Scoping study to review Mechanisation, Automation, Robotics and Remote Sensing in Australian horticulture

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Food Innovation Partners

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Project HG09044

Final Report

Mechanisation, Automation, Robotics and Remote Sensing (MARRS) for Australian horticulture

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HG09044 – Mechanisation, Automation, Robotics and Remote Sensing (MARRS) in Australian horticulture

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Purpose: This is the Final Report for project HG09044," Scoping study to review Mechanisation, Automation, Robotics and Remote Sensing in Australian horticulture". The final report

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TABLE OF CONTENTS

MEDIA SUMMARY

The objective of project HG09044, “Scoping study to review Mechanisation, Automation, Robotics and Remote Sensing (MARRS) in Australian horticulture” was to review the opportunities and likely impediments for the development and implementation of MARRS technologies into Australia’s horticulture industry. The project has developed a strategic vision and plan (based upon case studies, a review of current and future expectations across the horticulture industry, and an analysis of competitive overseas trends), to help advise Australia’s horticulture industry and Government in relation to future investment into Mechanisation, Automation, Robotics and Remote Sensing (MARRS) for its industry.

This scoping study has highlighted an industry need for MARRS solutions, and this translates into a compelling case for the building of a Centre in mechanisation automation robotics and remote sensing (MARRS) for the horticulture industry extending across Australia and New Zealand.

The first workshop which looked at syndicate members and participants experiences with development and implementation of MARRS technologies, found that there was already activity underway in various segments of the horticulture industry. These developments are being undertaken in isolation and in an uncoordinated fashion. The SWOT analysis showed there were looming threats from labour shortages and associated rising costs threatening the industry’s competitiveness. Australia’s horticulture industry lacks leadership in the areas of MARRS developments. The workshop identified the greatest opportunity lay in the development of a Centre that draws together the fragmented MARRS R&D capability in Australia and New Zealand and can provide leadership and drive, and most importantly provide a focal point for the industry to access capability and support for MARRS strategies.

The Scenario Planning workshop identified a preferred future for Australia’s horticulture industry: Scenario 2 - UTOPIA (utilising technology overseeing productive, intelligent innovation). The UTOPIA scenario pictured a horticultural industry ‘informed’ thanks to the uptake of MARRS technology that provided improved quality, decreased inputs, utilisation of the entire crop and greater eating quality and hence consumption. This scenario would provide a reinvigoration of horticulture in Australia with increased exports to the blossoming Asian markets and an industry that attracts people and expertise. As MARRS technologies are developed and taken up, so the cost of MARRS technologies will decrease. The export of Australian expertise in MARRS has the potential to become an industry itself.

The key strategic action identified from this scoping study is the development of a trans-Tasman Centre to focus the development of MARRS technology for the horticulture industry. A MARRS Centre will require a portfolio of investment to form the core of this new platform. It will require investment from commercial companies, industry, research organisations, State and Commonwealth Governments. By adopting a ‘Centre’ approach, the intention is to draw together and leverage the strengths of these partners, collaborators and service deliverers to add value throughout the horticulture chain.

TECHNICAL SUMMARY

The objective of this project HG09044, "Scoping study to review Mechanisation, Automation, Robotics and Remote Sensing (MARRS) in Australian horticulture" is to prepare a clear business strategic plan (based upon case studies, a review of current and future expectations across the horticulture industry, and an analysis of competitive overseas trends), to help advise the National Horticulture Research Network (NHRN) and Horticulture Australia Ltd in relation to a future investment into Mechanisation, Automation, Robotics and Remote Sensing (MARRS) for Australia's horticulture industry.

The key outcomes of the project are:

1. An understanding of the critical drivers for the development of MARRS solutions and the barriers to the uptake and adoption of these technologies in the horticulture industry in Australia and New Zealand. This was achieved through Workshop1: "Barriers to Implementation of MARRS Solutions", which gathered input from industry, research organisations and State Governments.
2. Development of plausible future scenarios for the horticulture industry in Australia and New Zealand in relation to the level of adoption of MARRS solutions. Workshop 2: "Plausible Scenarios for Horticulture in Australia in 2030" identified and described four possible and plausible future scenarios for the industry. The scenarios defined and assessed during the workshop were *Hand Crafted Brands, UTOPIA, Same Again but Automated* and *Future Focused Systems*.
3. A broad review of the work being undertaken globally in developing MARRS technologies and solutions for the horticulture industry. The review of Mechanisation, Automation, Robotics and Remote Sensing for Australian Horticulture considered developments around the world being applied to horticulture and how they might address the drivers affecting the competitiveness of Australia's industry. The implications of MARRS technology development and application were considered through the inclusion of Case Studies.
4. Development of a Business Case for a MARRS Centre in Horticulture. The Business Case also identified a possible structure for a future MARRS Centre, involving a partnership between industry, commercial companies, research providers and Government. Also included in the Business Case is a plan to initiate and build the MARRS Centre.
5. An assessment of options and recommendations on a MARRS research program that would build upon the capacity and skills identified during the study and address some of the potential gaps in capability.
6. A "Capability Map" of the research and expertise relevant to the development of MARRS solutions for the horticulture industry, where it is located in Australia and New Zealand, their strengths, achievements to date, how they can be contacted and whether they are commercially focused or academic as well as examples of their work. This "Capability Map" will eventually be made available through Horticulture Australia's web site.

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The key strategic action identified from this scoping study is the development of a trans-Tasman Centre to focus the development of MARRS technology for the horticulture industry. A MARRS Centre will require a portfolio of investment to form the core of this new platform. It will require investment from commercial companies, industry, research organisations, State and Commonwealth Governments. By adopting a 'Centre' approach, the intention is to draw together and leverage the strengths of these partners, collaborators and service deliverers to add value throughout the horticulture value chain.

In order for the development of a new MARRS Centre to proceed, it is essential to gain the support of all the major stakeholders, both in Australia as well as New Zealand. The first steps in a process of securing stakeholder support is to ensure there is HAL Board and NHRN endorsement of the concept for Centre for MARRS in horticulture for Australia and New Zealand, and to raise awareness and support from both industries.

The scoping study identified fourteen key recommendations for the development of a Centre for MARRS in horticulture;

Recommendation 1: Present the Final Report and recommendations of project HG09044 - Scoping study to review Mechanisation, Automation, Robotics and Remote Sensing in Australian horticulture, to the Executive Management team and Board of Horticulture Australia Ltd as well as the NRHN for review and endorsement.

Recommendation 2: Initiate the development of a new trans-Tasman Centre for MARRS in Horticulture.

Recommendation 3: Approach the largest horticulture sectors in Australia, Banana, Apple & Pear, Citrus, Vegetables, and in New Zealand Kiwifruit, to seek their endorsement and commitment as core partners of a MARRS Centre.

Recommendation 4: Design a MARRS Centre using the eighteen design principles identified from the NFIS Centres of Excellence Review.

Recommendation 5: Develop a Centre for MARRS that operates through a unitary management structure with good corporate governance, to facilitate operation with multiple partners from industry, research organisations and Government across both Australia and New Zealand.

Recommendation 6: Prepare an application to the Commonwealth Government's CRC Program for support.

Recommendation 7: Develop a business model for a future MARRS Centre that ensures financial viability long term.

Recommendation 8: The MARRS Centre establishes a Research Program with the following streams of activity;

- System and Application Analysis,
- Plant Varieties and Agronomy Systems,
- Autonomous Robot Platforms,
- Proximal and Remote Sensing Systems,

- Decision Support Systems and Data Management,
- End Effectors, and
- Automation Integration.

Recommendation 9: It is recommended that a detailed budget for the proposed Centre be developed during the next phase of the project in collaboration with potential partners.

Recommendation 10: Undertake economic modeling of MARRS at an Industry and Sector level using Hi_Link model developed by Centre for International Economics to support the case for a MARRS Centre. Engage the Centre for International Economics to run the Hi_Link model to simulate the economic effects of MARRS technologies at an Industry and Sector level.

Recommendation 11: Initiate a MARRS Centre Development Project to undertake the detailed development of a Centre for MARRS in horticulture and to prepare a CRC bid.

Recommendation 12: Develop a syndicate of organisations and companies willing to contribute to funding the MARRS Centre Development Project as Voluntary Contribution (VC) members.

Recommendation 13: Explore additional opportunities for funding towards a MARRS Centre Development project.

Recommendation 14: Select and engage a specialist consulting firm to assist with the preparation of a CRC bid for Round 14.

This study has also highlighted the critical importance of developing appropriate business models for successful commercialisation of any MARRS technology. The business model can be seen as the way in which the commercialiser of the technology will make money in the market place. Companies can create and capture value from their new technologies in three basic ways: through incorporating the technology in their current businesses, through licensing the technology to other firms or through launching new ventures that exploit the technology in new markets.

Maintenance and service infrastructure is the third critical dimension for successful implementation of MARRS solutions in the future. The development of a support infrastructure is crucial to successful deployment of MARRS solutions, as the horticulture industry is located in rural and regional Australia and traditional skill levels in these regions are not based around MARRS technologies. Going forward, strategies will need to be defined for the development of this infrastructure through training and remote support processes.

INTRODUCTION

The National Horticultural Research Network (NHRN) was established in 2001 and comprises the Horticultural R&D managers from the State Departments of Primary Industries, CSIRO and University of Tasmania. The focus of the NHRN is collaboration and strategic leadership for R&D to support viable horticulture industries in Australia. NHRN formally meets three times per year – primarily with Horticulture Australia Limited (HAL).

In 2008 the NHRN undertook a review of all the Horticulture Industry reports received from within its network for the review of prospects in "Mechanisation, Automation, Robotics, and Remote Sensing" (MARRS). The committee was of the opinion that there are a number of opportunities to introduce MARRS-related technologies and advances at all levels of Australia's horticultural operations.[1] However, the rate of success and the commercial viability of the possible solutions, vary to a great extent. From an engineering point of view, crop layout structure (eg. glasshouses/greenhouses, highly defined field rows, intensive orchards etc) is the most fundamental aspect for MARRS solutions to be applied most effectively to secure a commercial advantage. Despite structured crop layout, some crops do not lend themselves to bear fruit in a structured way. In such situations, major agronomical input is necessary in the area of plant research. As extreme examples, baby leaf and lettuce can be laid out in a very structured manner while avocado may not be able to be grown so as to present its fruit in a structured way that will facilitate automated harvesting.

MARRS-related opportunities can be broadly categorized into three areas – crop production, harvest and postharvest. In the case of crop production, crop yield monitors could use precision agriculture and crop sensor applications (remote sensors) allowing growers to provide more accurate water and fertiliser regimes critical in times of drought and high fertiliser costs. The grower would also be better informed to predict physiological events (eg. flowering, fruit set, pest incursions, maturity indices) enabling them to better manage spray regimes, worker schedules, and most importantly predict market yield for domestic and export markets. The technology and software associated with many of these applications is still very much in its infancy and would usually require the producer to be technology literate in order for them to obtain the greatest use from these systems.

For harvest operations, the degree of structure varies significantly across the types of crops, hence the success rate of MARRS uptake and application is likely to be varied. However, in the case of postharvest operations the structure remains significantly constant. Hence the prospects of MARRS usage in postharvest operations are much higher (certainly in the short-term) than those of harvest operations.

The main aim of undertaking MARRS research in horticulture is to achieve competitiveness in the Australian industry in relation to that of international markets. Therefore, performance rates are of utmost importance. Bearing in mind that Australia currently competes with other emerging economies with significantly larger and 'cheaper' labour pools, the solutions proposed must be able to match the traditional manual production rates. In some cases OH&S issues may also need to be addressed.

Australia is well placed to achieve significant gains by taking up MARRS-related technologies, particularly in the crop production and harvest operations of structured crops. To achieve commercial advantages in other crops, thorough investigations are necessary to reduce/eliminate or combine crop production, harvest and post harvest operations. As an example, a cucumber 'harvester' deployed in a protected plantation may be used to determine an individual plant's nutrition or pest incursion level for directed fertilizer and pesticide application, the ripeness quality and size, determine whether to harvest or not, then during harvest conduct an instant fruit inspection for blemishes and other defects, grade and package. The NHRN review indicated the possibilities of process integration to minimise costs and increase throughput so that a competitive solution with minimum labour can be achieved.

It is of utmost importance that Australia's horticulture industries start to recognize MARRS solutions as part of the entire process. Any MARRS assessment must be carried out on the entire process with and without automation to determine the commercial and economic advantages. Most often the assessment is carried out only on the part that is first considered for automation. It is also quite possible that MARRS solutions may introduce additional MARRS-associated problems to be solved and hence the entire process may have been adversely affected with its introduction, so it is important to thoroughly assess a situation prior to investment. The Review undertaken by the NHRN also recognized that much could be learnt from other industries that have already embraced these strategies both here in Australia as well as overseas programs around automation in agriculture, in particular New Zealand.

The committee also noted that there are crop groups that lend themselves to MARRS solutions however; they more than likely do not have the financial strength to fund the development of MARRS solutions that may benefit them. Hence there is a need to assess all industries to ensure replication does not occur and that knowledge of new applications is shared amongst the whole of the horticulture industry as much as possible to reduce costs. In this way, smaller industries will likely benefit from technologies developed by larger industries.

In December 2008, at the meeting of the National Horticultural Research Network (NHRN), it was agreed that they would seek to commission through Horticulture Australia (HAL) a scoping study on the application of Mechanisation, Automation, Robotics and Remote Sensing (MARRS) technologies to horticulture in Australia.

This scoping study would also develop the Business Case for commercial, industry, State and Commonwealth investment (via HAL) in the development and application of MARRS technologies to Australian horticulture. A Terms of Reference for this scoping study was prepared and Project HG09044: Mechanisation, Automation, Robotics and Remote Sensing (MARRS) in Australian horticulture commissioned.

Following consultation with industry, research providers, government and financial providers, a business case for a future Centre in MARRS Technologies will be prepared that outlines the opportunities for investment in the development of MARRS and associated technologies.

This Scoping Study consisted of the following activities;

1. Review and assessment of existing technologies and those in development, being applied to horticulture pre and post harvest around the world. This included case studies to provide examples of the value and advantages as well as crucial implications of MARRS applications in horticulture.
2. A workshop to engage with some of the key stake holders in the Horticulture industry, to understand the critical impediments and drivers impacting the industry now and in the immediate future and to test the demand for MARRS solutions. This workshop also undertook a SWOT analysis.
3. A Scenario Planning workshop, that built upon the outcomes from the first workshop in particular the SWOT analysis was undertaken to define a number of possible futures, define the industry's preferred future and develop an action plan to get there. The process also considered the consequences of not achieving the preferred future.
4. A review of the type and extent of MARRS technologies being applied in other agricultural based industries. Engagement with the other agriculture industry bodies has allowed us to capture some of their "Lessons Learnt", so that the horticulture industry can be aware of some of the pitfalls and to also determine if there is an opportunity to co-invest with these sectors of the agriculture industry in future MARRS strategies.
5. The development of a 'Capability Map'. The Capability Map lists the MARRS research and development capability relevant to the Horticulture industry; where it is located in Australia and New Zealand, their strengths, achievements to date, how they can be contacted as well as examples of their achievements.

6. Development of a Business Case for investment in the development and implementation of MARRS and associated technologies. The Business Case includes;
   i. The compelling need for a MARRS Centre.
   ii. An assessment of options and recommendations on the best structure for a MARRS Centre and how it will be implemented. The implications of the likely geographical separation of research agencies/companies,
   iii. Recommendations for a MARRS research program. The need to identify applications of MARRS technologies to horticultural crops as well as basic research,
   iv. Recommendations for appropriate commercialisation strategies for a MARRS Centre,
   v. The economic justification for investment in a MARRS Centre in horticulture,
   vi. Proposed plan for the detailed development of a MARRS Centre.

Australia's horticulture sector

The horticulture sector is the second largest sector within Australian agriculture, being slightly less than the grains industry, but well above the combined average contributions of the wool and dairy industries[2]. Horticulture is the second-largest and the fastest growing industry in agriculture; with some 30,000 businesses nationally, and a farm gate value of $9 billion. Total horticulture exports (including fresh fruit, vegetable, nuts and plants including flowers) were $751m (12 months to May 2008). As the most labour intensive of all agricultural industries, Horticulture employs around one-third of those employed in agriculture[3] as a whole.

Horticulture is diverse incorporating 140 commodities; including sectors such as vegetables, fruit, nuts, nursery, turf, cut flowers and extractive crops. Table and dried grapes, but not wine, are also part of the industry.

Horticulture is also geographically diverse – with horticultural production undertaken in almost all 56 catchment areas across Australia. The major growing areas for edible horticulture include the Goulburn Valley of Victoria; the Murrumbidgee Irrigation Area of New South Wales; the Sunraysia district of Victoria/New South Wales; the Riverland region of South Australia; northern Tasmania; southwest Western Australia and the coastal strip of both northern New South Wales and Queensland. Nursery and turf production generally occurs within or close to the capital cities and regional centres.

Banana, pineapple, mandarin, avocado, mango and fresh tomato production is concentrated in Queensland; stone fruit and oranges in New South Wales, Victoria and South Australia; processing potatoes in Tasmania; fresh pears, canning fruit and processing tomatoes in Victoria; with apples and fresh vegetables in all States.

Australian horticulture has many fundamental advantages. Australia has many climatic regions ideally suited to growing different horticultural crops and has a long tradition of success in agricultural sciences to underpin innovation activity.[4] Australia also has a unique partnership between industry and government to collect a levy for investment in agriculture innovation.

Productive capacity

The two largest product sectors of horticulture, fruit and vegetables have generally achieved increasing GVPs (Gross Value of Production) since 1999-2000. The fruit GVP increased every year apart from 2003-2004 which followed a severe drought. The vegetable GVP has been more variable and vulnerable to droughts. It has also experienced a significant market downturn for processing vegetables.

Since 2000-2001, the main constraint on the industry's productive capacity has been climate variability and the impact of two severe droughts in quick succession on production and farm profitability. Low water availability from natural rainfall and restricted irrigation water allocations has also been a key production-limiting factor.[5]

Drivers in Australia's horticulture Industry

The key drivers effecting Australia's horticulture industry in today's economic environment have been widely recognized as:

- Competitiveness, labour shortages,
- Green technologies and sustainability,
- Industry location,
- Food safety and security, and
- Consumer choice.

The increasing costs of production associated with a strong dependency on a secure labour force, greater scrutiny of food safety issues and consumer expectations for environmentally responsible production processes, are driving the industry to better understand, measure and strategically respond to issues involving mechanisation, automation, robotics and remote sensing capability. The labour roles in the Horticulture industry are evolving with people needing higher levels of skill across a greater breadth of functions[6]. For example seasonal workers in viticulture are being replaced by automatic pruning and harvesting machines.

Despite the challenges facing Australia's horticulture industry it has experienced strong growth over the past decade. The inadequacies of national data on industry employment requirements and the absence of aggregated vacancy data mean that it is difficult to systematically document the labour shortage issues in rural Australia.[7]

The Queensland Fruit and Vegetable Growers Association (Growcom) estimates that due to labour shortages, during harvesting, its members lose up to 10 per cent of their crops – produce estimated to be worth $900 million. Such problems are not confined to Queensland. Fruit growers from around Bunbury in the southwest of Western Australia say demand for orchard workers outstrips supply, particularly during harvest season. In Victoria, SPC-Ardmona, says that for the last three years production at their Shepparton cannery has been lower than it might have been because fruit has been left on the trees as there aren't enough people to pick it, while a Yarra Valley berry grower says labour shortages in 2004 forced him to 'drop' 6 tonnes of raspberries from his vines. A leading Australian fruit exporter says the lack of a reliable supply of seasonal labour significantly inhibits industry growth in the Murray Valley irrigation region and limits export income.[8]

The Horticulture Industry's strategic plan, Future Focus Report[4] identified some clear strategies for Australia's horticulture industry in relation to getting the most from technology;

Progressive technological change requires R&D that delivers:

- productivity growth in terms of more efficient resource use per unit of output and in particular yield growth, more consistent quality and the substitution of capital (mechanisation) for labour,
- better cool chain and transportation solutions,
- new products,
- products with new attributes valued by consumers or handlers.

The report also identified that getting the most from technology has long been a strategic imperative of the industry and can play an important role in building competitive advantage and in bolstering the effectiveness of supply chains.

An action plan for the horticulture industry, built around such an objective would need to:

- be informed about where current technological limitations are restricting Australia's competitive advantage or supply chain effectiveness,
- be informed about where current technological opportunities might bolster Australia's competitive advantage or supply chain effectiveness in terms of economies of scale and scope in R&D,

- identify what R&D actions and initiatives might be able to be devised to overcome limitations and exploit opportunities,
- evaluate the costs and expected market impacts of such action,
- identify where and why normal competitive commercial influences are unlikely to allow Australia to get the most from its technological capacity,
- assess Australia's current private and collective technical R&D capacity and its strengths and weaknesses relative to international competitors,
- identify if Australia's collective horticultural R&D capacity needs to be bolstered.

The Australian Horticulture Industry cannot afford to take a fragmented approach to MARRS and so consistency of knowledge, interpretation, and application within the industry is vital as the industry comes to terms with a wide range of challenging global issues.

The Australian Horticulture industry is looking to have a thorough and up-to-date understanding of the MARRS capabilities within Australia (and overseas where applicable) and what it can offer to this industry. To this end, this study has included the development of a MARRS Capability Map (Attachment 4). The NHRN, Future Focus process, and HAL Postharvest and Emerging Technologies Portfolio have all identified the need for an across-industry approach to the development of MARRS capability and applications.

Many other agricultural industries and businesses are already down the path of developing these capabilities. However, there is a need to ensure consistency and reduce the risk of duplication in future funding. It is therefore critical that this study is developed and accepted by the Horticulture Industry as a whole (which includes major Agribusinesses) and that it is capable of delivering meaningful outcomes for all stakeholders.

Mechanisation, automation, robotics and remote sensing in the horticulture industry are a high priority for the HAL Postharvest and Emerging Technologies Portfolio. There has been some significant investment in this area already, however HAL wants to ensure a consistency of approach and cost effectiveness of any future investment in this area as the industry moves forward.

Robotics and automation

Robotics and automation in Agriculture is not a new phenomenon: In controlled environments it has a history of over 20 years. However, with the latest increase in computational power combined with a cost reduction, robotics applications are spreading. The development of mechanical assistance or automation in harvesting systems began as early 1883 when Hugh Victor McKay, a 17 year old, tired of turning the heavy handle on his fathers' winnowing[i] machine in country Victoria, wondered if a harvester could be made to winnow as well. With the help of his brothers George and John, he built a prototype made of old metal scraps and farm tools. It was finished in 1884 and called the Sunshine Harvester. It was an immediate success because it separated the grain, straw and chaff using a rotary fan making the entire harvesting process automatic.

The study of robot applications for plant production also had an early start in 1984 with a tomato harvesting robot[9]. Currently there are automated harvesters in the research phase for cherry tomatoes, cucumber, mushrooms, cherry and other fruits. In horticulture, robots have been applied to harvest citrus and apples destined for the juice industry where visual product damage is not an issue. So far, no harvesting robot has reached the stage of commercialisation, because of their low operational speeds, low success rates, and high costs.

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[i] Winnowing is a method of separating grain from chaff using a fanning effect.

The key areas associated with the application of automation to horticultural production that have significant challenges to be addressed are:

- **Path finding**; navigation both within the rows of an crops and orchards and in order to get to the field,
- **Mapping**; keeping track of where the automation task has already been completed and where it remains to be done,
- **Vision**; computer vision recognition of the target such as the trunk, the fruit/produce, the bud, the flower, etc,
- The **design of the mechanical system** or robot which will perform the task of picking, spraying, pruning, pollinating, etc,
- Building an **automation platform** which is cost effective, can handle rough terrain, sloping ground, mud, soil and rain. This platform needs to be adaptable to other tasks and other crops,
- **Intelligent inspection** to decide which targets are appropriate for mechanical manipulation. For example, robotic picking is vastly more efficient if only produce of the correct size and colour is picked. Similarly, robotic pollination is most efficient when only female flowers with a suitable spacing are selected for pollination,
- **Produce handling**; many horticulture products need to be handled very gently once they have been harvested as a drop of even a small distance may cause bruising.
- **Obstacle avoidance**: computer vision recognition of obstacles such as people, poles, wires, stumps and rocks so that an autonomous robot can navigate safely around these.
- **Swarm behavior management**: to allow multiple autonomous robots to function together in one area without interfering with each other,
- **Cost**; most of the horticultural tasks, such as fruit picking, only last for a few months of the year and it is not cost effective to use a robot for such a short period. Ideally, robots should be capable of performing many different operations, such as picking, crop maintenance, bud count followed by pollination followed by fruit count, in order to extend the utilisation of the technology and ensure a reasonable payback period, and
- **Maintenance**; As the majority of the horticulture industry is located in rural Australia often in remote areas, it is important to be able to provide a maintenance and servicing infrastructure to support the development and adoption of these technologies. The introduction of MARRS technologies will require a significant up skilling and training program in order to maintain these new and emerging technologies and systems. But it also provides an opportunity to retain and attract a younger workforce to rural Australia, that have an interest in computing and the associated skills involved with automation.

BUSINESS CASE FOR MARRS CENTRE

The Compelling Need

Findings from Workshop 1: "Barriers to Implementation of MARRS Solutions"

This scoping study commenced with a workshop held in Sydney to engage with some of the key stake holders in the Horticulture industry, to understand the critical impediments and drivers impacting the industry now and in the immediate future and to test the demand for MARRS solutions[10]. During the workshop, participants outlined their experiences with MARRS technologies and discussed issues that their organisations have already identified.

The following is a summary of those key Issues and messages from Industry participants;

- The consumer has to be a consideration in the development of MARRS solutions,
- Australia's cost of labour is driving a lot of the innovation. The lack of suitable labour its high cost, is creating an industry crisis,
- Communication is critical; but there is a lack of information flow about what is happening and opportunities emerging for MARRS,
- Australia's horticulture industry has a small domestic market and, compared to our southern hemisphere counterparts has a limited focus on global markets – so whilst we can be a dominant supplier we are price sensitive,
- The industry application of MARRS is constrained by a lack of structure with field operations vs. the more structured environment of a pack-house or greenhouse for example. There is also a lack of alignment of critical processes making MARRS applications difficult to apply across the supply chain,
- There is an opportunity and a need to 'add-value' to in-field technologies,
- A lot of work has been done in the post-harvest environment vs. the pre-harvest environment. The harvesting aspect is an issue almost entirely unique to the horticulture industry,
- There is a need for 'whole system' approach to MARRS solutions – that are customised to the crops. But there is complexity in this with lots of different crop types. The 'whole system' approach needs to go from plant breeding upwards through the whole value chain.

The key issues and messages from the State Extension Services (Departments of Primary Industries) participants were;

- There is a question of who will drive innovation in the horticulture industry? Who will drive adoption of MARRS?
- Potential Costs /Benefits need to be carefully assessed. MARRS may be the determining factor with the competitive advantage and even future viability of various industry sectors (example of different development trajectories of carrot and cauliflower industries in Western Australia),
- How do we pick the 'winners': industries that could prosper with development of MARRS solutions? Need to undertake a broad assessment, including dimensions such as impact on 'carbon footprint' etc,
- Cost of development of technologies and innovation could be a key challenge,
- What can the Departments of Primary Industries bring to projects in MARRS? Connections to growers, Extend learning across borders, Develop links with grower groups, and Help with integration of technology into farming systems,

- What is the mechanism to draw resources together? Who should do it? There is an issue of a lack of overall leadership and co-ordination, and
- The technology adoption cycle is long. There is a tendency to work to the average. Need to focus on applying existing technology as well as development of new technology. Work with early adopters – and forget the tail of lagging slow adaptors.

The key issues and messages from Solution Providers and R&D organisations were as follows;

- People who 'need' the technology must have 'skin in the game',
- Question of how do we get industry levy funders on board with MARRS – this could be a critically important funding source for R&D work,
- We need to work out what is holding back adoption OR is it that the time is 'now right': we have reached a point where the critical pieces are in-place and we have to work out how to fit them together,
- There is a gap between solution providers and users – how do we commercialise ideas?
- Who is the winner? – might be the marketer? Might be the big players? – The owner of technologies might not be the growers. This has implications for adoption and funding pathways, and
- We have a lot to learn from other industries – need to explore the modular idea with bolt-on technologies – there are lots of pieces.

The participants at the Workshop also undertook a SWOT analysis (Figure 1).

	INTERNAL	EXTERNAL
POSITIVE	STRENGTHS • Pool of enthusiastic innovators with skills, R&D networks; Industry groups and Robotics expertise. • HAL can lead the industry – not be constrained by 'average'. • Australian industry are good adaptors – with capacity to learn from experiences across Tasman (NZ has export focus and supply chain expertise). • Government is willing to fund projects and initiatives (eg CRC's / R&D agencies). • Opportunity to adapt existing applications into Horticulture industry. • Australia has a strong R&D base stretching from State Government Departments, through Universities to CSIRO.	OPPORTUNITIES • Opportunity to improve product consistency and decrease variability. • Need to understand carbon footprint story and undertake holistic analysis of benefits. • Build innovation into supply chain. • Maybe able to make new businesses out of MARRS – put Australia on the cutting edge and create a point of difference. • Opportunity for new sources of funding – CRC / ARC. • Bigger players are entering the sector – the majority of the produce is coming from fewer players – consolidation occurring. • Improve competiveness through MARRS technologies.

	WEAKNESSES	THREATS
NEGATIVE	• Missing some key people and sectors at the "table". • Too much domestic focus – fixation with supermarkets – we need to be more export competitive. • Fragmentation of the industry - Supply chain dysfunctional - Some primitive business practices - Lack of capital • Unresponsive nature of industry (full of 'old men'). • Lack of young people and lack of innovation. • Volatile currency and $AUD high and high freight costs. • Diverse industry consisting of 43 sectors.	• External environment with decreasing competitiveness and increasing labour costs and restricted supply. • Overseas innovation may beat Australia. • Failed projects affecting future adopters of MARRS. • Not defining problem – it is the opportunity / outcomes that defines success of the project. • Commonwealth Government may not invest as exports decrease and imports increase. • No industry long-term plan. • Possible wavering industry support.

Figure 1. SWOT Analysis Results.

The Workshop participant's responses to the results of the SWOT analysis were as follows;

- There is a lack of individual industry foresight and vision,
- There is a shortage of resources including dollars, to support working group and there is a need for industry education and support,
- There is a funding gap between 'proof of concept' and 'commercial application' – might need to be consortium funding model to bridge the gap. Major players could potentially collaborate to lead process and innovation,
- Lack of appropriate development funds and capacity to turn technology into applications. Support should be focused at platform level, and
- Skills base: not a strong pool of people who have engineering / technology skills and agricultural background.

The SWOT analysis clearly identified the constraints impinging on the horticulture industry and the opportunities that are there to be captured. The workshop also discussed what the critical drivers are for the horticulture industry, and discussed how MARRS solutions can be developed and implemented and what the likely barriers to uptake are.

Discussions during the workshop conclude that:

- There were significant amounts of MARRS activity already occurring in Australian and New Zealand horticulture. The presentations that were given by participants were quite an 'eye-opening' experience,
- There is real potential to leverage off world-class R&D capability in MARRS that already exist in Australia; examples included CSIRO remote vehicle work; and automation in the mining and resource sectors, and
- It is critical to try to reach out to innovative producers and industry groups and build support to move forward with this strategy.

Towards the end of the Workshop, participants were asked if they believed there is a compelling case for the Horticulture Industry to pursue MARRS approach and solutions. The responses were;

- Major driver of MARRS is cost of labour. This creates a compelling case. This 'cost' includes aspects such as:

  - Volatility of labour supply,
  - Lack of availability of suitable labour,
  - High costs of management and support of labour,
  - Need to ensure labour is sourced ethically,
- There is a case for integrated supply-chain systems beyond MARRS. There is a strong case for more thinking about mechanisation – for example, CTA (Controlled Traffic Agriculture) could be a method of access to more structured approaches to farming and changing the thinking and culture of in-field operations,
- There is an issue of a lack of take-up of technology (including existing technology) – having a compelling case may not translate into adoption,
- MARRS is already happening in some areas – there are significant ‘pieces’ of activity,
- Development and adoption may be led by larger businesses. Smaller and medium business may not have resources or critical mass to invest. Need to ensure industry is on the ‘leading edge’ not the ‘bleeding edge’ of innovation and development,
- It is critical to share information,
- Yes there is a compelling case – but need to share development costs and work to make it viable to pursue at an industry level,
- Australian horticulture is traditionally more an adaptor than a developer or inventor of technology,
- Yes; could bring new people into the industry – there are potentially big yield gains,
- Need to take a ‘portfolio approach’ to technology and adoption,
- Could lead to better technology being available; could result in better use of resources,
- Potential to link across industries and adapt technology from the mining industry and other sectors,
- Should first look at technology already available that can be adapted,
- Could be important for IP already in Australia. Potential to develop some globally competitive new technology industries and sectors as a ‘spin-off’ – potential for new business platforms in Australia, and
- There is a challenge in achieving a suitable Return-On-Investment (ROI) – MARRS does not necessarily mean a premium for products; has to produce a cost advantage and/or a yield increase.

During the Workshop there was strong agreement that the horticulture industry needs to look across sectors and draw on existing technologies for a whole-of-system approach. There is a lot of work to do – but important steps have already been taken (Future Focus Report). The Workshop attendees indicated that there is strong interest in the potential for MARRS to revolutionise key industry systems and systemic changes – especially in the more ‘unstructured’ in-field environment. The tenure of the workshop was very positive: while people could see potential hurdles, the potential of MARRS technologies for horticulture was compelling.

Outcomes and recommendations from Workshop 2: “Plausible Scenarios for Horticulture in Australia in 2030”

A second Workshop was held in Brisbane in February 2010 involving forty eight participants from across the horticulture industry in Australia, plus representatives from New Zealand and included people from industry, research and Government. The workshop used the results of the first workshop and of the literature review to directly provide the drivers used in the development of the scenarios, and indirectly as important background information. During this scenario planning workshop, participants were guided through a modified scenario planning process to develop four plausible scenarios for the future of the horticulture industry in Australia.[11]

The critical drivers for the future of the horticulture industry in Australia in the short- and medium-term were identified at the first workshop held in Sydney in November 2009. Participants at that workshop identified from a Questionnaire[12] nine key drivers impacting on the future of Australia's horticulture industry and eleven key drivers for implementing MARRS technologies into horticulture/agriculture. The participants nominated the top four ranked drivers impacting on the future of the industry now and in ten years time. The participants also ranked the key drivers for implementing MARRS technologies into horticulture/agriculture in priority from most to least important.

The Key drivers impacting on the future of Australia's horticulture industry that were identified were;

- Labour supply,
- Carbon footprint/environmental issues (energy usage),
- Human ethics (worker conditions),
- Local domestic production needing to compete on a global scale,
- Cleaner safer food,
- Product Quality,
- Water efficiency and security,
- Product efficiency and Yield, and
- Increasing production efficiency.

The Key drivers that were identified as impacting on the implementation of MARRS technologies into horticulture/agriculture were;

- Increased crop yield,
- Reliance on human labour,
- Improved technologies,
- Access to information and skilled people,
- Access to money/grants,
- Commercialisation of MARRS technologies,
- Cost/cost effectiveness of MARRS technologies,
- Scale of business,
- International competitiveness of crops,
- Industry-R&D liaison through industry bodies, and
- Improved product quality.

These drivers were then plotted on a graph rating importance against uncertainty to highlight four clusters of drivers (Figure 2). Dominating the graph is labour supply. Labour supply has been recognised as an important driver of the future of horticulture in Australia. There is uncertainty in the medium-term regarding the availability of labour (e.g. domestic, imported or outsourced) and the relative cost of labour inputs in Australian horticulture in comparison to major competitors. In the centre of the plot are drivers of intermediate importance and uncertainty. These are not considered to be scenario-shaping drivers, but will be important in each of the scenarios. Two clusters of drivers are found in the top left and bottom right of the plot. These are the highly important drivers (Improved technologies, Reliance on human labour, Access to information & skilled people, Commercialisation of MARRS technologies) and those with a high degree of uncertainty (Scale of business, International competitiveness of crops, Industry R&D liaison through HAL, Improved product quality).

Together these two groups comprise the scenario-shaping clusters of drivers.

Adoption of MARRS technology

- Improved technologies
- Reliance on human labour
- Access to information and skilled people
- Commercialisation of MARRS technologies

Industry competitiveness, scale and integration

- Scale of business
- International competitiveness of crops
- Industry R&D liaison through HAL
- Improved product quality

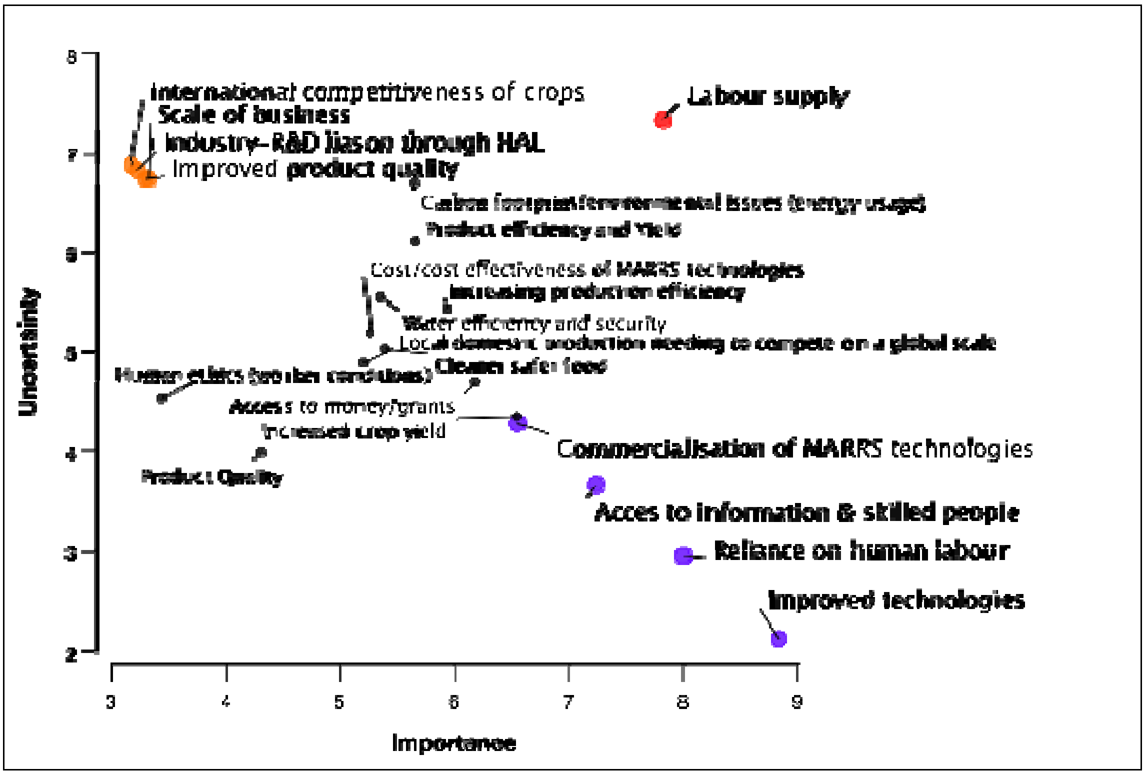


Figure 2. Plot of the importance and uncertainty ratings of drivers of the future of Australia's horticulture industry and of the implementation of MARRS technologies.

The scenario shaping drivers were used to define four scenario 'spaces', with quadrants either towards or away from each driver cluster (Figure 3). These quadrants were used to formulate four plausible scenarios. A detailed narrative for each scenario explored economic, environmental and social implications for the farm, industry and region out to 2030 is provided in Attachment 3 - Workshop 2: Plausible scenarios for horticulture in Australia in 2030.

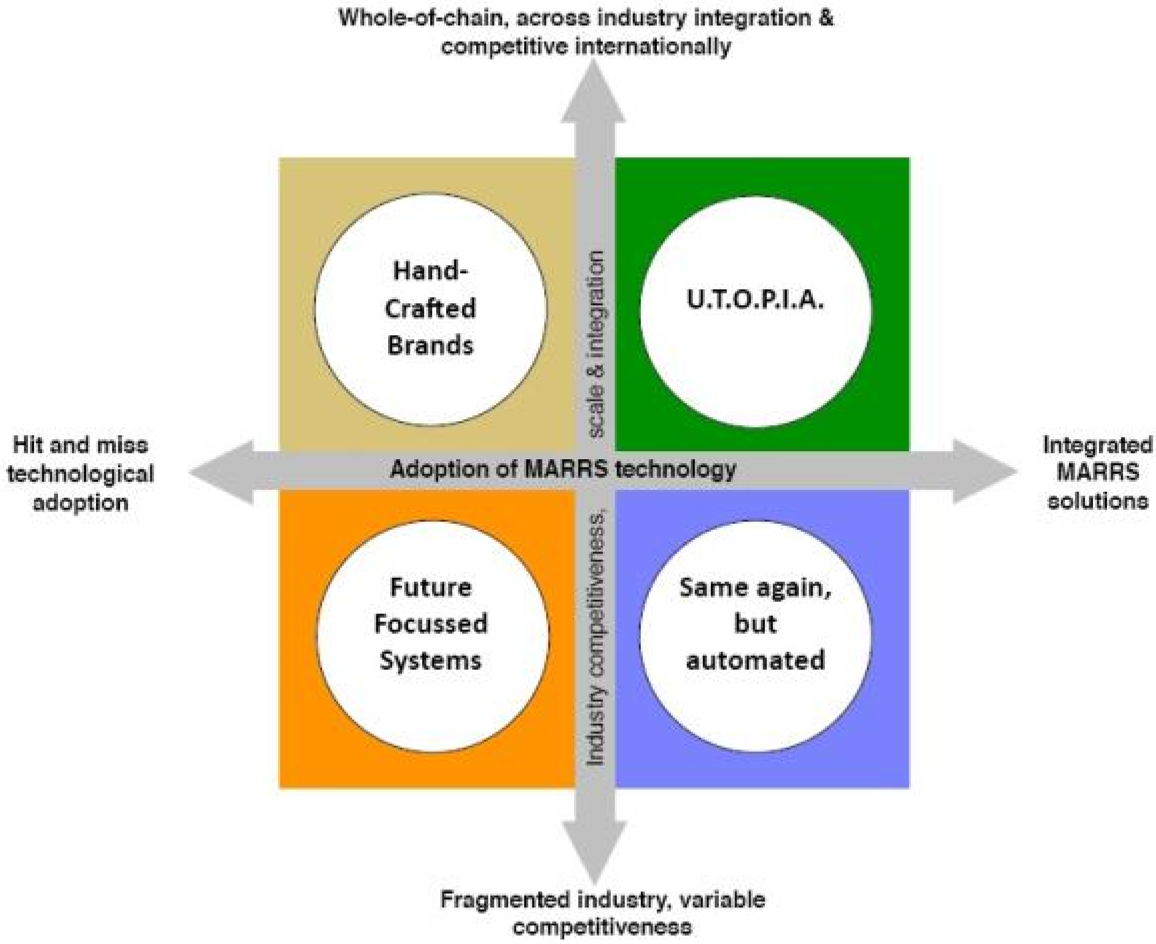


Figure 3. The scenario quadrants as defined by the scenario-shaping drivers.

The four scenarios defined are described as follows:

Scenario 1 - Hand-crafted brands: 'branded', high quality, high volume or 'niche' horticulture products providing specific, convenience produce to consumers. Industry development based on improved genetics, storage and handling, supported by a specialised workforce.

Scenario 2 - UTOPIA (utilising technology overseeing productive, intelligent innovation): horticultural systems are 'informed' thanks to the uptake of MARRS technology providing improved quality, decreased inputs, utilisation of the entire crop and greater eating quality and hence consumption. This has seen a reinvigoration of horticulture in Australia with increased exports to the blossoming Asian markets and an industry that attracts people and expertise.

Scenario 3 - Same again, but automated: the widespread implementation of MARRS technology has enabled small growers to remain viable, limiting rationalisation and consolidation, but this has contributed to the continued lack of a cohesive approach across the industry.

Scenario 4 - Future Focused Systems: widespread rationalisation sees only 5% of the growers from 2010 remaining as key 'nodes' of production. These businesses are vertically integrated, well-connected, adaptive and responsive. They are linked directly to wholesalers, the providers of technology and innovative solutions and providers of R & D. The remaining 95% have either exited the industry or are operating as service agents for the nodes.

These scenarios were used to explore an aspirational future for the industry: what is required to develop a common view of the future and strategies that the industry can act upon to drive towards a preferred future. Groups of workshop participants discussed the defined scenarios in relation to the SWOT analysis from the first workshop. Participants were asked to identify their aspirational scenario. Not surprisingly, *UTOPIA* was the aspiration of the majority of the participants (Figure 4), with the other three scenarios identified as the aspirational scenario by less than 10% of the participants.

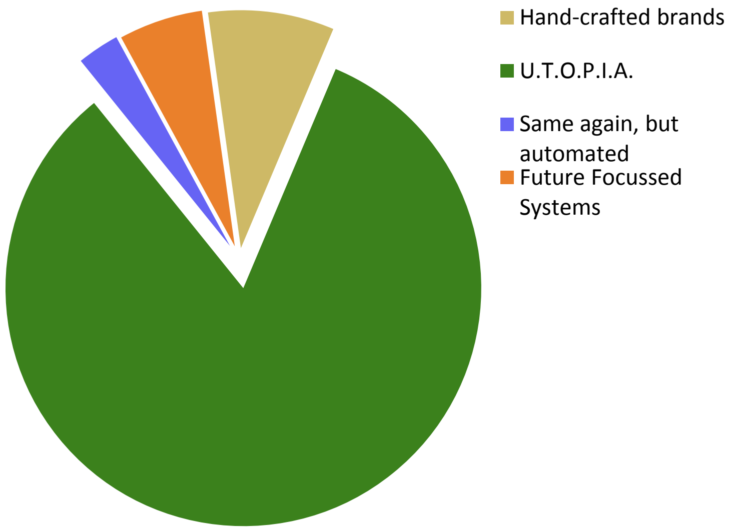


Figure 4. The proportion of participants nominating each of the scenarios as their aspirational scenario for the horticulture industry in Australia in 2030.

Participants who did not have *UTOPIA* as their aspirational scenario suggested several reasons for their choices.

- *Hand-crafted brands* was aspirational as it displayed resilience "without going too far",
- *Same again, but automated* was considered to be a robust system with winners and losers, and
- While *Focused Future Systems* had the appeal of being consistently moving, giving real people opportunities to go somewhere and providing no room for complacency.

Scenario 'shocks' are occurrences that have the potential to be scenario-changing, i.e. to move the industry from one path to another. The participants briefly explored some of the susceptibilities of the four scenarios to risk from 'shocks'.

Hand-crafted brands: was considered to be susceptible to competition from imports as it can be hard to protect a niche. There is a need for a higher margin with a point of difference to ensure that niche crops remain viable.

UTOPIA was considered to be possibly vulnerable in the early stages of the development of MARRS as well as to equipment failure and capital cost.

Same again, but automated: needs to be more innovative than 'same again' if it were to be the future of the industry. The challenge of competition from imports, which is part of this scenario, is seen as a potential susceptibility of a fragmented industry.

Focused Future Systems: participants considered that the nodes would be resilient, but the system susceptible to competition from more innovative competitors who have larger, more open R&D systems.

From the Scenario Planning Workshop, participants recommended five critical strategic actions;

1. Development of a trans-Tasman Cooperative Research Centre to focus the development of MARRS technology for horticulture (possibly in conjunction with the wider agriculture sector).
2. Showcase the “heroes”—case studies of growers who have already implemented aspects of MARRS to show what can be done.
3. Identifying research that is occurring already and options for a prototype system or industry as a demonstration of MARRS in horticulture.
4. Information for the horticulture associations, industry sectors, research organisations and commercial players through a road show to spread the ‘wow!’ about the potential for MARRS in horticulture (PMA, Horti Fair).
5. Promotion of the concepts and opportunities to industry, government and the general public.

Findings from the Review of Mechanisation, Automation, Robotics and Remote Sensing (MARRS) for Australian horticulture

A review of MARRS-related technologies with case studies of their implementation from around the world has also been conducted as part of this scoping study and is detailed in Attachment 2 - Review of Mechanisation, Automation, Robotics and Remote Sensing (MARRS) for Australian horticulture, of this final report (Rankin 2010).

The Review identified extensive examples of development work being conducted globally for the horticulture industry. For instance Professor Rory Flemmer from Massey University is developing an autonomous Kiwifruit picking robot that is being trialed commercially in Zespri’s orchards in New Zealand. In another example two groups of researchers at Carnegie Mellon University’s Robotics Institute received $10 million in grants from the U.S. Department of Agriculture (USDA) to determine the feasibility of building automated farming systems. One is for apple growers and one is for orange growers, but both are designed to improve fruit quality and lower production costs.[13]

The Review covered the development of MARRS technologies for horticulture field and orchard application, protected cropping (Glasshouse/Greenhouse), and Packhouse use. The study covered mechanical systems, robotics, vision systems and other non-contact sensing such as NIR and X-Rays. Case studies were included to show the value and advantages MARRS applications can provide horticulture in Australia and to raise awareness of the issues that need consideration in the development and implementation of these types of solutions.

It is of utmost importance for Australia’s horticulture industries to remain globally competitive, to start to recognize MARRS solutions as part of the entire process. Australia’s horticulture industry has a need for the development and implementation of MARRS technologies.

The review identified three critical areas of development that need to be carried out in conjunction with the development of MARRS technologies in horticulture. These are;

1. Agronomic and growing systems that are tailored to the application of mechanisation, automation and/or robotics,
2. Commercialisation of MARRS solutions in order to make them a viable part of commercial horticultural production, and
3. The parallel development of support, service and maintenance expertise and infrastructure, particularly in rural and regional Australia.

Lessons learnt from other industries

The scoping study has also undertaken a review of non-horticultural agriculture industries to determine their experiences and strategies for investment in MARRS technologies. This information contributes to the horticulture industry planning process through an understanding of how other industries have focused their resources to developing automation solutions as well as identifying some of the barriers they have faced in the implementation of those technologies. Engagement with the other agriculture industry bodies has allowed us to capture some of their "Lessons Learnt", so that the horticulture industry can be aware of some of the "pitfalls" and to also determine if there is an opportunity to co-invest with these sectors of the agriculture industry in future MARRS strategies.

Interviews were conducted with senior managers from Meat & Livestock Australia, Seafood CRC, Dairy Australia and Grains Research & Development Corporation (Attachment 5 – Lessons learnt from other Industries). The level of strategic importance and support given by each peak industry body was varied from minimal with the Grains Research & Development Corporation (GRDC) to MARRS being a core strategy with Meat & Livestock Australia (MLA).

MLA is involved in a broad range of research and development throughout the supply chain. On-farm projects include grazing management, parasite control, meat quality, animal genetics for improved efficiency and environmental management. Post-farm R&D activity covers environmental management, product development, supply chain management, health and safety, education and training, technology development and commercialisation, food safety and microbiological research, and co-product innovations. It is within post-farm R&D portfolio that MLA has developed its strategies around MARRS technologies. Meat & Livestock Australia (MLA) have had a clear strategy for MARRS technologies in place for a number of years, as part of its goal to develop competitive advantages for the red meat industry.

MLA has recognised that there needs to be investment in technology platforms that in the future lead to commercial outcomes. Their MARRS strategies include a "Lost leader" strategy. This strategy is used to get technology into plants, even though it was not commercially viable. This exposes the industry to automation and robotics, assisting to have technology accepted.

In the development of automation and robotic solutions there are two different contexts for the R&D: one is academic and science driven the other commercially driven. The investment in academic research provides the underpinning research capability as a foundation for commercial development.

Finally one of the most important lessons learnt from the meat industry is that industry was reluctant to adopt MARRS solutions on labour savings alone. When MARRS solutions can deliver an increase in yield as well as productivity improvements, then the industry readily adopted these new technologies.

Economic justification

The creation of a Centre for MARRS in horticulture will only be supported by industry and government if there is a clear demonstrable economic justification. Cost benefit analyses can be readily undertaken at an individual project level with standard techniques such as Net Present Value calculations. But this only estimates the economic value of one particular technology in one particular application. The economic justification for an industry wide strategy in MARRS technology is far more complex activity and that has been beyond the available resources of this scoping study, although a process for its undertaking has been determined.

Australia's horticulture industry through HAL, commissioned the Centre for International Economics (CIE) to develop the *Hi_Link* model. The *Hi_Link* model is an analytical tool that captures all of the main economic linkages between industries locally and globally, up and down the entire value chain[14]. The model covers fresh, processed and amenity horticulture, domestic production and consumption and exports and imports. The *Hi_Link* model covers forty four different horticulture commodity groups but also produces results for aggregates such as fresh fruit, fresh vegetables, and processed products or nuts.

The *Hi_Link* model is a powerful tool that can be used to analyse the repercussions and effects from "What if?" type scenarios. It can be used to assess payoffs from strategies and actions and therefore allow the Australian horticulture industry to focus on what is important for profitability. Its value is in the insights and understanding it adds to the knowledge base about the Australian horticulture industry and what the key drivers affecting the industry might be. The model is unique to the industry and the only one of its type for horticulture anywhere in the world.

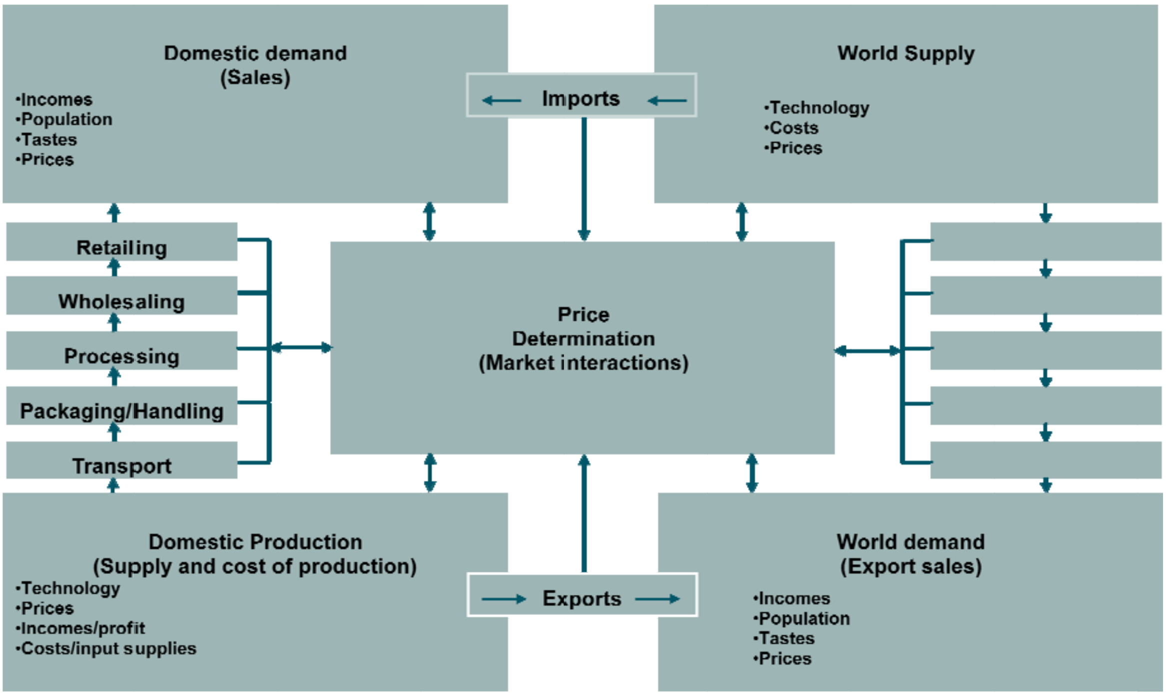


Figure 5: Graphical representation of the Hi_Link model.

The Future Focus Report commissioned by Horticulture Australia, which developed the Hi_Link model, estimated that productivity gains, for which MARRS solutions would provide a key contribution, had the potential to increase Australia's horticulture industry's profit by A$325 million per year by 2020 as shown in Figure 6.[15] The productivity attribute was shown to have the third largest potential contribution to the horticulture industry's profitability.

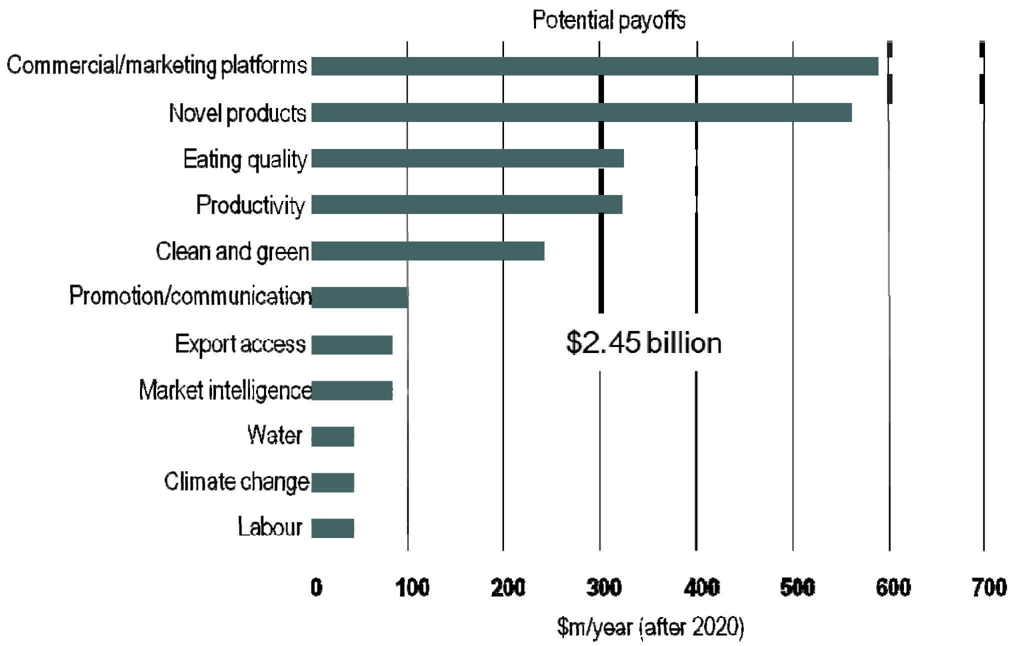


Figure 6: Productivity versus potential increased profitability.

Within the context of the Hi_Link model "Productivity" is proposed to be achieved through,

- Higher yields through breeding/genetic manipulation, better agronomic and farming systems for existing varieties and reduced losses due to pests/diseases; and
- Better machinery to lower labour costs and better farming systems to help improve water and labour use, and better handling, storage, processing and distribution systems to reduce wastage and lower costs.

Both of these factors are the core strategies that this scoping study has identified as essential in any future MARRS Centre and are inter-dependent.

Discussion

This scoping study has highlighted an industry need for MARRS solutions that can be translated into a compelling case for the building of a Centre in mechanisation automation robotics and remote sensing (MARRS) for the horticulture industry extending across Australia and New Zealand.

The first workshop which looked at syndicate members and participants experiences with development and implementation of MARRS technologies found that there was already activity underway in various segments of the horticulture industry. These developments are being undertaken in isolation and in an uncoordinated fashion. The SWOT analysis showed there were looming threats from labour shortages and associated rising costs threatening the industry's competitiveness. Australia's horticulture industry lacks leadership in the areas of MARRS developments. The workshop identified the greatest opportunity lay in the development of a Centre that draws together the fragmented MARRS R&D capability in Australia and New Zealand and can provide leadership and drive, and most importantly provide a focal point for the industry to access capability and support for MARRS strategies.

The Scenario Planning workshop identified a preferred future for Australia's horticulture industry: Scenario 2 - UTOPIA (utilising technology overseeing productive, intelligent innovation). The UTOPIA scenario pictured a horticultural industry 'informed' thanks to the uptake of MARRS technology that provided improved quality, decreased inputs, utilisation of the entire crop and greater eating quality and hence consumption. This scenario would provide a reinvigoration of horticulture in Australia with increased exports to the blossoming Asian markets and an industry that attracts people and expertise. As MARRS technologies are developed and taken up, so the cost of MARRS technologies would decrease. The export of Australian expertise in MARRS would have the potential to become an industry itself. The key strategic action identified from the Scenario Workshop was development of a trans-Tasman Centre to focus the development of MARRS technology for horticulture.

A MARRS Centre will require a portfolio of investment to form the core of this new platform. It will require investment from commercial companies, industry, research organisations, State and Commonwealth Governments. By adopting a 'Centre' approach, the intention is to draw together and leverage the strengths of these partners, collaborators and service deliverers to add value throughout the horticulture chain.

In order for the development of a new MARRS Centre to proceed, it is essential to gain the support of all the major stakeholders, both in Australia as well as New Zealand. The first steps in a process of securing stakeholder support is to ensure there is HAL Board and NHRN endorsement of the concept for Centre for MARRS in horticulture for Australia and New Zealand, and to raise awareness and support from both industries.

Recommendation 1: Present the Final Report and recommendations of project HG09044 - Scoping study to review Mechanisation, Automation, Robotics and Remote Sensing in Australian horticulture, to the Executive Management team and Board of Horticulture Australia Ltd as well as the NRHN for review and endorsement.

The case for a future MARRS Centre should not be dependent upon funding support from the Commonwealth Government's Cooperative Research Centre (CRC) program[16]. A future Centre needs to be built on a funding model that ensures its long term viability. It is though, recommended that an application be prepared and submitted, given that the program has substantial funds available and the concept of a Centre for MARRS aligns with the CRC Program's objectives and goals. The funding would support the central management, business functions and education program as well as providing seed funds towards the underpinning research activities.

Recommendation 2: Initiate the development of a new trans-Tasman Centre for MARRS in Horticulture.

Australia's horticulture industry is diverse, incorporating 140 commodities; including industry such as vegetables, fruit, nuts, nursery, turf, table and dried grapes, cut flowers and extractive crops. The challenge for the development of a Centre in MARRS is to define the overall scope. Not all segments of the industry have sufficient resources to be able to invest in a future Centre or fund projects involving the development and implementation of MARRS solutions. The three largest sectors within the Australian and New Zealand horticulture industry are Banana, Apple & Pear, Citrus, and then Vegetables. In New Zealand the largest horticulture sector by far is the Kiwifruit industry, followed by apple and pear, or better known in New Zealand as pip fruit. These are the Sectors of the industry that should be approached first to determine their commitment to the concept of a MARRS Centre.

Recommendation 3: Approach the largest horticulture sectors, Banana, Apple & Pear, Citrus, Vegetables, and in New Zealand Kiwifruit to seek their endorsement and commitment to a Centre for MARRS as core partners.

The Centre needs to be structured to have a core activity based around the industries represented by its core partners, but it must include a function to allow all sectors to access the outcomes and services provided. Operating in parallel to the Centre would be ongoing access to the support provided through Horticulture Australia's Voluntary Contribution (VC) program ensuring the smaller horticulture sectors are able to access the Centre's research outcomes and services.

Centre Objectives

A future MARRS Centre needs to define its scope in terms of clear industry challenges and opportunities. The Centre needs to be,

- Commercially focused with industry based outcomes,
- Provide a public good role (social & environmental),
- Facilitate end-user driven R&D partnerships,
- Address medium and long term major research challenges,
- Provide end-user focused education & training, and
- Include strategies to build SME innovation capacity.

The proposed Centre needs to have the following features:

- It links industry with researchers to focus R&D efforts towards commercialisation and adoption of outcomes,
- It will provide a virtual network and funding to build critical mass in development opportunities between end users and researchers to tackle clearly articulated, major challenges for end users. It will also fill gaps in capability needs of the horticulture industry.

In 2002 the Australian Commonwealth Government established the National Food Industry Strategy (NFIS) to assist the Australian food industry to improve its global competitiveness, capture new markets and build its market share. A key program within the strategy was to create two Centers of Excellence for the food industry, the Australian Food Safety Centre of Excellence (AFSCOE) and the National Centre of Excellence in Functional Foods (NCEFF).These Centers of Excellence would bring together industry and research organisations to be a central point to access leadership, research, knowledge and support. A review study[17] undertaken by Michael Edgecombe of Indigo Consulting Group identified a number of lessons that could be learned from the first three years of the Centers of Excellence program.

That review identified seven key recommendations:

1. *There is a continuing need for focused innovation hubs or centers within the Australian food industry system of innovation.*
2. *While primary research will continue to be an important foundation for innovation, hubs should focus on the delivery of science and technology services that support process, product and market innovation.*
3. *The services a hub can provide that is most highly valued by research purchasers are national leadership, research advice, research syndication, knowledge management and dissemination, and the provision of independent, expert opinions.*
4. *Where innovation hubs exist as joint ventures between committed commercial companies and science and technology partners, they should adopt corporate management structures with unitary management answerable to a board structured around key skills, supported by industry and science advisory panels.*
5. *Innovation hubs should be funded from a mix of industry investment, public sector investment, Government and user pays contributions.*
6. *Innovation hubs should have a business-oriented culture, supported by a performance management framework and business systems.*
7. *Innovation hubs should operate under professional management, including a dedicated executive and skilled, business development, communications marketing and project management staff.*

Design Principles

The findings from the review where then translated into eighteen Design Principles (DPs) that can be now used to guide the development of a Centre for MARRS in Horticulture.

<u>Role and objectives</u>

DP1: *The role of Centres is to facilitate industry product, process and market innovation through the provision of industry-driven research and technical skills.*

The objectives of the Centres are:

- to contribute to national leadership in industry development;
- to facilitate industry–science dialogue on industry challenges and opportunities;
- to support the development of relevant science and technology capability in Australia;
- to facilitate access to research and development capability by businesses of all sizes, by industry associations, and by government;
- to encourage collaborative investment in pre-competitive or broadly-based research;
- to facilitate access to relevant government support programs;
- to facilitate the dissemination and take-up of industry trends, research findings and technical know-how; and
- to provide a source of informed opinion for government and the media about relevant industry issues.

DP2: *Centres should be positioned as innovation hubs.*

DP3: *Centres should define the scope of the services they provide in terms of a defined industry challenges or opportunities and not in terms of a science capability.*

Services

DP4: *Centres should focus on delivering high value core services, including:*

- leadership, focused on the collaborative identification of research directions and development of national industry research agendas;
- research and development services and advice;
- commercialisation function;
- research syndication;
- knowledge management and dissemination;
- company challenge workshops;
- opportunity mapping and alerting;
- partnering with international research organisations to deliver solutions to Australia industry;
- education, training and professional development; and
- training in research management, innovation and commercialisation.

Structure, funding and governance

DP5: *Centres may construct themselves out of collaboration between industry, research and Government. Centres may be located in a larger host organisation, or may operate as a joint venture between partners.*

DP6: *Centres should operate through a unitary management structure even where there are multiple partners.*

DP7: *Before committing to joint venturing in a Centre, senior executives from potential partners should discuss in depth:*

- their needs;
- their strategic goals;
- their differing cultures;
- the complementary and competing strengths and weaknesses of their organisations; and
- how they intend to work collaboratively.

DP8: *Potential Centre partners should be required to enter into a suitable Memorandum of Understanding (MOU) as a prerequisite for launching the Centre.*

The MOU should include:

- the investment objectives of each partner in the Centre;
- the capability, expertise, and knowledge brought to the Centre by each partner;
- a commitment on the part of each partner to investing in and promoting the Centre as a single, unified brand, underpinned by a single, unified management structure and business development function;
- a commitment on the part of each partner to ensure that their own organisations are clear about their commitment to the Centre;
- explicit, shared understandings as to the strategic directions, culture, management policies and decision-making processes for the Centre; and
- agreed operational management processes and practices to ensure equity, transparency and ongoing trust.

DP9: *Each partner should nominate an alliance manage: tasked with managing the relationship between the partner organisations, other partners, and investors.*

DP10: *Funding for Centre infrastructure and core services should be provided by the partners from all tiers of government, industry associations and industry development agencies, and businesses.*

Centre should also generate revenue from a mix of other sources, including:

- membership, to which a range of benefits attach;
- advisory services, such as research and consultancy, on a fee-for-service basis;
- success fees paid by science and technology providers;
- information and knowledge services on a fee-for-service or subscription basis;
- facilitation of industry conferences;
- publications and tools;
- investment by public and private investors in specific pre-competitive research programs; and
- the creation of royalty streams through the licensing of intellectual property.

The Centre should be encouraged to be entrepreneurial and proactive in identifying, packaging and promoting opportunities for investment by industry and government.

DP11: *Centres must clarify their funding model to ensure they are sustainable.*

DP12: *A standard governance structure should be developed for Centres with three key components:*

- a small, lean, corporate board comprising representatives of major investors with strategic, marketing, financial and legal expertise;
- an Industry Advisory Panel, on which selected government stakeholders would also be represented; and
- a Science Advisory Panel.

<u>People and culture</u>

DP13: *Centres must develop close relationships with industry, and nurture an organisational culture that:*

- understands the different worlds of industry and science;
- is committed to a shared vision, mission and goals;
- is business-led, focused on commercial outcomes, entrepreneurial and motivated;
- is efficient and tightly managed to ensure competitiveness and the delivery of quality outcomes;
- is deliberate about communication and relationship management.

DP14: *Centres must have the right people in the right jobs. Staff should be carefully selected, and the structure should include:*

- Director, answering to a corporate board;
- Commercialisation Manager
- Business Development Manager;
- Syndicate Manager or Project Manager;
- Communications Manager; and
- Financial and administrative support.

DP15: *A standard performance management framework should be developed for Centres to monitor the performance of key tasks, such as commercialisation strategies, research agendas, and to measure:*

- financial performance;
- market profile;
- dialogue and collaboration;
- research, development and commercialisation;
- capability development;
- knowledge dissemination; and
- impact, including the overall return on investment.

DP16: *Centres require professional management systems for key processes, including:*

- planning and performance management;
- communication and knowledge management;
- business development and marketing; and
- syndicate or project management.

To reduce costs and assure high quality standards, it may be possible to develop shared management systems and infrastructure with a host organisation.

DP17: *In most instances Centres need to balance demand for commercial confidentiality with benefits to the wider industry and Australia.*

DP18: *Centres based in university environments should endeavour to expedite contract management by:*

- negotiating delegated budgets and contract signing rights, particularly for contracts under a significance threshold, such as $50,000;
- developing pro forma research agreements which can be approved quickly and easily;
- establishing account management procedures with commercialisation and legal units; and
- negotiating agreed document paths and performance criteria for contract negotiation and finalisation.

Recommendation 4: Design a MARRS Centre guided by the eighteen design principles identified from the NFIS Centres of Excellence Review.

A governance structure should be developed with three key components:

1. A small, lean, corporate board comprising representatives of major investors with strategic, marketing, financial and legal expertise;
2. An Industry Advisory Panel, on which selected stakeholders would also be represented; and
3. A Science Advisory Panel.

Recommendation 5: Develop a Centre for MARRS that operates through a unitary management structure with good corporate governance, to facilitate operation with multiple partners from industry, research organisations and Government across both Australia and New Zealand.

In order to provide the structure and functions envisaged, the proposed Centre for MARRS needs to have an appropriate amount of funding. Funding for a Centre could be sought from Horticulture Australia, individual potential partners such as Industry through peak bodies, commercial companies, research organisation, governments or other individual organisations. The Australian Commonwealth Government provides support for the establishment of collaborative centers through its Cooperative Research Centre (CRC) Program administered by the Department of Innovation, Industry, Science and Research.

The purpose of the CRC Program is;

- To support medium to long-term collaboration between the producers and end-users of research. That is public or private entities capable of deploying the research outputs to deliver significant economic, environmental and/or social benefits to Australia.
- Provide funding to build critical mass in research ventures between end-users and researchers which tackle major challenges for the end-users.
- To stimulate broader education and training for postsecondary students, particularly research students, to provide them with the skills needed to utilise research outputs and produce innovative end-user solutions.

The CRC Program is a well established mechanism for the formation of collaborative partnerships between publicly funded researchers and end users. Since the commencement of the CRC Program in 1991 there have been 12 CRC selection rounds completed, with the funding of 105 separate CRCs in the sectors of Agriculture, Forestry and Fishing, Mining, Manufacturing and Services. There are currently 42 CRCs operating.

Applications to the CRC Program are assessed against three core selection criteria, Research, Results and Resources.

Research; *The proposal will undertake excellent-quality research that addresses issues of economic, environmental and/or social significance to Australia,*

Results: *The outputs from the proposed research, when implemented, will deliver high levels of economic, environmental and/or social benefits to Australia, and*

Resources: *The proposed collaboration will marshal the appropriate participants and other resources necessary to achieve the proposed outputs.*

This next stage of development of a MARRS Centre should involve the preparation an application for funding support from the CRC Program.

Recommendation 6: Prepare an application to the Commonwealth Government's CRC Program for support.

The Centre must define a funding model to ensure it delivers on its goals and is sustainable in the long term.

Recommendation 7: Develop a business model for the MARRS Centre that ensures financial viability long term.

Centre Structure

This study has identified a number of possible embodiments of a future MARRS activity,

1. Cooperative Research Centre in MARRS for Horticulture. The CRC Program is funded by the Federal Governments through the Department of Innovation Industry Science & Research. The Program is designed to build critical mass in research activities between end-users and researcher providers to tackle clearly-articulated, major challenges for end users, usually industry.
2. Virtual Centre for MARRS. This type of structure brings together a focused capability and capacity through a "virtual network" rather than a formal rigid organizational structure. Each partner in this type of centre agrees on their roles and responsibilities before commencement. or
3. MARRS Program within Horticulture Australia Ltd. A MARRS Program within HAL would be likely structured along the lines of a research and commercialisation grant program, similar to the VC Program.

The final structure of the future centre will need to be further explored and finalised during the next stage of development of the MARRS Centre.

The structure of a future Centre for MARRS in horticulture must by virtue be a virtual centre with a “Hub” based within existing infrastructure. This constraint is imposed upon the structure of the Centre, due to the extensive industry base that will need to be serviced. This, along with the wide variety of potential partners from throughout Australia and New Zealand, makes the virtual centre structure model a viable option.

The Centre should have the core functions and activities as outlined in Design Principle 1 from the Centers of Excellence Lessons Learned 2003–2007 study[18]. That is,

- Contribute to national leadership in MARRS technology development and implementation;
- Facilitate industry–science dialogue on industry challenges and opportunities;
- Support the development of relevant MARRS technology capability in Australian industry and research organisations;
- Conduct underpinng research and development to address major challenges and capability gaps associated with the development and implementation of MARRS solutions;
- Facilitate access to research and development capability in MARRS by businesses of all sizes, by industry associations, and by government;
- Encourage collaborative investment in pre-competitive or broadly-based research objectives;
- Facilitate access to government support programs for both industry and research organisations;
- Facilitate the commercialisation, dissemination and take-up of MARRS, research outcomes, technical know-how and knowledge; and
- Provide a source of informed opinion for industry, government and the media about relevant technology issues, in particular economic, productivity and efficiency.

The Centre is anticipated to have core industry members through commercial horticulture companies and industry Peak Bodies, but it also needs to provide services and support to those sectors of the Horticulture industry not directly represented. This will allow for cross sector and industry wide uptake of the outcomes of MARRS research from the Centre. This function can be delivered by providing a business development role that can be the conduit to existing research capability and funding mechanisms such as HAL’s Voluntary Contribution (VC) program to develop and implement MARRS solutions on an individual company basis. The function would need to have the capacity to tap into the research outcomes from the Centre without the individual company being a core member. This would require structured management of the Centres IP and commercialisation strategies, but give significant spill over benefits to the wider horticulture industries in Australia and New Zealand.

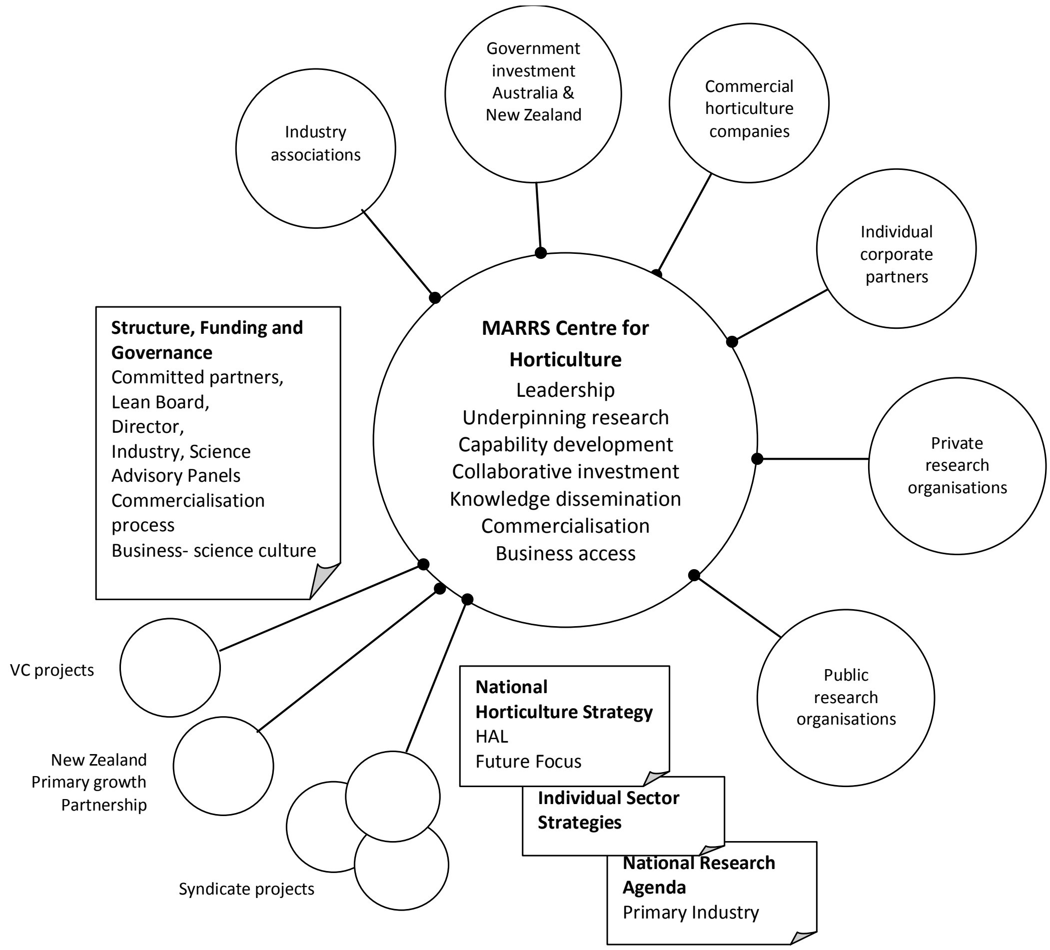


Figure 7: Graphical representation of possible structure for a Centre for MARRS.

Research Program

The research and development program for a new MARRS Centre needs to be developed that builds upon the capacity and skills of the proposed research partners, and addresses any existing gaps in capability that are critical to ongoing MARRS technology development. The research program must be industry and business driven: it needs to be focused on developing and providing solutions that have commercial application in the horticulture industry.

This section of the Business Case makes recommendations on an appropriate Research Program for the MARRS Centre.

System and Application Analysis:

One of the most important criteria for the development of MARRS solutions is selecting the most appropriate application in the context of the particular application. Professor Hugh Durrant-Whyte, Director of the ARC Centre of Excellence for Autonomous Systems emphasizes this strategy when discussing the ARC Centre's development of automation for the mining industry. Rio Tinto Mining was looking for automation solutions to address labour issues, but when the value chain was examined it was initially mining data integration and improved data utilisation that provides the greatest productivity increases and returns for companies.[19]

A MARRS Centre must have a System and Application Analysis stream that can undertake research and analysis of the value chains of sectors and firm level applications in the context of automation to determine the most economic and technological appropriate development and application of MARRS technologies for particular applications. This stream will have the capability to assess the value chain to determine the most appropriate areas for developing and implementing MARRS solutions.

Plant Varieties and Agronomy Systems:

This study has identified that the success of the development and implementation of MARRS solutions will often depend upon the parallel development of agronomy and growing systems that are optimised for the effective and efficient application of a mechanisation, automation or robotic system. This is important, in particular for harvesting and crop management systems[20].

Two critical streams of research (Plant Varieties and Plant Growing Systems) are required to be undertaken in parallel to the development of automation and remote sensing solutions for horticulture. Agronomy and growing systems need to be developed that are designed for the application of mechanisation, automation or robotic systems. This is critically important, in particular for harvesting and crop management systems. If plant varieties and growing systems are developed in parallel to automation solutions then the application of automation is likely to be more technically and economically effective. This was demonstrated in the Case Study – Automated Broad Acreage Harvesting of Broccoli: Matilda Foods, cited in the Review of MARRS Technologies as part of this project[21]. This Case showed the essential element of the development of automated harvesting, was to match the crop agronomy system with the automation. The agronomy system developed required the selection of the appropriate broccoli varieties that were tall enough for the harvester combined with growing practices that involved planting the seeds and seedlings in rows relative to the path of the sun to encourage increased plant height.

Autonomous robot platforms:

Many of the tasks associated with horticulture, such as picking, pruning, pest and weed control, are repetitive and arduous and there is a problem in getting and retaining labour to do them. Such tasks seem ideally suited to robots and, in countries where labour costs are high, there is an economic incentive to use automation as a solution to the problem. However, while robots are commonly used for repetitive tasks in other industries, they have to-date not been successfully applied in horticulture.

An industrial environment is typically clean, well-lit, dry and uniform while the horticultural environment is extremely variable in terms of weather, terrain, structure and light. The components which are manipulated in industrial settings are uniform, unobscured, stationary and robust whilst those in horticulture are generally very variable in terms of shape, colour and size, hidden amongst foliage, moving (for example, in the wind) and are soft and easily damaged during handling.

Autonomous robots are robots which can perform desired tasks in unstructured environments without continuous human input. Fully autonomous robots need to have the ability to,

i. Gain information about the environment,
ii. Work for an extended period without human intervention,
iii. Move either all or part of itself throughout its operating environment without human assistance, and
iv. Avoid situations that are harmful to people, property, or itself unless those are part of its design specifications.

This then gives rise to the following key challenges associated with horticultural automation:

i. Path finding; navigation both within the rows of an orchard and in order to get to the orchard,
ii. Mapping; keeping track of where the automation task has already been completed and where it remains to be done,

iii. Vision; computer recognition of the target such as the trunk, the fruit/produce, the bud, the flower, etc.

iv. The design of the mechanical system which will perform the task required,

v. Building a mechanical platform which is cost effective, can handle harsh environmental conditions,

vi. Intelligent inspection to decide which targets are appropriate for manipulation. For example, robotic picking is vastly more efficient if only produce of the correct size and colour is picked,

vii. Produce handling; many fruits need to be handled very gently once they have been picked as a drop over a small distance will cause bruising,

viii. Obstacle avoidance: computer vision recognition of obstacles such as people, poles, wires, stumps and rocks so that the system can navigate safely around these,

ix. Swarm behavior management to allow multiple systems to function together in one area without interfering with each other,

x. Overall cost; most of the horticultural tasks, such as harvesting, only last for a few months of the year and it is not cost effective to use automation for such a short period. To ensure maximum utilisation of capital, systems must be capable of performing many different operations in order to ensure a reasonable return on investment.

Proximal and Remote Sensing Systems:

An essential aspect in the application of MARRS technologies is being able to sense the environment in which the automation is being operated. You can't manage what you don't measure, is an old management adage that is applicable to automation. Unless you measure something you can't manipulate it. How you measure is as important as what you measure.

The development of proximal sensing technologies that guide automation and can enable assessment of product external and internal quality, are critical to the development of automation solutions. This includes improved visual resolution- for detection of pests, diseases, defects, plant parts; measures of internal colour, texture, density, dry matter, sugars, starches, oils, defects etc using a range of detection methods. These technologies have application pre and postharvest.

Remote sensing is the small or large-scale acquisition of information of an object, by the use of either recording or real-time sensing device(s) that are wireless, or not in physical or intimate contact with the object (such as by way of aircraft, spacecraft, satellite, etc). In practice, remote sensing is the stand-off collection through the use of a variety of devices for gathering information on a given object or area. Magnetic Resonance Imaging (MRI), Near Infar-Red (NRI), Positron Emission Tomography (PET), LIDAR (Light Detection and Ranging), and X-radiation (X-RAY) are all examples of remote sensing.

There are two main types of remote sensing: passive remote sensing and active remote sensing. Passive sensors detect natural radiation that is emitted or reflected by the object or surrounding area being observed. Reflected sunlight is the most common source of radiation measured by passive sensors. Examples of passive remote sensors include film photography, Infrared, charge-coupled devices, and radiometers. Active collection, on the other hand, emits energy in order to scan objects and areas whereupon a sensor then detects and measures the radiation that is reflected or backscattered from the target. RADAR is an example of active remote sensing where the time delay between emission and return is measured, establishing the location, height, speed and direction of an object.

The development of remote sensing technologies and applications will for example, allow for disease mapping or the mapping of spatial variability of crop conditions.

LIDAR (Light Detection and Ranging) is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target. Typical applications for horticulture or vine-based management systems include:

- Identification of vegetation vigor or health,
- Assessment of broad scale production impacts,
- Integration with other geospatial datasets to undertake multi-criteria analysis,
- Assessment of change over time, during growing season or between seasons

This research stream needs to develop sensing solutions that aid in both the identification and control of the automation in an unstructured environment. Some of the key attributes required from such a sensing system are,

- Path finding; navigation both within the rows of crops and orchards and in order to get to the field,
- Mapping; keeping track of where the automation task has already been completed and where it remains to be done,
- Vision; computer recognition of the target such as the trunk, the fruit/produce, the bud, the flower, etc.

Decision Support Systems and Data Management:

Managing horticulture production requires the observation and measurement of the production itself, as well as the economic and ecological environment, and to make decisions in order to adapt the production to the changing conditions. Horticulture production can be characterised as a complex system and the performance of this system depends on internal factors as well as on a whole group of controllable and uncontrollable external factors[22].

Decision Support Systems (DSS) are a specific class of information system that supports business and decision-making activities. A DSS research stream will develop system to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions. The following are examples of the application of the outputs from this research stream,

- Precision management of cropping systems in terms of fertiliser, chemicals, water and other inputs (this includes adaptive real time management based on current status of the crop and environmental conditions) – Weed mapping and control, adaptive control irrigation applications etc,
- Yield estimation (quantity and quality) for optimal management. For example, Nut tree yield mapping,
- Development of integrated systems for data collation and analysis (including environmental conditions, inputs/outputs) for productivity improvement and compliance/regulations.

End Effectors:

A critical requirement for the application of mechnisation, automation and robotics to the horticulture industry is the successful development of appropriate end effectors. An end effector is the device often at the end of a robotic arm, designed to interact with the environment. The structure of an end effector and the nature of the programming and hardware that drives it depend on the task to be performed.

There are four general categories of End Effectors, these are:

1. Impactive – jaws, claws or mechanisms which physically grasp by direct impact upon an object,

2. Ingressive – pins, needles or hackles which physically penetrate the surface of an object,
3. Astrictive – suction forces are applied to the objects surface (whether by vacuum, magneto– or electro adhesion), and,
4. Contigutive – requiring direct contact for adhesion to take place (such as glue, surface tension or freezing).

This research stream would focus on the development of novel end effectors that are simple, fast and don't damage the product or plant when applied, such as the application to fruit picking.

Automation Integration:

This research stream addresses the challenges in relation to the overall integration of automation into materials handling processes.

Recommendation 8: The MARRS Centre establishes a Research Program with the following Streams;

- System and Application Analysis,
- Plant Varieties and Agronomy Systems,
- Autonomous Robot Platforms,
- Proximal and Remote Sensing Systems,
- Decision Support Systems and Data Management,
- End Effectors, and
- Automation Integration.

Centre Budget

At this stage of the scoping study it is not possible to determine a likely budget requirement. Based upon the experience of other CRCs in the area of agriculture, it is estimated that the proposed Centre would require a budget of a minimum of $8 million per annum to support the research program, the commercialisation function and Centre management. This budget will also vary depending on how the horticulture industry decides to proceed. For instance if the industry decides to submit a CRC bid then the budget will also need to include an education and training stream.

Recommendation 9: It is recommended that a detailed budget for the proposed Centre be developed during the next phase of the project in collaboration with potential partners.

Commercialisation Strategies

The core driver for the Centre for MARRS is the development and implementation of MARRS solutions that are adopted into industry at a firm level to address the issues that Australia and New Zealand's horticulture industries are beginning to face due to labour scarcity.

Critical to the success of a MARRS Centre will be appropriate commercialisation strategies. Developing appropriate business models for successful commercialisation of any MARRS technology will be crucial. The business model is the way in which the commercialiser of the technology will make money in the market place for the product or service.

Companies can create and capture value from new technologies in three basic ways: through incorporating the technology in their current businesses, through licensing the technology to other firms or through launching new ventures that exploit the technology in other markets.

The functions of a business model are as follows:

- Articulate the value proposition (the value created for users by the offering based on the technology),
- Identify market segments. Users to whom the technology is useful and the purpose for which it will be used,
- Define the structure of the commercialiser's value chain which is required to create and distribute the offering and determine the assets needed to support the firm's position in this chain,
- Specify the revenue generation mechanism for the commercialiser,
- Describe the position of the commercialiser within the value network, linking suppliers and customers,
- Formulate the competitive strategy by which the commercialiser will gain and hold advantage over rival solutions,
- Assess capability required to achieve commercialisation, and
- At a firm level, the critical issue will be the economic return and the payback period on their investment. Also critical at the firm level is on-going maintenance: servicing and spare-parts related to these technologies.

As well as having a strong and focused research agenda the Centre must have an achievable path to adoption in industry of the research outcomes. Adoption and utilisation is where the Centre will have impact upon the industry and other end users. The Centre's commercialisation strategy needs to protect, manage and create value from the commercial exploitation of intellectual property and technology developed.

The commercialisation strategy needs to be more the licensing of intellectual property. It needs to take a role in fostering the development and adoption of technologies from the research laboratory, through the development stage and into the commercial environment to ensure industry impact.

The development of the commercialisation strategy is an opportunity to employ an "Open Innovation" policy. Open innovation is a strategy that can be employed to reduce development time to adoption in the market. It means that valuable ideas can come from inside or outside the Centre and be incorporated into technology development programs. This sort of policy places external ideas and external paths to market on the same level of importance as that reserved for internal ideas and paths. An open innovation policy means the Centre maybe able to reduce the R&D costs and time by accessing existing IP that resides elsewhere. This will increase the "speed to market" and provide the opportunity to unlock the value from existing IP that is not critical to the industry's competitive advantage.

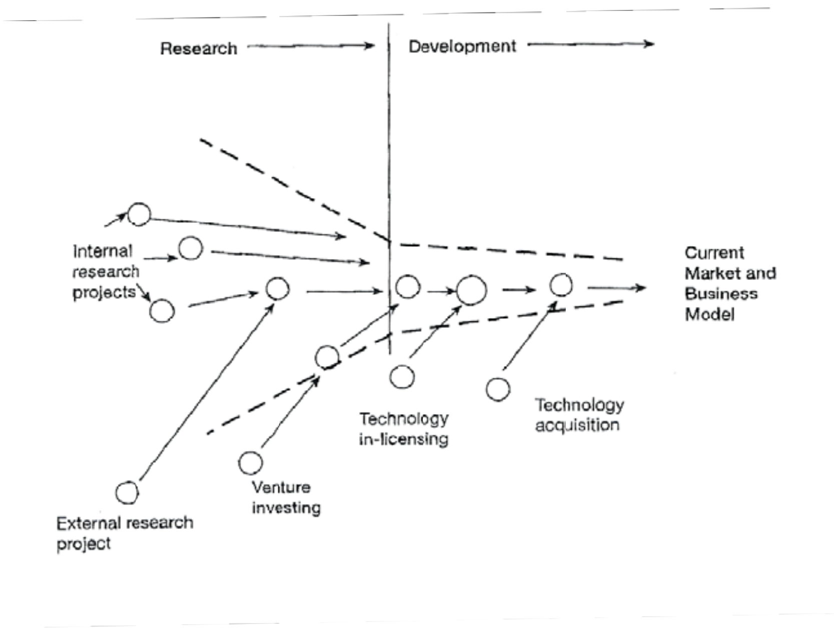


Figure 8: Representation of an “Open Innovation” technology pipeline.

Another important factor for the commercialisation and implementation of MARRS technologies is the development of maintenance and service infrastructure. The development of a support infrastructure is crucial to successful deployment of MARRS solutions as the horticulture industry is located in rural and regional regions and traditional skill levels in these regions are traditionally not based around MARRS technologies. Strategies need to be developed to build the support infrastructure from maintenance and repair to training.

Cost Benefit Analysis

Determining the Cost/Benefit of MARRS technologies can be calculated at two distinct levels. One is at a firm level for a specific application, while the other is at an industry level. Determining the cost benefit ratio or Return on Investment (RIO) for specific applications with a company’s operations can be done using traditional financial modeling tools such as Net Present Value (NPV). Undertaking a cost/benefit analysis at an industry or sector level is far more complex and involves an economic analysis of the industry using Horticulture Australia’s *Hi_Link* model.

At this stage of the project, the scoping study has not had sufficient resources available to undertake a detailed economic analysis such as that offered by the Hi_Link model. It is recommended that during the next stage of development of a future MARRS Centre that the Hi_Link model be used to assist in assessing the impacts that application of the MARRS technology may have on horticultural producers’ income, production, imports, exports and consumption.

Potentially MARRS technologies can help overcome labour shortages by increasing labour productivity in horticulture, that is, use capital to replace labour. But they can have other impacts as well. They can enhance other horticulture operations through precision horticulture which will help reduce resource usage or waste or increase yields. They may also be able to enhance quality.

The Hi_Link model provides a framework for assessing changes in major economic drivers of the horticulture industry. Major drivers included in the model are, available labour supply to horticulture, labour costs and productivity by industry, productivity of other horticultural operations and quality which affects consumer demand. MARRS technologies will change unit labour costs and other productivity parameters as well as (potentially) the quality preferences of consumers.

The essence would be to use the Hi_Link model to assess the impact on horticulture income of applying MARRS technology in the face of labour shortage and provide economic data to support the creation of a MARRS Centre for the horticulture industry.

Recommendation 10: Undertake economic modeling of MARRS at an Industry and Sector level using Hi_Link model developed by Centre for International Economics to support the case for a MARRS Centre. Engage the Centre for International Economics to run the Hi_Link model to simulate the economic effects of MARRS technologies at an Industry and Sector level.

Economic modeling of MARRS

The Centre for International Economics has proposed the following methodology for the economic modeling of Australia's horticulture industry in relation to the broad implementation and adoption of MARRS technologies.

Phase I – Industry-wide analysis of MARS benefits

- Review the recent macroeconomic and horticultural trade developments to modify the *Hi_Link* model baseline of the Australian horticulture to 2020.
- Simulate various labour supply scenarios reflecting tightening of the horticultural labour market in coming years.
- Use *Hi_Link* model to identify potential sources of gains from applying MARRS technology to overcome labour shortages by simulating increases in labour productivity in horticulture sectors and assessing the potential payoffs from such 'what if' scenarios.
- Use *Hi_Link* model to identify potential sources of gains from applying MARRS technology to improve the efficiency and productivity of other aspects of horticultural operations such as may arise from precision planting, fertilising, biotic stress control, harvesting and reduced resource wastage.
- Use *Hi_Link* model to identify potential sources of gains from applying MARRS technology to improve quality and achieve increased packhouse efficiency.
- Conduct sensitivity tests to identify key economic drivers affecting relative payoffs from application of MARRS technologies.

Phase II — Sector specific analysis of MARRS benefits

- Formulate more specific, indicative, sector-specific shocks of MARRS application with inputs from other analyses of the scoping study. The estimates from Phase I would simply be 'what if' estimates of standardised changes that might occur. In Phase II, effort would focus on calibrating changes in productivity and quality to indicators of the sorts of the potential of MARRS technologies. This would require examining some known examples of changes induced from MARRS technologies elsewhere and/or calibrating the sorts of changes expected by MARRS technologist.
- Use *Hi_Link* model to simulate these shocks.
- Conduct sensitivity tests.

Centre Development Project Plan

It is a recommendation of this study that a transition project (Syndicate project) be initiated for the detailed development of the new MARRS Centre and for preparation of CRC bid for Round 14 in 2011. The outcomes from this process would form the basis of a new Centre for MARRS in Horticulture that did not depend on CRC funding. The Centre Development and CRC Bid project would involve the following steps,

1. HAL Board and NHRN endorsement to proceed with development of Centre for MARRS in horticulture for Australia and New Zealand,
2. Raise awareness and support from all potential stakeholders for MARRS Centre in Australia and New Zealand,
3. Engage with New Zealand's horticultural peak bodies and the New Zealand Government to raise awareness and gather support,
4. Develop a syndicate of industry, research organisations, service providers and State Governments willing to participate in this next stage of development of the Centre.
5. Secure funding for the Centre Development and CRC Bid Project from Syndicate members, HAL VC Program and State Government support mechanisms,
6. Identify and select a suitable specialist consulting company to assist with the preparation of a CRC bid,
7. Build upon the foundation recommendations of this scoping study to develop a detailed structure, and operational plan for Centre for MARRS,
8. Undertake Hi_Link modeling of the horticulture industry with and without automation as economic justification of a new Centre for MARRS,
9. Identify suitable commercial and academic participants for a Centre for MARRS and discuss involvement as core partners,
10. Secure commitments from proposed partners towards a Centre for MARRS in horticulture,
11. Submit a CRC bid to the Australian Commonwealth Government[ii].
12. Sign agreements to commence Centre for MARRS in horticulture for Australia and New Zealand.

Raising industry awareness and support

Before the development of a Centre for MARRS in horticulture proceeds it is essential that there is wide support from the horticulture industry here and in New Zealand, the future stake holders. Without industry demand, drive and commitment the development of a future Centre is unlikely to succeed.

The first step in the process of raising awareness and endorsement of the proposition is to secure the endorsement of Horticulture Australia Ltd's Board, the National Horticulture Research Network (NHRN) and the peak horticulture industry bodies.

Securing industry's endorsement and commitment will require an extensive program of raising awareness of the issues and drivers facing the industry as highlighted during the course of this study, along with the value proposition that a Centre for MARRS could deliver.

Centre development project syndicate

The development of a new Trans-Tasman Centre for MARRS in horticulture will require the establishment of a new syndicate project that will then be able to access support from the Commonwealth Government through the Voluntary Contribution (VC) Program within Horticulture Australia. Initially the Syndicate Members from this scoping study should be approached to determine if they would like to continue to be involved in this next stage both in terms of funding as well as contributing to the strategic direction.

Preliminary discussions have been held with some of the existing Syndicate Members, and they have indicated that they would like to continue to contribute to the development of the Centre for MARRS. Preliminary discussions have also been held with the Queensland University of Technology (Professor John Bell, Assistant Dean - Research, Faculty of Built Environment and

[ii] Note that a new Centre for MARRS in horticulture is not dependent upon a successful CRC application.

Engineering 0419 803 424), and they have provided a Letter of Support (Attachment 6) for their involvement going forward. Discussions have also been held with Intellectual Ventures, (www.intellectualventures.com Chris Somogyi, Senior Strategist) a global invention investment organisation that has indicated interest in developing a relationship with the intention of investing in a future Centre for MARRS.

Recommendation 11: Initiate a MARRS Centre Development Project to undertake the development of a Centre for MARRS in horticulture and to prepare a CRC bid.

Recommendation 12: Develop a syndicate of organisations and companies willing to contribute to funding the MARRS Centre Development Project as Voluntary Contribution (VC) members.

Centre development project funding

It is a recommendation of this report to explore the opportunity to fund the Centre Development and CRC Bid Project through industry and State Government support mechanisms such as the Queensland Governments, Partnership Alliance Facilitation Program which provides support up to $50000. http://www.industry.qld.gov.au/dsdweb/v4/apps/web/content.cfm?id=8168. This could then be a contribution towards a VC Project Proposal with Horticulture Australia. Other funding contributions for this project would be sought from the syndicate members.

Recommendation 13: Explore additional opportunities for funding towards a Centre Development project.

Centre development project Budget

An estimated budget for the Centre Development Project is as follows,

Consultants fees for the coordination, management and syndication activities	$80,000
Engagement of CIE to run Hi_Link model with MARRS at Industry and Sector level.	$24,000
Engage specialist consultant to assist with CRC bid preparation.	$160,000
Contingency	$20,000
Total	$284,000

CRC Proposal Development

The CRC Program is funded by the Commonwealth Government through the Department of Innovation Industry Science & Research. The Program is designed to build critical mass in research activities between end-users and researcher providers to tackle clearly-articulated, major challenges for end users, usually industry. CRC's pursue solutions to these challenges that are innovative, of high impact and capable of being effectively implemented by the end users. The CRC Program provides a source of funding can be leveraged from resources that would be committed by industry, research providers, commercial organisations and Research Development Corporations such as Horticulture Australia Ltd (HAL).

The development and preparation of an application to the CRC Program requires specialist skills and knowledge to ensure the best chance of success. To assist the horticulture industry to mount a successful bid to the CRC Program, a specialist consulting firm should be contracted. Firms already indentified that have experience in preparation of CRC bids, and could assist in this process are,

- Kiri-ganai Research Pty Ltd[23], and
- Capital Hill Consulting[24],
- Capital Technic Group[25]

The CRC Program follows an annual application cycle with the announcement of successful applications in mid December. The CRC timing for Round 14 in 2011 is likely to be similar to the previous Round as follows,

- CRC Selection Round opens online first Monday in March,
- Applications close first Friday in July,
- Stage 1 assessment and outcomes in late August,
- Interviews in early November,
- Decisions and outcomes early December.

Recommendation 14: Select and engage a specialist consulting firm to assist with the preparation of a CRC bid for Round 14.

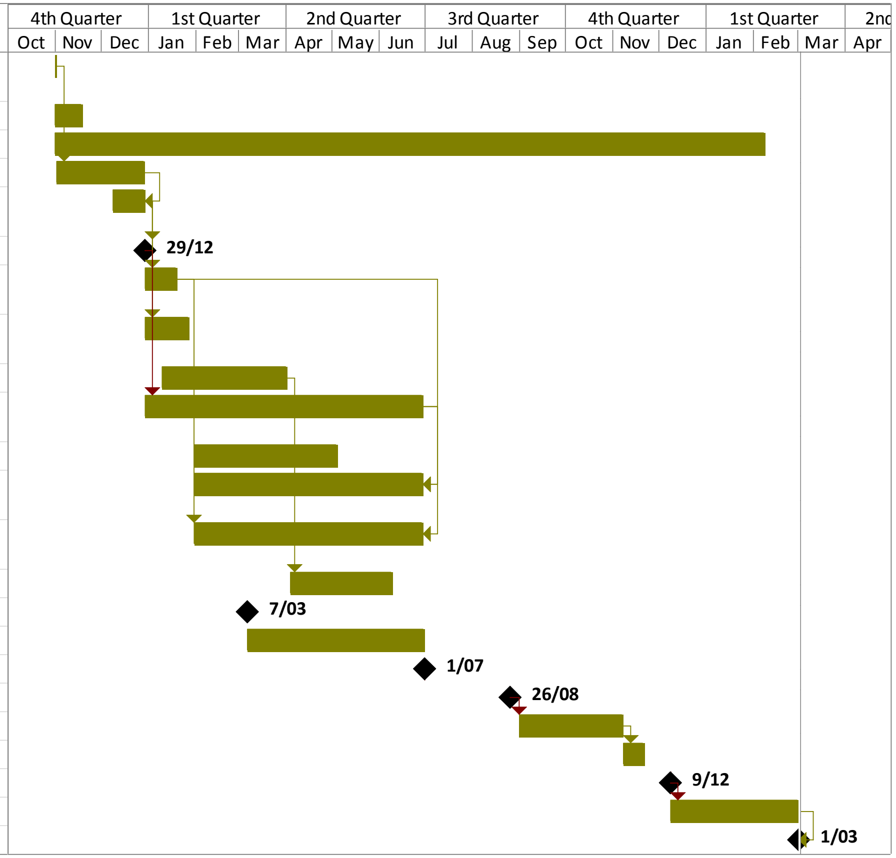
Critical Success Factors for a CRC bid

The Department of Innovation Industry Science & Research has provided public feedback from the application process of Round 11 of the CRC Program[26] to provide indicators as to the critical success factors that contribute towards a successful bid. These are,

- The CRC branch of the Department and the reviewers need to be convinced collaboration is significant. A submission with too many collaborators leaves doubt on how it would function. The bid must present a challenge that cannot be done by one organisation, but rather requires national collaboration and integration.
- Taking a global position would be encouraged particularly if international partners were providing support. International linkage is essential. Australia is only 2% of global research and we cannot claim to be able to do everything. We need to leverage off international partners. International investment in the bid via cash is important.
- Risk, particularly research risk, needs to be addressed. The CRC program recognises that research in CRC's is a higher risk investment.
- A bid must clearly articulate a clear challenge for key end users that require collaboration over the medium to long term.
- A broad research scope is unlikely to be accepted.
- The needs of the sector need to be clearly articulated. Strong industry support is essential.
- A strong intellectual property strategy is important even if a significant public good is involved.
- Do not assume that the assessment committee has a good understanding of the sector.
- The percentage of "tied cash" needs to be kept low. Tied cash can be viewed as contract research. Cash (untied) is essential. In-kind is not rated the same as cash in the bid. A bid with a strong in-kind rather than cash commitment will not be successful.

Gantt Chart – Centre Development Project

ID	Task Name	Duration	Start	Finish
1	NHRN & HAL Board agree to proceed with Centre Development project	1 day	Mon 1/11/10	Mon 1/11/10
2	Establish project Steering Committee	14 days	Mon 1/11/10	Thu 18/11/10
3	Raise Industry awareness and support for new MARRS Centre	333 days	Mon 1/11/10	Wed 8/02/12
4	Establish VC Syndicate for Centre Development project	42 days	Tue 2/11/10	Wed 29/12/10
5	Application to HAL VC program and State Governments for project funding	15 days	Thu 9/12/10	Wed 29/12/10
6	MARRS Centre Development Project commenced	0 days	Wed 29/12/10	Wed 29/12/10
7	Undertake Hi_Link modelling of industry with and without automation	15 days	Thu 30/12/10	Wed 19/01/11
8	Identify and select specialist consultant to assist in CRC bid preparation	21 days	Thu 30/12/10	Thu 27/01/11
9	Advertise, interview and select MARRS Centre CEO	60 days	Mon 10/01/11	Fri 1/04/11
10	Build on initial design for MARRS Centre: Structure, Operations, R&D Program, Education and Commercialisation strategies.	130 days	Thu 30/12/10	Wed 29/06/11
11	Commence preperation of CRC application	68 days	Mon 31/01/11	Wed 4/05/11
12	Identify potential core research partners and secure investment commitments	108 days	Mon 31/01/11	Wed 29/06/11
13	Identify potential commercial partners and secure investment commitments	108 days	Mon 31/01/11	Wed 29/06/11
14	Select Centre Board members	49 days	Mon 4/04/11	Thu 9/06/11
15	CRC Round 14 opens for applications	0 days	Mon 7/03/11	Mon 7/03/11
16	Finalise CRC Application	84 days	Mon 7/03/11	Thu 30/06/11
17	Lodge CRC Round 14 application	0 days	Fri 1/07/11	Fri 1/07/11
18	CRC Round 14 Stage 1 Assessment and outcomes	0 days	Fri 26/08/11	Fri 26/08/11
19	Prepare presentation team for interview process	48 days	Thu 1/09/11	Mon 7/11/11
20	CRC Round 14 Interviews	10 days	Tue 8/11/11	Mon 21/11/11
21	CRC Round 14 Decisions	0 days	Fri 9/12/11	Fri 9/12/11
22	Finalise MARRS Centre partner agreements and CRC agreement	60 days	Fri 9/12/11	Thu 1/03/12
23	Commence operations of MARRS Centre	0 days	Thu 1/03/12	Thu 1/03/12



RECOMMENDATIONS

This scoping study has identified fourteen key recommendations for progressing the opportunity for the development of a trans-Tasman Centre for MARRS in horticulture;

Recommendation 1: Present the Final Report and recommendations of project HG09044 - Scoping study to review Mechanisation, Automation, Robotics and Remote Sensing in Australian horticulture, to the Executive Management team and Board of Horticulture Australia Ltd as well as the NRHN for review and endorsement.

Recommendation 2: Initiate the development of a new trans-Tasman Centre for MARRS in Horticulture.

Recommendation 3: Approach the largest horticulture sectors in Australia, Banana, Apple & Pear, Citrus, Vegetables, and in New Zealand Kiwifruit, to seek their endorsement and commitment as core partners of a MARRS Centre.

Recommendation 4: Design a MARRS Centre using the eighteen design principles identified from the NFIS Centres of Excellence Review.

Recommendation 5: Develop a Centre for MARRS that operates through a unitary management structure with good corporate governance, to facilitate operation with multiple partners from industry, research organisations and Government across both Australia and New Zealand.

Recommendation 6: Prepare an application to the Commonwealth Government's CRC Program for support.

Recommendation 7: Develop a business model for a future MARRS Centre that ensures financial viability long term.

Recommendation 8: The MARRS Centre establishes a Research Program with the following streams of activity;

- System and Application Analysis,
- Plant Varieties and Agronomy Systems,
- Autonomous Robot Platforms,
- Proximal and Remote Sensing Systems,
- Decision Support Systems and Data Management,
- End Effectors, and
- Automation Integration.

Recommendation 9: It is recommended that a detailed budget for the proposed Centre be developed during the next phase of the project in collaboration with potential partners.

Recommendation 10: Undertake economic modeling of MARRS at an Industry and Sector level using Hi_Link model developed by Centre for International Economics to support the case for a MARRS Centre. Engage the Centre for International Economics to run the Hi_Link model to simulate the economic effects of MARRS technologies at an Industry and Sector level.

Recommendation 11: Initiate a MARRS Centre Development Project to undertake the detailed development of a Centre for MARRS in horticulture and to prepare a CRC bid.

Recommendation 12: Develop a syndicate of organisations and companies willing to contribute to funding the MARRS Centre Development Project as Voluntary Contribution (VC) members.

Recommendation 13: Explore additional opportunities for funding towards a MARRS Centre Development project.

Recommendation 14: Select and engage a specialist consulting firm to assist with the preparation of a CRC bid for Round 14.

ATTACHMENT 1 - WORKSHOP 1: BARRIERS TO IMPLEMENTATION OF MARRS SOLUTIONS.

The aim of this workshop was to understand from the project's syndicate members, representatives of the National Horticulture Research Network (NHRN) and a selection of commercial and research providers operating in MARRS arena, the drivers and barriers to the uptake of MARRS-related technologies across a range of horticulture industries, as well as the supply chains they work within. The outcomes from this workshop would help in the development of a capability map of MARRS know-how as well as the strategic and economic business case for examining the best options to invest and deliver a coordinated trans-Tasman (AUS and NZ) approach.

The workshop was held over two days, Thursday 5th and Friday 6th November 2009, in Sydney. During the workshop each of the syndicate members and some special guests were given 10 minutes to outline their organisations involvement in MARRS technology and issues that their organisations have already identified. The workshop discussed what the critical drivers are for the horticulture industry now and in the future, and discussed how MARRS solutions can be implemented and likely barriers to its uptake.

General comments and tenor of discussions during day one of the workshop included:

1. There was generally surprise at the significant amounts of MARRS activity already occurring in Australian industry and horticulture. The presentations were quite an 'eye-opening' experience for participants.

2. There seems to be real potential to leverage off world-class R&D capability in MARRS that already exist in Australia; examples included CSIRO remote vehicle work; and automation in the mining and resource sectors. This presented exciting possibilities for the future.

3. There was strong agreement that Horticulture needs to look across industries and sectors and draw existing technologies into a whole-of-system approach. There seems to be a lot of work to do – but important steps have already been taken (Future Focus Report). There is strong interest in the potential for MARRS to revolutionise key industry systems and systemic changes – especially in the more 'unstructured' in-field environment.

General comments and tenor of discussions during day two of the workshop included:

1. The general tone of the discussion throughout the workshop was very positive. While people could see potential hurdles, the potential of MARRS approaches was intriguing and compelling to the workshop participants.

2. It was seen as critical to try to reach out to innovative producers and industry groups and build support to move forward.

An important deliverable for this project was to conduct a workshop (refer to Appendix 1 for workshop agenda) with the project's syndicate members, representatives of the National Horticulture Research Network (NHRN) and a selection of commercial and research providers operating in MARRS arena to discuss what the critical drivers are for the horticulture industry now and in the future, and to discuss how MARRS solutions can be developed then implemented and likely barriers to uptake.

To help get the attendees thinking about the issues that would be addressed in the first workshop, a MARRS Questionnaire (refer to Appendix 2) was sent out to each participant, and again distributed in the workshop handout notes. These questionnaires play an important role in gaining personal feedback from not only the workshop participants but industry players who were unable to attend on the day.

The topics covered by the workshop were around;

Where should the horticulture industry direct its effort in the area of MARRS?
What are the barriers to implementation of MARRS technologies?
How can industry access MARRS solutions?
What support is required in the future?
What lessons can we learn from others?

The Workshop over the two days discussed core issues covering the following themes;

Is there a compelling case for MARRS?
What are some of the challenges we see?
Strategic analysis – SWOT
What are critical gaps?
How should we structure support?
Is there a need for a coordinated MARRS Research and Development Program?

Day 1 involved each of the Syndicate Members and some special guests giving a presentation outlining their organisations involvement in MARRS technologies and issues that their organisations have already identified as crucial to the development and implementation of MARRS solutions.

Day 2 involved detailed discussion of the following issues;

Based on the presentations and your own industry and commercial experience, do you believe there is a compelling case for the Horticulture Industry to pursue MARRS approach and solutions?
Assuming there is a sufficient critical mass of industry interest to pursue MARRS approaches and solutions, what is the strategic environment we need to consider for next 5 years?
SWOT analysis (via break-out groups).

Based on the discussion from the SWOT analysis the Workshop members discussed;

- Where they saw the biggest GAPS?
- What support they thought would be required to develop and implement MARRS solutions?
- Should MARRS support be industry based or across industry and why?
- If there is a stated need for a MARRS Development / Research Program, what are some thoughts on:
    - Structure / partners
    - Development/Research objectives / priorities
    - Budget / Funding needs and sources
    - IP / knowledge

The following is a summary of the key points concluded in each segment of presentations and the overarching implications.

Key Issues and Messages – Industry Presentations

Summary points from post-presentation discussions included:

Consumer has to be a critical part of the equation.
Australian cost of labour is driving a lot of the innovation. The lack of suitable labour and the high cost, is presenting an industry crisis.
Communication is critical; but there is a lack of information flow about what is happening and opportunities emerging for MARRS.
Our industry has a small domestic market and, compared to our southern hemisphere counterparts, Australia has a limited focus on global markets – so whilst we can be a dominant supplier we are price sensitive.

The industry application of MARRS is constrained by a lack of structure in the on-field operations vs. the more structured environment of a pack-house and greenhouse for example. There is also a lack of alignment of critical processes that make MARRS applications difficult across the supply chain.
There is an opportunity and a need to 'add-value' to in-field technologies.
There is a lot of work done in the post-harvest environment vs. the pre-harvest environment. The harvesting aspect is an issue almost entirely unique to horticulture industry.
There is a need for 'whole package' MARRS solutions – that are customised to the crops – but there is complexity in this with lots of different crop types. The 'whole package' approach needs to go from plant breeding upwards through the whole value chain.

Key Issues and Messages – State Extension Services

Summary points from post-presentation discussions included:

Question of who will drive innovation? Who will drive adoption of MARRS?
Potential Costs /Benefits – needs to be carefully assessed. MARRS may be the determining factor in various industry competitive advantages and even future viability (example of differential trajectories of carrot and cauliflower industries in Western Australia).
How do we pick the 'winners'- industries that could prosper with development of MARRS solutions? Need to take broad measure to assess –including dimensions such as impact on 'carbon footprint' etc.
Cost of development of technologies and innovation could be a key challenge.
What can DPI's bring to projects in MARRS?
Connections to growers
Extend learning across borders
Develop links with grower groups
Help with integration of technology into farming systems
What is the mechanism to draw resources together? Who should do it? There is an issue of a lack of overall co-ordination.
The technology adoption cycle is long. There is a tendency to work to the average – need to focus on applying existing technology as well as development of new technology – work with early adopters – and forget the tail of lagging slow adaptors.

Key Issues and Messages – Solution Providers and R&D organisations

Summary points from post-presentation discussions included:

People who 'need' the technology must have 'skin in the game'.
Question of how do we get industry levy funders on board with MARRS – this could be a critically important revenue source for R&D work.
We need to work out what is holding back adoption OR is it that the time is 'now right' – that we have reached a point where the critical pieces are in-place and we have to work out how to fit them together.
There is a gap between solution providers and users – how do we commercialise ideas?
Who is the winner? – might be the marketer? Might be the big players? – The owner of technologies might not be the growers. This has implications for adoption and funding pathways.
We have a lot to learn from other industries – need to explore the modular idea with bolt-on technologies – there are lots of pieces.

Over-Arching Implications

The workshop participants discussed what they viewed as the over-arching implications to MARRS development and application, from the set of presentations.

The key implications were recorded as:

- With the application of MARRS – the on-farm skill set required will change dramatically.
- There will need to be significant changes in farm operations – to create a more structured system and environment for MARRS applications to operate.
- Automation is likely to attract a new workforce (that might be tech-literate) and attract new participants to the industry.
- MARRS technologists need to understand the product – the nature of food and food industries will require an intimate knowledge of the product and handling needs.
- Larger forces are likely to drive a shift in industry – both location and concentration. This will be increasingly driven by who has access to the best land and water resources.
- Carbon-miles may become increasingly important.
- It is critical that Australia / New Zealand develop a knowledge and IP 'bank'. There seems to be some potential for our region to become a world leader in this field and potentially develop valuable new technologies and their associated industries.
- It is critical that the industry does not lose site of the consumer – consumer choices will continue to be crucial.
- It is likely we will continue to see consolidation in the industry in parallel to development and application of technology. Costs of technology may make smaller more traditional enterprises less competitive and viable.
- There will be some critical economies of scale and break-even points, especially if technology and MARRS options are expensive.
- Need to redesign agronomic practices and systems in parallel to MARRS developments – there may be some innovative MARRS solutions that require a rethink of the traditional farming and production systems.

ATTACHMENT 2 - REVIEW OF MECHANISATION, AUTOMATION, ROBOTICS AND REMOTE SENSING (MARRS) FOR AUSTRALIAN HORTICULTURE.

In 2008 the NHRN undertook a review of all the Horticulture Industry reports received from within its network for the review of prospects in “Mechanisation, Automation, Robotics, and Remote Sensing” (MARRS). The committee was of the opinion that there are a number of opportunities to introduce MARRS-related technologies and advances at all levels of Australia’s horticultural operations.[27] However, the rate of success and the commercial viability of the possible solutions, vary to a great extent. From an engineering point of view, crop layout structure (eg. glasshouses/greenhouses, highly defined field rows, intensive orchards etc) is the most fundamental aspect for MARRS solutions to be applied most effectively to secure a commercial advantage. Despite structured crop layout, some crops do not lend themselves to bear fruit in a structured way. In such situations, major agronomical input is necessary in the area of plant research. As extreme examples, baby leaf and lettuce can be laid out in a very structured manner while avocado may not be able to be grown so as to present its fruit in a structured way that will facilitate automated harvesting.

MARRS-related opportunities can be broadly categorized into three areas – crop production, harvest and postharvest. In the case of crop production, crop yield monitors could use precision agriculture and crop sensor applications (remote sensors) allowing growers to provide more accurate water and fertiliser regimes critical in times of drought and high fertiliser costs. The grower would also be better informed to predict physiological events (eg. flowering, fruit set, pest incursions, maturity indices) enabling them to better manage spray regimes, worker schedules, and most importantly predict market yield for domestic and export markets. The technology and software associated with many of these applications is still very much in its infancy and would usually require the producer to be technology literate in order for them to obtain the greatest use from these systems.

For harvest operations, the degree of structure varies significantly across the types of crops, hence the success rate of MARRS uptake and application is varied. However, in the case of postharvest operations the structure remains significantly constant. Hence the prospects of MARRS usage in postharvest operations are much higher (certainly in the short-term) than those of harvest operations.

The main aim of undertaking MARRS research in horticulture is to achieve competitiveness in the Australian industry in relation to that of international markets. Therefore, to performance rates are of utmost importance. Bearing in mind that Australia currently competes with other emerging economies with significantly larger and ‘cheaper’ labour pool, the solutions proposed must be able to match the traditional manual production rates. In some cases OH&S issues may also need to be addressed.

Australia is well placed to achieve significant gains by taking up MARRS-related technologies, particularly in the crop production and harvest operations of structured crops. To achieve commercial advantages in other crops, thorough investigations are necessary to reduce/eliminate or combine crop production, harvest and post harvest operations. As an example, a cucumber ‘harvester’ deployed in a protected plantation may be used to determine an individual plant’s nutrition or pest incursion level for directed fertilizer and pesticide application, the ripeness quality and size, determine whether to harvest or not, then during harvest conduct an instant fruit inspection for blemishes and other defects, grade and package. The NHRN review indicated the possibilities of process integration to minimize costs and increase throughput so that a competitive solution with minimum labour can be achieved.

It is of utmost importance that Australia’s horticulture industries start to recognize MARRS solutions as part of the entire process. Any MARRS assessment must be carried out on the entire process with and without automation to determine the commercial and economic advantages. Most often the assessment is carried out only on the part that is first considered for automation. It is also quite possible that MARRS solutions may introduce additional MARRS-associated problems to be solved and hence the entire process may have been adversely affected with its introduction, so it is important to thoroughly assess a situation prior to investment. The Review undertaken by the NHRN also recognized that much could be learnt from other industries that have already embraced these strategies both here in Australia as well as overseas programs around automation in agriculture, in particular New Zealand.

The objective of this component of the project HG09044, “Scoping study to review Mechanisation, Automation, Robotics and Remote Sensing (MARRS) in Australian horticulture” is to provide a broad review of work being undertaken in developing MARRS technologies and solutions, and how these might address the drivers affecting the competitiveness of the industry.

As the extent of MARRS developments are vast, varied and the horticulture industry consists of many crops from lettuces and carrots through to grapes, apples and bananas this approach was adopted to enable the project to gain a broad understanding of progress globally in relation to developments and potential barriers to successful commercialisation. In Australia the horticulture industry is made up of 47 separate sectors.

Case studies have been included to provide examples of the value and advantages MARRS applications provide horticulture in Australia and raise awareness of the issues that need consideration in the development and implementation of these types of solutions. These Case Studies also demonstrate some of the critical factors identified below.

Both pre-harvest and post-harvest applications have been included. This review identified a number of critical factors that need to go hand-in-hand with the development and introduction of MARRS technologies to horticulture. They are;

- Agronomy and growing systems that are designed for the effective and efficient application of a mechanisation, automation or robotic system. This is important, in particular for harvesting and crop management systems.
- A clear path to commercialisation of the technology solution. This activity needs to also consider the business model that a firm will create to make the operation viable.
- Maintenance and service infrastructure. The development of a supporting infrastructure is also crucial to successful deployment of MARRS solutions as the horticulture industry is located in rural and regional Australia where traditional skill levels in these regions are not focused on MARRS technologies although this is rapidly changing.

The development and application of remote sensing technologies is maturing and its implementation and usage increasing. Advances in the technologies and increases in their applications will continue. There are fewer challenges to the application of remote sensing technologies due to the fact that these types of the technologies are non-contact. This is not the case with development of automated harvesting, pruning and plant management systems.

This report identified that for applications of MARRS technologies where plant contact is required such as harvesting; there are significant challenges to be overcome. For example the development of robotic harvesting systems will require developments in agronomy in parallel. The elements of agronomy that in many cases will be critical in successful development and implementation of automation solutions will be plant structure and size through both variety selection as well as modified growing structure. For example the development of robotic apple harvesting may require apples to be grown under a trellis system. The orientation of these trellis systems will also be important in terms of maximizing the sunlight exposure for plant growth and fruit ripening.

This report has also highlighted the critical importance of developing appropriate business models for successful commercialisation of any MARRS technology. The business model can be seen as the way in which the commercialiser of the technology will make money in the market place.

Companies can create and capture value from their new technologies in three basic ways: through incorporating the technology in their current businesses, through licensing the technology to other firms or through launching new ventures that exploit the technology in new markets.

The functions of a business model are as follows:

- Articulate the value proposition (the value created for users by the offering based on the technology)
- Identify market segments. Users to whom the technology is useful and the purpose for which it will be used.
- Define the structure of the company’s value chain which is required to create and distribute the offering and determine the assets needed to support the firm’s position in this chain.
- Specify the revenue generation mechanism for the company
- Describe the position of the company within the value network, linking suppliers and customers
- Formulate the competitive strategy by which the company will gain and hold over rivals.
- Assess capability required to achieve commercialisation.
- At a firm level, the critical issue will be the payback period on their investment and on-going maintenance: servicing and spare-parts related to MARRS technologies.

Maintenance and service infrastructure is the third critical dimension to successful implementation of MARRS solutions in the future. The development of a support infrastructure is crucial to successful deployment of MARRS solutions, as the horticulture industry is located in rural and regional Australia and traditional skill levels in these regions are not based around MARRS technologies. Going forward, thought will need to be given to the development of this infrastructure through training and remote support processes.

ATTACHMENT 3 - WORKSHOP 2: PLAUSIBLE SCENARIOS FOR HORTICULTURE IN AUSTRALIA IN 2030.

A Scenario Planning Workshop was conducted as part of this scoping study: Project HG09044 “Mechanisation, Automation, Robotics and Remote Sensing (MARRS) in Australian horticulture”. Participants at the workshop developed plausible scenarios of how MARRS technology may be incorporated into Australian horticulture. This report of the scenario planning workshop serves two purposes: Firstly as a record for participants and, secondly to assist in communicating the scenarios and the strategic actions that were identified to direct the industry towards an aspirational future in the context of the development and implementation of MARRS technologies in the horticulture industry in Australia and New Zealand.

Background

Project HG09044 was initiated to examine ways of taking a strategic approach on mechanisation, automation, robotics and remote sensing (MARRS) to improve the international competitiveness of Australian horticulture. The project aims to identify options for a coordinated, trans-Tasman (Australia and New Zealand) approach to the investment in MARRS technology.

To this end, the project has involved two important activities. Firstly, a workshop held in Sydney in November 2009, to identify the drivers and barriers to the uptake of MARRS-related technologies across the horticulture industries, including the supply chains within which they work. Secondly, a review of how MARRS-related technologies are being used around the world to identify how such technologies have been implemented and to learn from the experiences of others.

At the two-day workshop held in Sydney on November 2009, members of the project syndicate, representatives of the National Horticulture Research Network (NHRN), a selection of commercial and research providers operating in the MARRS arena and representatives of some commercial agri-food companies, identified the critical drivers for the future of the horticulture industry in the short- and medium-term. The participants also discussed how MARRS solutions could be developed and implemented in Australian horticulture and what the likely barriers to its uptake were.

Several key points and conclusions came from the workshop (Rankin and Beurle 2009).

1. Surprise and excitement at the level of MARRS work already happening in Australian industry, including some in horticulture, and the potential to utilise world-class R&D capability in MARRS that already exists in Australia.
2. Recognition of a core cluster of innovators in the field, but also the lack of any integrated or focussed approach across or within the industry.
3. Labour supply and cost is the critical issue that is producing a potential crisis in the industry and is the catalyst for making MARRS a compelling case in some situations. This issue is impacting on the international competitiveness of Australian horticulture and the price of local produce relative to imports.
4. The fact that horticulture consists of multiple, fragmented industries with fragmented support infrastructure, research and capital, complex requirements and an uncertain capacity for change: based on culture, capital and technology, is a challenge to the widespread development and adoption of MARRS technologies.
5. There is strong interest in the potential for MARRS to

“Labour supply and cost is the critical issue that is producing a potential crisis in the industry and is the catalyst for making MARRS a compelling case”

revolutionise key industry systems and to bring about systemic changes, especially in the less 'structured' environment of a horticultural field. Reaching out to innovative producers and industry groups is seen as critical to build support to progress the development of MARRS-based solutions.

A review of MARRS-related technologies and case studies of their implementation from around the world has also been conducted as part of the project and is detailed in Attachment 2 of this Final Report (Rankin 2010). The review identified three critical areas of development that need to be carried out in conjunction with the development of MARRS technologies in horticulture. These are agronomic and growing systems that are tailored to the application of mechanisation, automation and/or robotics; commercialisation of any MARRS solutions in order to make them a viable part of commercial horticultural production; and the parallel development of support, service and maintenance expertise and infrastructure, particularly in rural and regional Australia.

"The review identified three critical areas of development... agronomic and growing systems that are tailored to the application of mechanisation, automation and/or robotics; commercialisation of any MARRS solutions... and the parallel development of support, service and maintenance expertise and infrastructure, particularly in rural and regional Australia."

This important background information set the scene for the scenario planning workshop. The drivers that were identified at the preliminary workshop were used in developing the scenarios and the critical areas identified by the review featured in the scenarios that were developed at the Scenario Planning Workshop.

Drivers

The critical drivers for the future of the horticulture industry in Australia in the short- and medium-term were identified at the preliminary workshop held in Sydney in November 2009. Participants at that workshop identified from a Questionnaire[28] nine key drivers impacting on the future of Australia's horticulture industry and eleven key drivers for implementing MARRS technologies into horticulture/agriculture. The participants nominated the top four ranked drivers impacting on the future of Australia's horticulture industry now and in ten years time. The participants also ranked the key drivers for implementing MARRS technologies into horticulture/agriculture in priority from most to least important.

Key drivers impacting on the future of Australia's horticulture industry

- Labour supply,
- Carbon footprint/environmental issues (energy usage),
- Human ethics (worker conditions),
- Local domestic production needing to compete on a global scale.
- Cleaner safer food,
- Product Quality,
- Water efficiency and security,
- Product efficiency and Yield,
- Increasing production efficiency.

Key drivers for implementing MARRS technologies into horticulture/agriculture

- Increased crop yield
- Reliance on human labour
- Improved technologies
- Access to information and skilled people
- Cost/cost effectiveness of MARRS technologies
- Scale of business
- International competitiveness of crops

- Access to money/grants
- Commercialisation of MARRS technologies
- Industry-R&D liaison through HAL
- Improved product quality

For scenario planning, important drivers of the future are rated in terms of their importance in determining the future (higher rating representing more important) and the uncertainty regarding either the nature of the driver in the future or its impact in shaping the future (higher rating means greater uncertainty; i.e. less certain). Therefore, the rankings of the drivers that had been completed by the participants as part of the Questionnaire from the November workshop, needed to be converted into ratings of importance and uncertainty. This was done in the following manner.

- The rankings of the 'top four key drivers now' were changed to the importance rating. A rank of 1 was changed to a rating of 10, rank of 2 to a rating of 9, and so on. Where respondents had simply nominated their four top drivers, these were all given a rating of 8.5. The drivers that were not ranked were given a rating of 3.
- The rankings of the 'top four key drivers in ten years' were changed to be the uncertainty rating. A rank of 1 was changed to a rating of 10, rank of 2 to a rating of 9, and so on. Where respondents had simply nominated the four top drivers, these were all given a rating of 8.5. The drivers that were not ranked were given a rating of 3.
- The "Key drivers for implementing MARRS" were considered to be important and certain drivers. The priorities given by the respondents were changed to ratings of importance and uncertainty in the following manner: a priority of 1 was given an importance of 10 and an uncertainty of 1, a priority of 2 was given an importance of 9 and an uncertainty of 2, and so on. Any drivers that did not have a priority recorded by a respondent were given an importance of 3 and an uncertainty of 7.

A plot of the resulting importance and uncertainty ratings highlighted four groupings of drivers (Figure 1). Dominating the graph is labour supply. This is an important driver of the future of horticulture in Australia. There is uncertainty in the medium-term regarding the availability of labour (e.g. domestic, imported or outsourced) and the relative cost of labour inputs in Australian horticulture in comparison to major competitors. In the centre of the plot are drivers of intermediate importance and uncertainty. These are not considered to be scenario-shaping drivers, but will be important in each of the scenarios. Two clusters of drivers are found in the top left and bottom right of the plot. These are the highly important drivers (Improved technologies, Reliance on human labour, Access to information & skilled people, Commercialisation of MARRS technologies) and those with a high degree of uncertainty (Scale of business, International competitiveness of crops, Industry R&D liaison through HAL, Improved product quality). Together these two groups comprise the scenario-shaping clusters of drivers.

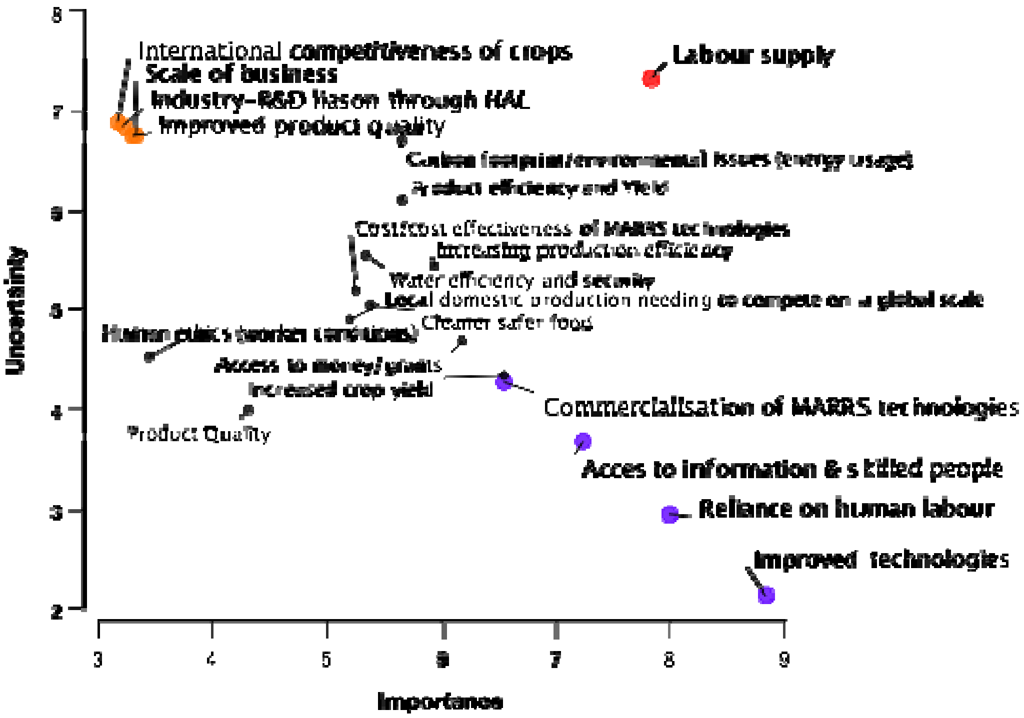


Figure 1. Plot of the importance and uncertainty ratings of drivers of the future of Australia's horticulture industry and of the implementation of MARRS technologies.

Scenario-shaping clusters of drivers

The scenario shaping drivers were used to define four scenario 'spaces', with quadrants either towards or away from each driver cluster (Figure 2). These quadrants were used to formulate four plausible scenarios. A detailed narrative for each scenario explored economic, environmental and social implications for the farm, industry and region out to 2030.

Adoption of MARRS technology

- Improved technologies
- Reliance on human labour
- Access to information and skilled people
- Commercialisation of MARRS technologies

Industry competitiveness, scale and integration

- Scale of business
- International competitiveness of crops
- Industry R&D liaison through HAL
- Improved product quality

Following the description of the scenario spaces, but prior to dividing into groups to develop the scenarios, the participants were asked to indicate which quadrant they thought the industry was heading towards. The split of responses was fairly even with 14% indicating A, 9% B, 19% C, 14% D and 44% uncertain.

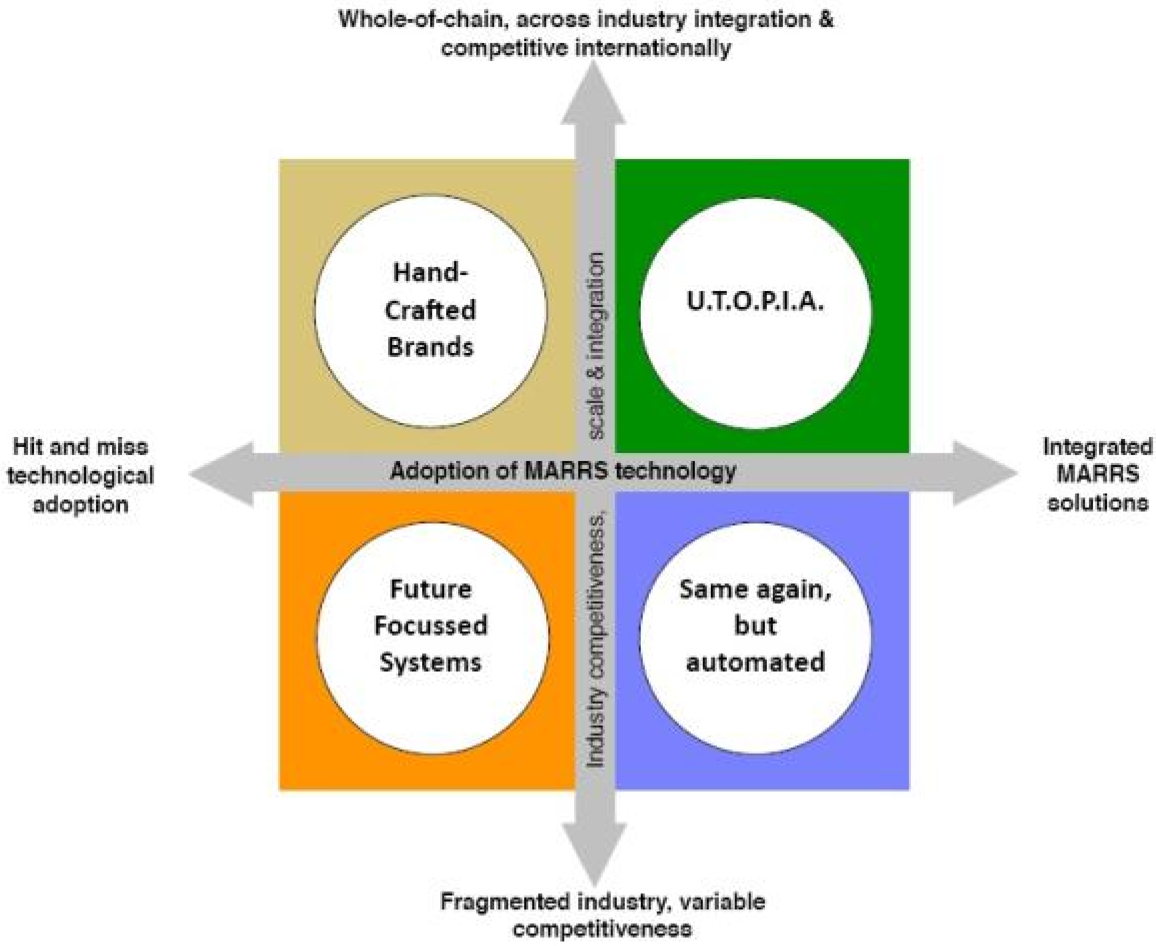
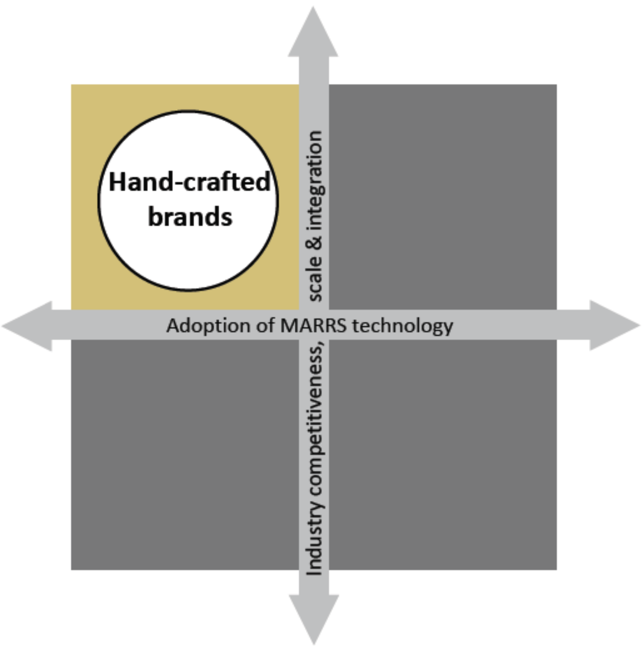


Figure 2. The scenario quadrants as defined by the scenario-shaping drivers.

Hand-crafted Brands

The industry is characterised by specific, 'branded' products based on highly-tuned genetics (including GM) and dramatic improvements in storage technology which together provide premium products which fetch premium prices. There are two broad categories of produce; high volume, high quality lines produced to meet exacting specifications as well as high price, low volume 'niche' products. There is total utilisation of the crop by a number of quality streams e.g. high end, manufacturing and recycling or bioactive products. The industry is serviced by a skilled, highly differentiated work force.

Fewer products are distributed through supermarkets, due to home delivery of processed ready-to-eat food and other clearly defined markets.



Sector	Description
Grower	• Point of difference in product • Low labour input production • Highly skilled labour/training • Highly valuable genetics/non MARRS technology • Producing to high quality specifications • Total crop utilisation
Industry	• Consolidation (less, larger growers) • Commercial protection/exclusivity (trademark) • Dichotomy of supply chains/networks
Wholesaler / consumer	• Move from retail space to more home delivery of processed ready to eat meals • Quality guarantee expectations

The scenario 'space'

The scenario 'space' for Hand-Crafted Brands is defined by an internationally competitive industry in which there is whole-of-chain, across industry integration, but where the adoption of MARRS technology has been variable. The participants who developed the scenario for this quadrant were faced with conceiving an industry that made the best of available resources to be productive an internationally competitive industry without widespread implementation of MARRS-based solutions. They pictured a rationalised industry, focussed on high quality, high value product that is able to pay for inputs from human labour through high-value produce.

Future History

Five years in the future

Restructuring has seen some growers exit horticulture. Development of the industry is occurring based mainly on non-MARRS technologies such as improved genetics and storage technology. There is only limited use of MARRS technologies, principally in more precise management of inputs. Emerging crops have improved attributes related to human nutrition, health and well being. These are increasingly being sold as fresh cut or semi-processed foods with home delivery for added convenience.

Ten years in the future

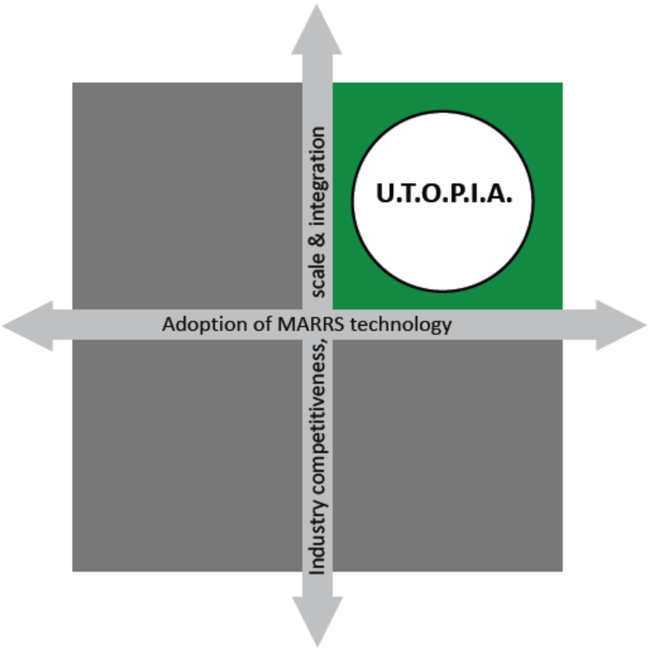
Further industry consolidation sees more, larger operations and co-operatives. The scale of these operations enables improved and increased vertical integration. Product development continues to be driven by the second-generation GM crops which focus on human health and well being, coupled with storage and handling systems which deliver a level of convenience, freshness and consistent quality that was undreamed of a decade earlier.

Twenty years in the future

The industry is typified by integrated commercial platforms from paddock to plate producing specific, branded produce of guaranteed quality. Per capita consumption has increased dramatically since the first decade of the century due largely to guaranteed quality and additional nutritional benefits. The industry is serviced by a highly skilled, work force that is helping to deliver a premium product. The development of the industry over the last twenty years has been mainly driven by genetics (especially GM) and improved storage and handling technologies, but now other technologies are evolving, including improved precision agronomy and some robotic and mechanised approaches to specific applications.

UTOPIA – Utilising technology overseeing productive, intelligent innovation

Horticultural systems are 'informed' thanks to the uptake of MARRS technology. The integration of the technology along the supply chain has resulted in improved quality, decreased inputs, utilisation of the entire crop, greater eating quality and hence increased consumption. There is a sense of 'sexiness' about the industry—the thrill of eating fruit. This has seen a reinvigoration of horticulture in Australia with increased exports to the blossoming Asian markets and an industry that attracts people and expertise. A highly technological sector requires skilled people and affords a clear career path. As the technology has developed and been taken up, so the cost of MARRS has decreased. The export of Australian expertise in MARRS is now an industry itself.



Sector	Description
Grower	• Integrators of growing, harvesting, marketing and more understanding of supply chain • Informed decisions on production (water, environment) • Markets and customers • Change of skill and mind set
Industry	• Internationally competitive rebirth of horticulture: major supplier to Asia • Skilled and responsive, greater investment into horticulture, create pathways from schools to industry, bring back 'sexiness' of industry • Cheaper technology due to larger uptake
Wholesaler / consumer	• More consumption of horticultural products. • Healthier consumers due to greater enjoyment of produce • Wholesalers serve food service industries • Integrated supply chain (grower to retailer)

The scenario 'space'

The scenario 'space' for *U.T.O.P.I.A.* is defined by an internationally competitive industry in which there is whole-of-chain, across industry integration based on the development and adoption of MARRS. This scenario represents the 'double-positive', but the pathway is not entirely a smooth one as the industry develops and implements MARRS solutions only after overcoming resistance to and limitations of the technology.

Future History

Five years in the future

There has been an increase in R&D on MARRS technologies including larger growers who have invested directly in MARRS approaches. This work has initially focused on precision agriculture, especially managing inputs of nutrients and water, and the development of mechanised and robotic platforms that are suitable across crops. The technology has its detractors as mechanised and robotic approaches are the still rudimentary and are slower than humans. Nevertheless, there are now moves to integrate and to adapt existing technologies with MARRS technology. This includes the slow re-design of the supply chain and the development of production systems in parallel with MARRS.

Ten years in the future

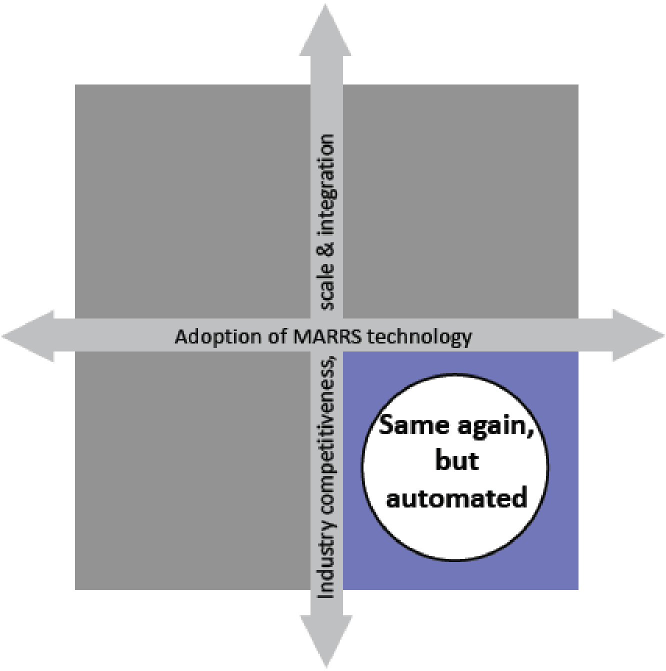
Investment in MARRS continues to bear fruit. Platforms have been developed and refined for individual crops and agronomic systems are being re-designed to suit new robotic machines (e.g. pruning), with breeding programmes also designed to suit the new crop technology. MARRS systems are now considered to be close to human labour in speed and are showing benefits in terms of quality. Industry consolidation has resulted in a greater number of large operations with a larger and more diverse customer base. The corollary is that the growing customer base has seen more growers attracted to the industry in recent years. The potential for greater product specification is tipped to result in less domination in the supply chain with more customers and suppliers.

Twenty years in the future

The horticultural industry in Australia-New Zealand is now general recognised as leaders in MARRS technology, which is an export industry in its own right. Within horticulture the 'MARRS revolution' has produced an 'informed' industry along the entire supply chain. Intelligent systems based around precision production (e.g. integrated pest management, fuel/energy, nutrient and water management), precise harvest (such as assessment of maturity to enable production to specific customer requirements), packing and sorting using sensing to guarantee even grading and real-time feedback regarding product volumes has resulted in more consistent product grades, improved efficiency of production and improved environmental sustainability. Robotic MARRS technology is now clearly faster, more precise and more reliable than human labour. The increased consumption of fruit (particularly) and vegetables have been largely attributed to improved specification and product guarantees and a renewed 'sexiness' in the industry—"the joy of fruit". The industry is supported by and supports highly skilled, adaptive workforces who are recognised world leaders in the development and implementation of MARRS technology to industry.

Same again but automated

MARRS technology has been adopted across the horticultural industries with production techniques and crop genetics optimised for MARRS. There has been some industry consolidation, but the technology has leveled the playing field with applications for both large businesses and specialised, small-medium enterprises. The wide range of technologies has enabled producers to optimise their production to a market and seasonal niche. This has lead to a fragmented, segmented industry. There are numerous approaches to distribution and retail including contracting, virtual brokers, supermarkets, greengrocers, virtual markets and mobile systems with ordering directly from the farmer. Imported produce is common with specialised, local produce competing in specific local and export markets.



Sector	Description
Grower	• Growers consolidate but not all large, as small and medium businesses are faster at adoption, • Adapting technologies levels playing field for smaller growers, • Specialised growers for more variety new crops and vegetables, • Some growers focussed on direct to customer (iPhone app).
Industry	• Fragmentation "food security", • Contracting throughout supply chain, • Virtual broker (middle man), • Better reliability/quality measures.
Wholesaler / consumer	• Diversification of wants, • More supermarkets, • More greengrocers - chain organised, • More virtual markets: mobile devices, order direct to farmer.

The scenario 'space'

The scenario 'space' for *Same again, but automated* is defined by a fragmented industry with the adoption of MARRS. This scenario represents an industry that has developed and adopted MARRS-based solutions, but in an uncoordinated fashion. The widespread implementation of MARRS technology has enabled the small growers to remain viable, limiting rationalisation and consolidation, but this has contributed to the continued lack of a cohesive approach across the industry.

Future History

Five years in the future

Automation and sensing are at the early stages of development, with automation mainly utilised in the more structured environment off-farm, particularly post-harvest. Current automated approaches on-farm are slower than human labour and so are only used by a few, early-adopting growers and in circumstances were labour supply is erratic and/or expensive. Consolidation of growers is continuing.

Ten years in the future

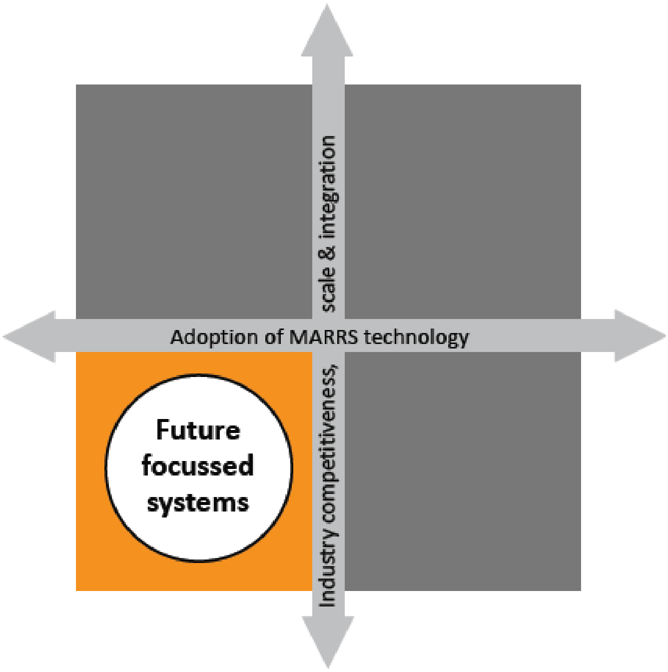
MARRS technologies are now common post-harvest, but are also being utilised on-farm in specific industries and locations. This, combined with the removal of restrictions on imports, has resulted in a rationalisation of industries on the basis of competitive advantage and market specification. Increased consumer discretion, afforded by on-line ordering and distribution has resulted in the fragmentation of supermarkets and the rise of a range of retail options.

Twenty years in the future

A wide range of MARRS technologies are in use throughout the supply chain. Production systems and crop genetics have been optimised to fit with MARRS. These developments have enabled producers to optimise their market niche with seasonal production and retailing options. Australian horticultural produce from both large and small-medium producers is competitive in the local and export markets, but for a limited range of products and quality specifications. Retailing of horticultural produce matches the diverse wants of consumers with large supermarkets, specialised greengrocers and virtual markets accessible via mobile devices with direct ordering from vertically integrated farmers.

Future focused systems

The industry has been completely restructured and rationalised since 2010. Production is lead by the 5% of growers (2010 numbers) who are vertically integrated in the market, well-connected, adaptive and responsive. The remaining growers have either left the industry or are contract growers for the 5%. Innovative growers are linked to other parts of system directly (wholesalers, providers of R&D, technology and innovative solutions) and indirectly (government and consumers). These segments interact via R&D forums, which also include representatives of consumers and government. These are dynamic with a focus on market specifications, but IP is not shared. The implementation of new technology filters from leading growers via links to other producers, principally in their service.



Sector	Description
Grower	• 5% (industry leaders): niche/premium markets—internationally competitive, • 95% exit or service the above, • IP strongly managed, • Packaged technology, • Flexible people and technology, • Less diverse.
Industry	• Structural change, • System operators, • Supply providers.
Wholesaler / consumer	• Stronger linkages to the 5% of growers, • More imports—lower quality, • Relationships between 5% growers and wholesalers and customers will be more predictable.

The scenario 'space'

The scenario 'space' for *Future Focused Systems* is defined by a fragmented industry without widespread adoption of MARRS. This scenario represents an industry that has clear winners and losers based largely on the adoption of MARRS-based solutions and other technology. As there is no coordinated approach across the industry, individual growers and businesses seek innovative solutions and partnerships with R&D providers.

Future History

Five and ten years in the future

Major rationalisation of the Australian horticultural industry is occurring. Smaller producers, principally, are exiting the industry with the dual 'incentives' of increased levels of imports and assistance from government restructuring programmes. Adoption and adaptation of technology is occurring at an increasing rate among the remaining growers, assisted by technology forums that are an industry initiative (HAL) with start-up investment from government. These provide information exchange and direct R&D but are limited to the industries and production systems that are emerging as industry 'winners'.

Twenty years in the future

The restructuring of the industry was completed by '21 and the new industry structure has been in place for the last nine years. This is characterised by the major producers ('the 5 %') who are the key 'nodes'. They are vertically integrated and are linked to the R&D forums which help them to be adaptive, responsive and flexible. This system protects IP as a suite of approaches that are available only to the 5%. As the numbers are too small to fund significant research by the industry, the approach to continued innovation is to seek appropriate ideas from other areas; buying the technology or solution that is required to solve any problem e.g. a growing system to deliver a particular product. Mechanisation is currently limited to crops with even maturity— the difficulty of applying it to those with uneven maturity remains a challenge. The restructured industry is claimed to be 30% (overall) more productive for selected products and are world leaders in these industries. On the contrary, there has been a 20% decrease in overall supply of horticultural products, a gap that has been filled by greater imports.

ATTACHMENT 4 - CAPABILITY MAP

A key outcome of this project has been the development of a “Capability Map”. The Capability Map has been designed and developed to list all the MARRS research capability relevant to the Horticulture industry; where it is located in Australia and New Zealand, their strengths, achievements to date, how they can be contacted as well as examples of their achievements.

The concept is for the Capability Map to be a tool that will provide a starting point for the horticulture/agriculture industry to identify the appropriate skills, experience and resources to help in the development and implement a MARRS solutions that can address some of the critical drivers effecting profitability and sustainability such as labour shortage, increase yield and productivity etc. This Capability Map will in the future be made available through Horticulture Australia’s Web site.

Applications	Organisation Company	Area of Expertise	Example project/s	Contact person	Position	Address	State	Contact Number	Email
Complete automation and robotic solutions	**Australian Centre for Field Robotics**	Robotics and Autonomous Systems, Sensing, Data integration.	Autonomous mining equipment. Rio Tinto mine automation.	Prof. Hugh Durrant-Whyte	Director	Rose Street Building J04 University of Sydney	NSW	(61) 2 9351 5583	hugh@acfr.usyd.edu.au
Complete automation and robotic solutions	**Machinery Automation & Robotics Pty Ltd**	Robots, automation, control, vision systems	MAR has completed greater than 1000 vision, automation, robotic, picking, packing & handling applications, autonomous ground vehicles, aerial inspection (UAVs), computer vision.	Clyde Campbell	Chief Executive Officer	Unit 1, 101 Derby Street Silverwater NSW 2128	NSW	(61) 2 9748 7001	ccampbell@machineryautomation.com.au
Applications requiring constant monitoring or automation	**CSIRO ICT Centre**	Field Robotics, Wireless Sensor Networks		Jonathan Roberts	Research Director	QCAT, Technology Ct, Pullenvale QLD 4069	QLD	(61) 3327 4501	jonathan.roberts@csiro.au
Automated and/or autonomous harvesters/vehicles, special purpose machine design and gripper design, and crop sensing.	**Robotics and Autonomous Systems Research Group at Mechanical Engineering, UNSW**	Robotics and Autonomous Systems, Sensing, Data fusion and image processing	On-tree fruit apple recognition, lettuce harvester, autonomous tractor and autonomous GreenWeeder	Jay Katupitiya	Leader of Autonomous Systems research group and Associate Professor	School of Mech. & Manf. Eng., The University of New South Wales, Sydney NSW 2052	NSW	(02)9385 4096	J.Katupitiya@unsw.edu.au
Research, development and demonstration projects for PA and CTF in vegetables; some RDE capacity in perennial horticulture.	**Tasmanian Institute of Agricultural Research (Vegetable Centre; Horticulture Centre)**	Integration and demonstration of CTF mechanisation and PA related technologies in vegetable production	Development and demonstration of CTF systems for vegetable production; Vari-rate vegetable irrigation based on real-time soil moisture sensing.	1. Colin Birch; 2. Dugald Close; 3. John McPhee	1.Leader, Vegetable Centre; 2.Leader, Horticulture Centre; 3.Engineer, Vegetable Centre	TIAR UTAS, Private bag 98, Hobart, TAS 7001; Level 2, Life Sciences Building (building no.16) College Road Sandy Bay Campus University of Tasmania Hobart Tasmania	TAS	(61) 3 6226 6368	colin.birch@utas.edu.au ; Dugald.close@utas.edu.au john.mcphee@utas.edu.au

						7005			
Automated fruit picking and packing, intelligent machine vision, robotics, automation, orchard analysis with geosynchronous satellites	**Nimbl Inc. Ltd.**	Automated fruit picking and packing, intelligent machine vision, robotics, automation, orchard analysis with geosynchronous satellites , mechanisation	Completed and current projects are summarised on Rory Flemmer's Web page: http://www.massey.ac.nz/~rcflemme/flemmerrc.php	Dr. Rory Flemmer	Chief Executive Officer	37 Elmira Ave. Palmerston North, 4410, New Zealand	New Zealand	(64) 6 021 801 015	r.c.flemmer@massey.ac.nz
Mechanisation, Remote sensing, automation, Precision irrigation and agriculture for horticulture.	**National Centre for Engineering in Agriculture, University of Southern Queensland**	Robotics, machine vision, automation and control systems, agricultural engineering, remote sensing	See web site	Erik Schmidt	Director NCEA	West Street , Toowoomba, 4350	QLD	07 4631 1347	schmidte@usq.edu.au
Research, development extension and industry development aimed at maintaining the competitiveness of Qld/Aust Horticulture industries.	**Horticulture & Forestry Science DEEDI Qld**	Industry coordination, research expertise in crop agronomy/physiology and adaptive architecture. Extensive breeding capacity and international genetic sourcing	Re-engineering project with Australian bananas	John Chapman	General Manager	Gate 3, 80 Meiers Rd Indooroopilly Qld 406 0408986751	QLD	(07) 38969714	john.chapman@deedi.qid.gov.au
Industrial Automation for Defence manufacturing, commercial	**University of Wollongong - Engineering Manufacturing**	Robot and machine grippers, design of special purpose machines, computer control and	Over 25 years experience in design and installation of installations in a wide variety of Industries	Prof.Chris Cook	Dean of Engineering	University of Wollongong, Northfields Avenue, Gwynnville	Wollongong, NSW	(61) 2 4221 3062	ccook@uow.edu.au

aerospace, mining, food, textiles, fabrication, energy pipelines, etc.		interfacing for automation and materials handling systems, lean automation and robot manufacturing system design, materials welding and joining and novel materials design, force, vision and other sensing systems.	including: electronic assembly; quality control and materials handling systems for biscuits, beef patties, blood products, machined parts; automated programming systems for welding and materials handling robots; robot gripper changing systems; parts profile measuring; precision position and velocity control systems for CNC machines; automated systems for aircraft component manufacture; joining systems for steels, light metals and plastics.						
Industrial Microwaves for Food processing Textile processing Chemical processing	**University of Wollongong - Advanced Manufacturing Technology**	Industrial microwave laboratory testing, prototype machine design, full production machine design.		David McLean	Research Director	University of Wollongong PO Box U17 NSW 2500, Australia	Wollongong, NSW	(61) 2 42 21 5463	dmclean@uow.edu.au
Decision Support Systems & Planning and Management of R&D, commercialisation and product development	**Mark Loeffen & Associates Ltd**	Development of horticulture decision support systems both pre- and post-harvest, using existing data to add commercial value, assisting companies in the planning and management of R&D, commercialisation and product development	We have developed a number of decision support systems that are in commercial use for three seasons, we have planned and managed numerous R&D, commercialisation and product development projects	Mark Loeffen	Managing Director	Waikato Innovation Park, Ruakura Road, Hamilton 3216 & PO Box 9466, Waikato Mail Centre, Hamilton 3240	New Zealand	(64) 7 857 0853 & (64) 27 294 2217	Mark.Loeffen@mla.co.nz

Fruit and food grading; Fruit ripeness sensors; Ethylene treatment systems	**Plant and Food Research**	Non-destructive techniques for fruit and food quality measurement; spectroscopy; volatiles assessment	New sensors for fruit grading; RipeSense fruit ripeness indicators; Ethylene Release Canister technology.	Peter Schaare	Science Group Leader	Private Bag 3123, Waikato Mail Centre, Hamilton 3240, New Zealand	NZ	(64) 7 959 4493	peter.schaare@plantandfood.co.nz
Solutions that enable manufacturing and processing companies to completely automate, mechanically and electrically, their fabrication, assembly, packing lines and overall logistics, in uniform and non-uniform raw material industries	**Scott Technology Group (including Scott Technology Limited and Scott Technology Australia Pty Limited)**	Process (manufacturing and assembly) automation, including machine design, mechanical and electrical automation underpinned by advanced vision and sensing and supported with 24hour on-call support and service/maintenance contract.	1. White goods assembly line automation, 2. Poker machine assembly line automation, 3. De-boning of lamb carcasses with X-ray vision and sensing, 4. Flavour pallet straw (Sipahh) automated assemble including plastic welding	1. Sean Starling (Australia), 2. Chris Hopkins (New Zealand), 3. Andrew Arnold (New Zealand)	1. Director (Scott Technology Australia Pty Ltd), 2. CEO (Scott Technology Ltd), 3 Head of Automation and Robotics (Scott Technology Ltd.)	1. 357-359 Military Road, Cremorne, NSW, 2090 2. 630 Kaikorai Valley Road, Dunedin, New Zealand	Australia, New Zeeland , Europe, China and America	1. +61 2 8012 1703 2. +64 3 478 8110	s.starling@scottechnology.com.au c.hopkins@scott.co.nz a.arnold@scott.co.nz
Robotics, computer vision and sensor network research	**Queensland University of Technology**	Robotics, mechatronics, computer vision, sensor networks, artificial intelligence		Gordon Wyeth, Peter Corke	Professor, School of Engineering Systems	2 George St, Brisbane QLD 4000	QLD	(61) 7 3138 2223, (61) 7 3138 1794	gordon.wyeth@qut.edu.au, peter.corke@qut.edu.au
Robotic aircraft and automated data collection systems	**V-TOL Aerospace Pty Ltd**	Robots, automation, control, vision systems, integrated sensor networks	Weeds, Crop Sensing, Farm Management Contact POC for further information	Peter Hill	Director Unmanned Systems	Unit 18, 1645 Ipswich Road, Rocklea Q 4106	QLD	61 7 32752811 0402038722	peterhill@v-tol.com
Research and development in advanced automation for various industries with a focus on non-rigid and variable products	**Industrial Research Ltd**	Advanced automation, vision guided robotics, cognitive mapping, telerobotic, knowledge based control	Ovine Y-cut robotic system; Automated orchid packaging system; Automated mussel opening system;	Patrick Lim	Team Manager	24 Balfour Road, Parnell, Auckland 1052	NZ	(64) 9 920 3688	p.lim@irl.cri.nz

Production to market systems solutions for horticulture products	**Department of Agriculture and Food Western Australia (DAFWA)**	New product development; production, harvest and post harvest systems; supply and value chain development	Breeding new apples, development regional evaluation and commercialisation of selections from Australian fruit and wildflower breeding projects. Bulk bin shipping solutions for apples. Production systems for 'single pass' harvesting for cauliflower and broccoli. High density production systems for pome fruit	Dennis Phillips	A/Director Horticulture Industries - Department of Agriculture and Food WA	3 Baron-Hay Court, South Perth 6151	WA	(61) 8 93683568	dennis.phillips@agric.wa.gov.au
Improved Processing Equipment	**University of South Australia**	Mechanisation	Novel grain cleaning equipment for sizing of sunflower seeds, Complete dried grape processing line (cleaning, washing, drying, sorting, packing), Dried apricot cutting machine, Dried apricot tray scraping machine, Dried apricot picking platform, Dried apricot tray washing machine, Pistachio sorting, Almond sorting, Colour sorter evaluations, Development of micro-grafting equipment, Improved vineyard sprayer, Spray droplet deposition analysis, Improved splitting of grain legumes	John Fielke	Associate Professor	Mawson Lakes SA 5095	SA	(61) 8 8302 3119	john.fielke@unisa.edu.au

Robotics and Machine Visions Systems	**University of South Australia**	Machine vision & Robotics	Identification of weed species, Automatic pig weight estimation using machine vision system, Weed mapping for selective herbicide application, Automatic detection of citrus fruits for automatic harvesting, Colour image processing for crack detection for almonds, Colour image processing for sorting clay fish, Automatic pig disease detection in slaughter house, Automatic marbling scoring system for beef industry, mobile robots for chicken welfare monitoring, Robot manipulator for citrus fruit harvesting	Dr San-Heon Lee	Senior Lecturer	Mawson Lakes SA 5095	SA	61 8 8302 3018	sang-heon.lee@unisa.edu.au
Turnkey automation and robotic solutions	**Applied Robotics Pty Ltd**	Robots, automated machines, control, vision systems	CSR: Bricks QC & Multi-robot Packing System, Fletcher Insulations: Batts Packing Lines, BP: Wafer Etching Lines, On-the-move extrusion Robots Holes Drilling, AMCOR: Carton Blanks Palletisng, Plaspak: Plastic Bottles Cartoning.	Dr Paul Wong	Managing Director	15 - 17 Egerton St, Silverwater, NSW 2128	NSW		paulw@appliedrobotics.com.au

Applied R&D in automation & robotics	**Applied Robotics Pty Ltd**	Applied R&D for novel applications	Silicon Slivers Assembly (In-house Robot with 5 micron accuracy), Opal Assay System with CSIRO, Robotics Fabrics Handling & Sewing Project (for Norwegian Govt), Brick QC/Sortation by Vision, Wool Sample Acquisition, Handling & Testing, High-speed Biscuits Handling, Bowel Cancer Screening Robot System with CSIRO.	Dr Paul Wong	Managing Director	15 - 17 Egerton St, Silverwater, NSW 2128	NSW	(02)9737 8633	paulw@appliedrobotics.com.au
Product and material handling solutions	**Viscon Australia**	Robots, product handling systems, vision systems, packaging systems.	http://viscon.eu/index.php?id=212	Henk van den Heuvel	General Manager - Australia	39 Sunblest Crescent, Mt Druitt NSW 2770	NSW	0401682511	henk@viscon.com.au
Machine vision solutions	**CSIRO Quantitative Imaging**	Computer vision, imaging and image analysis	www.cmis.csiro.au/iap/ia_work.htm	Paul Sims	Business Development Manager	E6B, Macquarie University Campus, North Ryde, NSW 2113	NSW	(61) 2 9325 3256	Paul2.Sims@csiro.au
Operational adoption of high spatial resolution, remotely sensed imagery by the commercial forestry sector	**Forest Biosecurity & Resource Assessment, Science & innovation, Industry & Investment NSW**	Monitoring forests & plantations for inventory & health	Adoption of new airborne technologies for improving efficiencies and accuracy of estimating standing volume and yield modeling in Pinus radiata plantations. Funded by Forest & Wood Products Australia	Christine Stone	Program Leader - Forest Biosecurity & Resource Assessment	Forest Science Centre, PO Box 100, Beecroft, NSW 2119	NSW	(61) 2 98720132	christine.stone@industry.nsw.gov.au

Machinery Safety Solutions and Safety Engineering Consultancy and Training	**Pilz Safe Automation Pty Ltd.**	Machinery Safety Solutions and Safety Engineering Consultancy and Training	Many in many different industries - we draw on wide ranging experience.	Frank Schrever Alistair Keenan	Managing Director National Sales Mgr	C1/756 Blackburn Road, Clayton VIC 3168	VIC	(61) 3 9544 6300	f.schrever@pilz.com.au a.keenan@pilz.com.au
Develop smart non invasive measurement solutions using image processing, radio frequency and microwave sensing, and mechatronics for industry	**Lincoln Ventures Limited**	Non invasive measurement using Image processing, Radio Frequency and Microwave sensing Autonomous vehicles Mechatronics	Developed a number of image, measurement and sensing systems including: Kiwifruit counter Apple Marker detection Apple spur growth analyser Grapesense: Grape canopy porosity measurer Aerial spray pattern and droplet size analyser Moisture measurement: including soil with Aquaflex Water flux sensor Non invasive microwave sensing of material and properties Radar & Ultrasonic ranging and velocity measurement Foreign object detection Bulk produce measurement	Ian Woodhead	Manager Lincoln Technologies	Engineering Drive Lincoln University Christchurch 7640 New Zealand	NZ	(64) 3 325 3700	ian.woodhead@lvl.co.nz

ATTACHMENT 5 - LESSONS LEARNT FROM OTHER INDUSTRIES

An important strategy in the scoping study for MARRS technologies for the horticulture industry has been to undertake a review of non-horticultural food industries and their investment in the MARRS technology sector. This information allows the horticulture industry to gain an understanding of how other industries have focused their resources to developing automation solutions as well as identifying some of the barriers they may have faced in the implementation of these technologies. Engagement with the other agriculture industry bodies has allowed us to capture some of their "Lessons Learnt", so that the horticulture industry can be aware of some of the "pitfalls" and to also determine if there is an opportunity to co-invest with these sectors of the agriculture industry in future MARRS strategies.

Meat & Livestock Australia Ltd

Sean Starling - Process and Systems Engineering Program Manager

www.mla.com.au

Meat & Livestock Australia is the peak industry body for the meat industry and it activities cover beef cattle, sheep and goats. The total value of Australia's off-farm beef and sheep meat industry is A$16.1 billion in 2009.

Meat & Livestock Australia (MLA) provides R&D and marketing services to the Australian red meat industry. The organisation is a producer-owned company, working in partnership with industry and government to drive red meat and livestock industry. MLA has the unique role of providing marketing and research services to over 47,000 livestock producer members and the broader red meat industry to help them meet community and consumer expectations.

MLA's core goals are

1. Growing demand for Australian red meat,
2. Increasing market access for our products,
3. Enhancing competitiveness and sustainability, and
4. Increasing industry capability.

In relation to the organisations objective *Enhancing competitiveness and sustainability*, MLA conducts research and development throughout the red meat supply chain to develop a competitive advantage for the red meat industry.

As part of MLA's goal to develop competitive advantages for the red meat industry, the company is involved in a broad range of research and development throughout the supply chain. On-farm projects include grazing management, parasite control, meat quality, animal genetics for improved efficiency and environmental management. Post-farm R&D activity covers environmental management, product development, supply chain management, health and safety, education and training, technology development and commercialisation, food safety and microbiological research, and co-product innovations. It is within this objective that MLA has developed its strategies around MARRS technologies.

Where is the meat industry up to in terms of acceptance of technology?

> Dollars need to be invested in technology platforms that in the future lead to commercial outcomes. MLA technology strategies included a "Lost leader" strategy. This strategy was to get technology (robots) into plants, even though it was not commercially viable. This strategy was to expose the meat industry to automation and robotics and to have the technology accepted.
>
> Two paths for implementation of automation & robotics were developed: one the optimum development path and the other path for industry acceptance.

During 2002 to 2004, projects were of 12 month duration but 80% of the automation solutions in plant were not fully functional. By 2004 to 2007, 80% of the R&D program expenditure was focused on the development of enabling platforms.

In the development of automation and robotic solutions there are two different contexts for this R&D: one is academic and science driven the other commercially driven.

The hardest thing has been to get commercial R&D providers to work with academic R&D providers. They have different views of the world and very different drivers, but both have complimentary capability.

The MLA developed a strategy to build innovation capability within companies. http://www.redmeatinnovation.com.au/working-with-mla/collaboration/collaborative-innovation-strategies-0. MLA's strategy at the firm level is multi-pronged and involves innovation diagnostics, development of innovation strategies, professional development, and project financial support.

A corner stone of the strategy at the firm level is the appointment of an Innovation Manager and that role has the following attributes,

- Must report to CEO,
- New position, and
- Understand business decision process with in their company.

How is Meat & Livestock Australia's Automation Strategy funded?

Of the organisation's budget of $64mill, 50% ($30million) is allocated to Off-Farm R&D.

The Meat Industry is able to access additional financial support through the AMPC/MLA industry Funds Program. AMPC is Australian Meat Processors Corporation, the body representing all the meat processors.

The AMPC/MLA Industry Funds are divided up as follows;

- Technology $1.8 to $2.0 million
- Environment $1.5 million
- OHS $700,000

Projects selected for funding are fully funded under AMPC/MLA mechanism.

Another program available to the meat processing industry is Plant Initiated Projects (PIP). Projects under this mechanism are funded 25% processer, 25% AMPC and the remaining 50% from MLA.

Also available to the meat industry is the MLA Donor Company model (http://www.mla.com.au/TopicHierarchy/ResearchAndDevelopment/FundingOpportunities/PartnersinInnovation/Default.htm). Projects put forward for support are funded 50:50. 50% of the project costs are covered by the applicant and the other 50% from MLA through its Donor Company mechanism. Within the project budget a Management fee of 10% is charged by MLA for administration support.

This mechanism is similar to HAL's Voluntary Contribution (VC) program.

The approval process for projects through the Donor Company

- <$50k one week turnaround,
- $50k - $1m four week process,
- >$1m then it is a three month cycle.
-

How does MLA manage project IP and commercialisation?

MLA's preference is to own the intellectual property of projects it funds, as this is seen as protecting the Federal Government's investment.

In relation to commercialisation of IP, MLA can control the commercial selling of research outcomes indirectly. MLA insist on a 3year business plan if you are commercialising IP they own. Through their strategy of structured commercialisation processes they can maximise benefit to Australia.

Licensing agreements contain performance clauses that if key commercialisation milestones aren't met then the IP can be offered to others.

MLA has an internal strategy of funding right the companies to work with;

- Company tolerant of "playing" with automation or MARRS,
- Respected player in the industry,
- Have the right people in the company. People that understand the opportunities afforded by innovation and have a passion.

MLA also encourages the formation of joint ventures between research providers and companies. Under this arrangement the costs, risks and potential rewards associated with the project are shared.

Australian Seafood Cooperative Research Centre

Jayne Gallagher - Program Manager, Product and Market Development

www.seafoodcrc.com

Australia's seafood industry is the sixth most valuable of Australia's food-based primary industries, with a gross value of production of $2.05 billion in 2006-07. The Seafood CRC is an industry focused organisation that has been established to stimulate and provide comprehensive seafood-related research & development and industry leadership on a national basis.

Some thirty five companies, industry bodies, research institutions and government agencies are participating in the Australian Seafood CRC. Twenty five are company members.

The mission of the Australian Seafood CRC is to assist end-users of its research to profitably deliver safe, high-quality, nutritious Australian seafood products to premium markets, domestically and overseas.

What was the process that the industry went through to develop the Seafood CRC?

The seafood industry sought guidance from Capital Hill Consulting (www.capitalconsulting.com.au), who specialise in putting CRC bids together. The question for horticulture is do they still have right contacts with the change of Government.

A successful CRC bid needs someone to drive the process. Don't over promise to industry the possible dollar leverage.

A CRC needs a particular dedicated structure

- Management and Administration,
- Research,
- Training and education, and
- Commercialisation

The Fisheries Research & Development Corporation (FRDC) has too much influence and doesn't adhere to normal CRC procedures.

Insure the budget is managed with a proper project finance system. This should be an off the shelf system. FRDC insisted on using their system which is called FishBase developed by F1 Solutions.

A CRC consists of tied and untied funds. Don't allow participants to commit all "Tied Funds" as this will allow little ability to undertake strategic research. It ends up stifling innovation. Financial arrangements with partners need special consideration. You need to enforce a rule of "No cash – no participation".

The best leverage the CRC has managed to secure from Universities is in capability building. The training program needs to involve Industry and University. CRCs are about capability building. Training money was set aside in the Seafood CRC to assist in commercialisation training. The CRC does not have a formal commercialisation position.

Seafood CRC Research Program is the largest component of the CRC. It is developing underpinning research. It has a dollar for dollar funding mechanism for projects, trying to focus on four core research areas. Ensure there are commercial outcomes.

Communication and extension need to be important strategies within the CRC. The outcomes need to be more than research reports.

Suggestions for the overall development of the CRC proposal are;

- Employ a writer to assist with preparing the CRC proposal,
- Give thought about how the CRC mechanism may work,

- How do you get the best researcher to work on project when they don't belong to CRC participating organisation?
- Interview coaching.

It took two years to put together the Seafood CRC bid.

Grains Research & Development Corporation

Dr Stephen Thomas - Executive Manager, Practices

www.grdc.com.au

The Grains Research & Development Corporation (GRDC) is the grains industry's research organisation, responsible for planning, investing and overseeing research and development, delivering improvements in production, sustainability and profitability across the Australian grains industry.

The GRDC's research portfolio covers 25 different crops spanning temperate and tropical cereals, oilseeds and pulses, worth over $7 billion a year in farm production. The GRDC is a statutory corporation, operating as a research investment body in partnership with growers and Government. Funding is provided through a levy on grain growers. This is determined each year by the grains industry's peak body, the Grains Council of Australia (GCA). The Australian Government matches this funding, up to an agreed ceiling.

What is GRDC strategy for MARRS technologies in the grain industry?

The Grains industry undertakes elements of MARRS technology. Automation is largely around Precision Agriculture and Variable Rate agronomy practices. Precision Agriculture practices are widely used in the grains industry, and the industry also is using yield mapping technology.

Uptake of Variable Rate agriculture is marginal. The issues for low adoption are;

- capital cost is an issue,
- relating to the technology, and
- Integration and tech support.

The MARRS research focus for GRDC is with the Australian Centre for Plant Functional Genomics (ACPFG) www.acpfg.com.au where we are investigating automated watering and nutrient application. Contact is Mark Tester, Adelaide University

GRDC are also funding work on In-field Nitrogen sensors.

There is a small amount of research work with Unmanned Ariel Vehicles (UAV) and remote sensing.

Not sure if the GRDC invested in the development of the Weed Seeker.

What is GRDC's annual spending on automation development?

GRDC does not have a separate automation program and so can not quantify the amount spent. This is usually integrated into individual projects.

Acceptance of MARRS technologies varies widely across the industry. It depends on awareness and perceived value creation. Precision Agriculture is highly accepted where as Variable Rate technology has limited uptake to date.

What are GRDC's funding arrangements?

GRDC collects 0.9% on 25 Levy crops which are then in turn matched dollar for dollar by the Federal Government. Usually Grower money.

Does GRDC have a formal Strategic Research program in MARRS?

- No formal strategy
- Have a defined initiative in Precision Agriculture.

What is GRDC's Commercialisation strategy?

- Usually commercialisation is based around deals with the Private Sector.
- GRDC co-invests and retains an equity position.

GRDC would be willing to co-invest in MARRS projects that are important to the Grains industry.

What are some of the important lessons learnt?

If don't have end users involved at the start then it is hard to get Buy-in. Implementation on farms has to be viable.

Case and John Deer have internal R & D programs in automation.

What are the Drivers?

These are variables. Sustainability is a key driver i.e. Natural Resource Management. Control the input costs such as fertiliser and labour.

Is GRDC involved in any research collaborations?

Need to check, but most likely with the Cotton RDC. GRDC is also involved in the Weed CRC. Usually on a project by project basis with commercial companies.

Dairy Australia Ltd

Ian Mitchell - Nutrition Bioscience Manager

www.dairyaustralia.com.au

The dairy industry continues to be one of Australia's major rural industries. Based on a farm gate value of production of $4.0 billion in 2008/09, it ranks third behind the beef and wheat industries.

Dairy Australia is the national services body for the Australian dairy industry. Its role is to build a sustainable and internationally competitive industry and to provide solutions that help farmers adapt to an ever-changing operating environment.

The annual Dairy Levy amounts to approximately $28 million dollars. In addition to this money, Dairy Australia receives annual Federal Government funding of approximately $19 million dollars. The Australian Government supports the dairy industry by providing one dollar for each dollar of levy funds that the industry invests in research, development and extension activities. Further funding is attracted from other dairy and agricultural bodies including the Geoffrey Gardiner Foundation and the state Departments of Primary Industries, which also support investment in research, development and extension activities.

In Europe, over half of new milking machine installations involve automation (robotic milkers). It is milking technology with great potential for improving labour use efficiency. In Australia there is a research program into automation, along with some commercial robotic milkers.

What is Dairy Australia's strategy for MARRS technologies in the dairy industry?

Dairy Australia investments are in the key areas of feed-base development, animal performance, sustainable resource management, vocational education and training and farm business management. The dairy processing industry is already highly automated largely due to the basic product range being largely milk and other liquid by products. The industry's automation strategy is focused around the automation of the milking process, on farm.

Under Dairy Australia's Investment Theme of “Farm Productivity & Delivery” is the sub-program “FutureDairy”. The objective for “FutureDairy” is to deliver practical farm technologies for a broad range of Australian dairy farm systems. It has a budget of $939,000 which equates to 1.7% of Dairy Australia's investment.

Under the FutureDairy project the industry had begun the development of an Automated Milking System (a system around the milk harvesting technology). In addition to developing future Automatic Milking Systems, FutureDairy is also evaluating those technological innovations with the greatest potential to impact on labour efficiency and farm productivity. MARRS innovations being investigated that have potential to impact on labour efficiency and productivity include:

- Automatic gates that open and shut at pre-set times,
- Robotic fencing that moves break fences at pre-set times and pre-set distances,
- Automatic measurement and evolution of live weight changes and body condition score,
- Remote sensors of animal functions with an automatic message sent to a computer to alert when treatments are required or the ration needs adjusting,
- GPS device attached to cows' collars that monitors activity as an indicator of oestrus attached to individual cows, and
- In-line testing of metabolites in milk (e.g. progesterone to determine early pregnancy with accuracy).

ATTACHMENT 6 - LETTER OF SUPPORT FROM QUEENSLAND UNIVERSITY OF TECHNOLOGY

QUT

Queensland University of Technology
Faculty of Built Environment and Engineering

2 George Street GPO Box 2434 Qld 4001 Australia

Phone 07 3864 2111 Fax 07 3864 1510 **www.qut.edu.au**

CRICOS No. 00213J ABN 83 791 724 622

Russel Rankin
Food Innovation Partners
Russel@food-innovation.com.au

Dear Russel,

Thanks you for visiting us at QUT last week. We are very keen to participate in the development of the ideas around Mechanisation, Automation, Robotics and Remote Sensing (MARRS) in horticulture, and we will be very pleased to support the development of a Cooperative research Centre in this area. We have some clear capacity in this area, represented by Professor Peter Corke and Professor Gordon Wyeth, but we also have a number of other areas, in particular in remote sensing and farm automation, which we believe will be able to contribute to this research area.

We will be organising an internal workshop to help us to understand our capability in this field so that we can make the most appropriate contribution to the proposed CRC, or other research emerging from your current work with Horticulture Australia. We will invite you to this workshop once we have identified a suitable time and place.

QUT has participated in many CRC's and we are aware of both the pitfalls and benefits of these organisations. We believe that the approach you are taking is very appropriate, both in having a clear industry strategy up front, and also in ensuring that adequate time is available to prepare for the CRC application. QUT will be keen to be part of a Steering Committee guiding the development of this CRC and we hope to be able to make significant contributions to its development.

Yours sincerely

Professor John Bell
Assistant Dean (Research)
Faculty of Built Environment and Engineering
Phone: (07) 3138 4298
FAX: (07) 3138 1529
Mobile: (0419) 803 424

ATTACHMENT 7 - HG09044 SYNDICATE MEMBERSHIP

	Organisation	Contact	Position	Telephone	Industry Sector	Value Chain	Email
1	One Harvest International Pty Ltd	Rob Munton	Business Development Manager	040948-2728	Salad, Fruit	Producer/Processor	Robert.Munton@oneharvest.com.au
2	Tasmanian Institute of Agriculture Research, University of Tasmania	John McPhee	Vegetable Research, Development & Extension	0407 845 612	Government	Research Provider	john.mcphee@utas.edu.au
3	MAR (Machinery, Automation Robotics) Pty Ltd	Clyde Campbell	Managing Director	02 9748 7001	Automation	Research Provider	ccampbell@machineryautomation.com.au
4	Primary Industries Resources South Australia Horticulture Industry Development	John Fennell	Principal Horticulturist	0401121891	Government	Research Provider	John.Fennell@sa.gov.au
5	University of Wollongong	Chris Cook	Dean of Engineering	04400435572	Research	Research Provider	ccook@uow.edu.au
6	University of Southern Queensland	Erik Schmidt	Director	0423029976	Research	Research Provider	Erik.Schmidt@usq.edu.au
7	Horticulture & Forestry Science, Queensland Primary Industries and Fisheries, DEEDI	John Chapman	General Manager, Horticulture and Forestry Science	0408 986 751	Research	Research Provider	john.chapman@deedi.qld.gov.au
8	Future Farming Systems, Victorian Department of Primary Industries	Peter Fisher		0358335341	Government	Research Provider	Peter.Fisher@dpi.vic.gov.au
9	Zespri International Pty Ltd	Dr David Tanner	Technical Director	07 572 7600	Fruit	Producer/Processor	David.Tanner@zespri.com
10	CSIRO ICT	Jonathan Roberts	Acting Director Autonomous Systems Laboratory	07 3327 4501	Research	Research Provider	Jonathan.Roberts@csiro.au
11	Fibre King Pty Ltd	John McVeigh	Chairman	0417 782847	Packaging	Service Provider	john.mcveigh@fibreking.com
12	Costa TomatoExchange Pty Ltd	Richard Hamley	General Manager	0428 303352	Fruit	Producer/Processor	rhamley@costagroup.com.au

13	SPC Ardmona Limited	Michael Wilson		03 5833 3777	Fruit	Producer/Processor	MWilson@spcardmona.com.au
14	Plant & Food Research	Dan Ryan	Australian Business Manager		Research	Research Provider	Dan.Ryan@plantandfood.co.nz
15	Department of Agriculture and Food Western Australia	Dennis Phillips	Acting /Director Hort Industries Development	0404819621	Government	Research Provider	dennis.phillips@agric.wa.gov.au
16	ARC Centre of Excellence for Autonomous vehicles, University NSW	Jay Katupitiya		(02)93854096	Research	Research Provider	J.Katupitiya@unsw.edu.au

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- Tasmanian Institute of Agriculture Research, University of Tasmania,
- MAR (Machinery, Automation Robotics) Pty Ltd,
- Primary Industries Resources South Australia, Horticulture Industry Development,
- University of Wollongong,
- University of Southern Queensland,
- Horticulture and Forestry Science, Queensland Primary Industries and Fisheries, Department of Employment, Economic Development and Innovation,
- Future Farming Systems, Victorian Department of Primary Industries,
- Zespri International Pty Ltd,
- CSIRO ICT,
- Fibre King Pty Ltd,
- Costa TomatoExchange Pty Ltd,
- SPC Ardmona, Limited,
- Plant & Food Research,
- Department of Agriculture and Food Western Australia, and
- ARC Centre of Excellence for Autonomous Vehicles, University New South Wales.

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