historic structures that access large segments of the community, is the dominant land use, and is supported by entrenched policies and social structures, Project 5.2 will start with agriculture while recognising the multi-industry realities of districts and region. Project 5.2 will analyse the business and environmental benefits from cooperation using spatial information, and develop community and regional directions and strategies. Fundamentally, the agricultural solutions will incorporate other industries, particularly mining, construction and local government, into regional solutions.

The sites chosen in Project 5.1 will cover a wide spectrum of social, economic, environmental and industry situations. The challenge for Project 5.2 is to identify directions and strategies that apply specifically while built on generic components. These directions and strategies should then be widely applicable in Australia and internationally.

Community benefits are based on the general concept of separating social and emotional requirements from business and environmental solutions that hopefully recognise both streams. And the new, independent driver is spatial information.

Project 5.2 will support Project 5.1 and requires clear understanding of the primary win/win options being proposed. It is essential that the CRC rapidly gets runs on the board and credibility with the target communities. Project 5.2 will be the key community engagement, interaction and communication Project.

Triple bottom line benefits come from efficient, cooperative processes that reduce duplication and encourage innovation and new developments. This will occur at all scales – farmers will cooperate by sharing machinery, marketing and purchasing; industries by sharing positioning and telecommunications and transport and support services; and districts by general access to the spatial information age which will provide similar services to the city and the bush.

Project components will be:

- ⇒ Identify the “guaranteed successful” technology systems (a key part of Project 5.1), do a SWOT analysis, and establish the job description for the independent Project “Think Tank”.
- ⇒ Establish the Think Tank and support its social, economic, environmental functions.

- ⇒ Establish community communications particularly with spatial information and crowd sourcing methods. The basic concept is to break from traditional processes and systems to address agreed targets and goals.
- ⇒ Develop institutional arrangements and policies to achieve Project 5 goals.

Partners needed in addition to Project 5 partners, are innovative project management and communications groups. (Not identified at this stage.)

Key processes clearly are related to Think Tank functions and will be researched in Project 5.4.

The constraints on Project 5.2 are the capacities of the proposed methods to break through the social and cultural comfort zones, initially in agriculture and subsequently across the community. The concept is that spatial technologies overcome many of the structural boundaries that support these comfort zones, e.g. poor and inequitable communications and access to community knowledge and opinion, and poor and inequitable access to technologies and services.

The driver is that other CRC projects will develop processes to allow communities to rapidly change from little or none of SI technologies to high levels of SI technologies that are simply seen as black boxes that perform highly beneficial functions.

5.3 Building capacity, engagement and up-skilling in the agriculture service sector to support appropriate and innovative uses of spatial information

Description

Despite high levels of education, skills and experience across the whole service sector to agriculture, these are very traditional and isolated within the competition ethos. This appears to be reinforced by current institutional policies. Spatial information education, skills and experience is very tightly held by surveying related units.

Despite possibly 20 Australian Universities having SI products "coming out our ears" (Peter Gregg), SI knowledge and background in the agricultural service industry (and all rural based industries except surveying) are limited to maybe 20 of the 1000+ consultants and advisers. Most consultants and advisers have tertiary qualifications.

CTF Solutions reported recently that the SI skills, capacities and services required for the future of the grains industry are clearly defined, but are desperately lacking.

Agriculture offers a service sector that is highly educated but culturally constrained. This group is expected to recognise the benefits of skills upgrades and the necessity of further training and development. The sector is also able to recognise applications and innovations for their clients and agriculture as a whole.

The CRC clearly offers this service sector new knowledge and tools, nothing threatening their current intellectual property. It is expected that appropriate training packages will be widely accepted.

The impact of this up-skilling with SI on agriculture is expected to be revolutionary as the service sector internally challenges itself and SI provides new accurate measures of performance and impacts that can not be ignored. For example, CTF Solutions reported that a 50% increase in productivity and sustainability and similar social benefits is achievable in the short term with continuous improvement providing long term benefits.

The sites in Project 5.1 will be chosen to engage the widest possible range of service sector participants. The various groups were identified in the previous paper. Because of agriculture's dominant place in rural communities it is expected that the initial focus on agriculture will provide effective entry into the whole community. However, particular emphasis will be applied to the mining industry at the two sites where mining dominates the local economy and creates tensions between different industries and community groups. Can SI bring these industries together to address mutually beneficial outcomes for business, environment and the whole community?

The triple bottom line benefits revolve around capacity building in the whole community and making SI available to all.

Project components are:

- ⇒ Identify specific up-skilling foci identified in Project 5.1, what are a few must-have skills and capacities?
- ⇒ Develop materials and processes to apply these foci, and to encourage continuous further improvement
- ⇒ Deliver materials and identify further needs, and the cycle goes around.

Partners have been identified. Key CRC personnel and partners must provide the SI, Project 5 will access the target communities and establish partners as appropriate. As previously stated, all key groups are essential.

A key focus should be to bring more women into our industries. Women are probably more suited than men for many SI tasks. Women are also taking increasing roles in the business and environmental aspects of agriculture and this will be an excellent entry for the CRC.

Adult learning and on-the-job interactions are essential processes. Agriculture has a long history of providing such services to farmers but up-grading these processes is also required. Using SI tools is a key approach to create new ways to engage particularly this professional sector.

This Project could be constrained by poor understanding of this sector. Why have these professionals so neglected the up-grading with new skills? Why have information providers so neglected this group? Are these agricultural cultural and comfort zone issues? Do other industries have the same issues? These questions must be answered in the first Sub-project to ensure that the materials developed are appropriate.

The service sector is particularly broad but all components must be engaged. Of course, if some sections progress this will pressure others to follow. The benefit will be that skills developed in agriculture will also be applicable in other industries.

5.4 Facilitating spatial information think tanks to seek innovative solutions to a range of 'wicked problems' or issues of complexity

Description

Major social, cultural and comfort zone issues have been identified as constraining agriculture and many rural industries and communities. Within sectors there has been innovation and change, e.g. tractors have developed a lot, but with little consideration has been given to impacts on farming systems or standardisation of components. A major internal supporter of this situation is the lack of industry strategic direction or a group representing whole of industry interests.

A similar situation has developed with RTK GPS – many similar products are available, in reality they all try to provide the same product, but they are neither compatible nor transferable. The duplication and isolation are enormous costs on industry for no material gain, and this further constrains innovative or even simple, widely applicable solutions. Again, lack of direction and leadership are drivers.

These situations have developed over time and are “what we have always done”. In simple terms these can be described as a competition approach.

Increasingly, cooperation is seen as a necessary, maybe the only, way we can address complex or multi-faceted, spatial problems, e.g. climate change, water, etc. But, cooperation can clearly solve the local problems described above. The concept proposed is cooperation with independence – apply either depending on which gives the best outcome.

CTF Solutions has identified linkages in the agricultural information chain that optimise agricultural outcomes and SI processes. These are driven by the potential now for automated data collection and transfers, data management and processing to information, and interactive presentation and delivery. The weak links are compatibility between processes and methods and assured quality.

Do these issues have systems solutions, holistic and measurable outcomes? Systems thinking is the driver for solutions to these multi-faceted, highly interactive problems. The system solutions of interest involve both physical (technical) and human dimensions to achieve adoption and change.

The initial goals are to define agricultural systems with SI needs and then SI system solutions.

Project 5.4 will initially seek systems solutions to three key issues for SI as sub-projects:

- ⇒ Defining whole of industry positions
- ⇒ Cooperation with independence
- ⇒ Information chain solutions

The process will be independent Think Tanks where up to 10 people are chosen to develop system directions or strategies relevant to issues within these general topics. The Think Tank statements will be offered to industry and the community for responses but will also guide the CRC activities, i.e. lead the industries. The outcomes will be better understanding of the systems functioning in SI technology applications in agriculture and community responses. These think tanks will provide direction for Project 5.

Think Tanks will use SI processes such as crowd sourcing, wikis and webinars for input data and community feedback, and these will be evolving and dynamic statements.

Project 5.4 will research and develop Think Tank processes and applications for SI issues. The background concept is that the CRC is itself new and independent to agriculture and can perform as a very interested outsider without vested interests but with the goal of maximising benefits from CRC outputs. We assume that processes developed for agriculture will be widely applicable in rural areas.

At least one partner with experience of these concepts is needed. This will probably come from our partner Universities. Project 5.4 will be outcome focussed, not an academic focus. Of course, successful impacts will be of academic interest and wide application.

Project 5.4 will be constrained by the people involved and the clarity of the tasks presented to them, i.e. the leadership and direction of the teams.

While the initial focus will be specific Australian SI applications, the processes will have wider industry and international interest.