Final Report

Opportunities to improve labour use efficiency through automation and improved management practices (RB21003)

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Delivery partner:

The Growth Drivers

Project code:

RB21003

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Opportunities to improve labour use efficiency through automation and improved management practices (RB21003)

Disclaimer:

Funding statement:

This project has been funded by Hort Innovation, using the raspberry and blackberry research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

Publishing details:

Published and distributed by: Hort Innovation

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Hort Innovation

Improved Labour Efficiency

Opportunities to improve labour use efficiency through automation and improved management practices

Final Report

28th of March, 2023

Hort Innovation
Strategic levy investment

RASPBERRY AND BLACKBERRY FUND

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Acknowledgements

Thank you to the individuals and organisations who helped in completing this work and offered their time and contributions.

Core Delivery Team

The team responsible for authorship, editing and conducting this research.

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Special Thanks

We would like to thank the industry representatives, industry/regional development officers and other industry key stakeholders who provided valuable insights during the course of this project. We would especially like to extend our thanks to the following organisations and the individuals within who assisted this research:

Berried in Tas, Berries Australia, Burlington Berries, Costa Group, Driscoll's, Hillwood Berries, OzGroup, Perfection, Pinata, Queensland Berries, Tasmanian Berries, Westerway Berry Farm and Fruit Growers Tasmania

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Executive Summary

'Opportunities to improve labour use efficiency through automation and improved management practices' project is a rubus industry initiative funded through Hort Innovation. Led by innovation consultants at The Growth Drivers and supported by a reference group of rubus industry experts, this project seeks to support rubus growers across Australia to enable advancements in labour use efficiency. This project has made significant progress in the identification of technology-based solutions that lead to improved labour effectiveness and productivity and with many broadly applicable across agriculture. With the contributions of leading Australian rubus growers, we have prioritised these solutions into a list of top progression priorities and provided meaningful direction for future progression that aligns with the needs and aspirations, expressed form our cohort of Australian rubus growers.

Through this project, TGD was able to identify thirteen solutions with strong potential for significant impact in improving on-farm labour effectiveness and productivity. Of the thirteen solutions identified (shown in overview pg 23) five priority solutions emerged. These priority areas were selected as they were rated highly by growers across desirability, feasibility, viability and scalability.

- Data empowered resource planning & deployment
- Advanced recruitment assessment
- Computer vision quality assessment
- Autonomous collaborative robots
- Virtual reality training & assessment

The process for identifying these solutions and arriving at this outcome consisted of four major steps that were achieved in a four-stage approach (that is provided with more detail on pg 8).

1. **Problem Statements**
   Crystallising five problem statements through grower engagement, complimentary research and mapping & assessing the processes. These problem statements are usable in the future to use a comprehensive and well-articulated definition of the problem.
2. **Solutions**
   Through an iterative process of engaging with technology owners, researchers, our expert network and growers we explored a range of solutions utilising the problem statements as a framework for exploration. This led to the identification of thirteen solutions of which nine were further explored and developed into more resolved solution concepts.
3. **Validation and prioritisation**
   The nine solution concepts were then validated through grower engagement that included an in-person workshop with a broad group of growers best representative of Australian commercial rubus growers. Through this workshop, five priority solutions emerged for the industry to consider for future investment.
4. **Solution pathways**
   Based on new insight through engaging with growers, each of the solutions was further iterated to reflect their feedback and with the addition of clear actionable recommendations. For the five priority solutions, a series of next steps have been included that provide clear actionable steps for solution development. Additionally, two areas for further research that support baseline information that will underpin several solutions. This consists of
   a. Picker movement study: A digital capture of picker movements to create an understanding of the anthropological and ergonomic factors supportive of picking proficiency
   b. Fruit impact study: A targeted study to understand the force thresholds that fruit can withstand to guide the assessment of solutions that involve fruit movement.

This body of work has been completed to provide clear guidance for future work and funding to progress the rubus and adjacent industries in improving labour effectiveness with substantial evidence and practical recommendations. This work was completed by TGD on behalf of Hort Innovation and the Australian rubus sector with support form Berries Australia, Tas Fruit Growers and numerous Growers, funded through the Raspberry & Blackberry research and development levies

01

Project Overview

Project Overview

This project is an initiative led by innovation consultants at The Growth Drivers and funded through Hort Innovation, aimed at supporting Rubus growers across Australia to improve labour use efficiency. The project is supported by a reference group of Rubus industry experts.

The Challenge:
Like many other horticultural industries, Rubus growers face ongoing challenges with labor costs and efficiency. The Rubus industry has experienced significant growth in both volume and value, but is heavily dependent on hand-picking to meet the demand for fresh fruit. As such, the labor cost and efficiency challenge is critical to the industry's viability.

Within the Rubus industry, the labor cost and efficiency challenge is unique to each grower's labor requirements, which are determined by factors such as farm size, production complexity, and regional issues. Production complexity includes critical timing of crop emergence, pest management, weed pressure, seasonal harvests, and post-harvest and packhouse efficiency. Given this variability among Rubus growers, it is unlikely that a one-size-fits-all approach would lead to significant adoption of solutions or substantial improvements in farm viability.

The Project:
In order to ensure the ongoing viability of the Rubus industry, a comprehensive approach is needed that identifies solutions across different grower segments and supports growers in advancing these solutions through improved knowledge and capabilities.

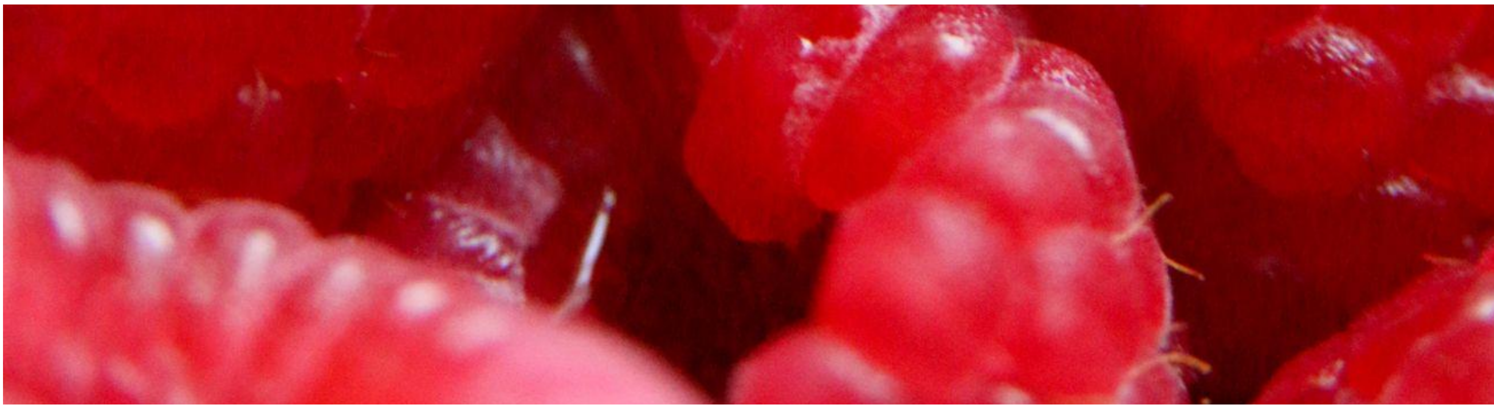
This project aims to achieve these goals by actively engaging with the industry to identify and assess potential solutions to their unique labor challenges.

To ensure that the project delivers strong outcomes for Rubus growers, a Reference Group has been established to provide guidance on project direction and support the design and innovation capabilities of the TGD team. This group consists of industry experts and leaders, as well as individuals with diverse perspectives from outside the industry.

The project will culminate in a series of standalone assets that will empower growers to make practical changes, support technology providers in developing solutions, and provide a foundation for future research and development in the Rubus industry.

Project Objectives:

- Support future work through detailed segmentation of rubus growers capturing the heterogeneity of the industry.
- Develop a deep understanding of the areas of the labour spectrum that are able to be manipulated and prioritised.
- Identify solutions, align them to grower segments and establish an understanding of the gap in implementation.
- Establish pathways for the advancement of solutions.



Project Timeline

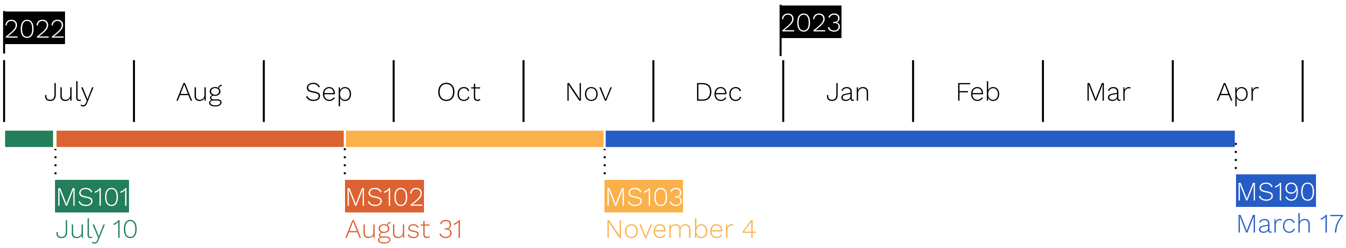
The project timeline consists of 4 stages spanning July 2022 through to March 2023. Over the past year, we delved into the problem space and grower context through a range of research and engagement activities, followed up by an exploration of the solution ecosystem and assessed these representatives from the industries leading growers.

The first stage assisted in laying out a clear vision for the project and an order for how the project will be governed over the period.

The second stage explored the problems and pain points growers and pickers face, through interviews and onsite studies, concluding with a research report, and validation survey.

The third stage embedded the feedback and validation from the industry in the findings and conducted a technology scan to build out a set of potential solutions that address problem statements and a solution validation workshop, that allowed growers to direct the viable solutions. This concluded with a design report that included international case studies, critical control points, and technologies and solutions ready for assessment.

The fourth and final stage of the project saw the execution of a growers technology workshop in Launceston, TAS that allowed growers to learn about the suite of solutions, engage with technology providers and assess solutions. This document is a culmination of these stages and the technology assessments of these industry leading growers.



			This Report
01 Intent	**02 Explore**	**03 Validate**	**04 Deliver**
Activities	**Activities**	**Activities**	**Activities**
Intent Meeting Initial Research Research Scoping	First PRG Meeting 13 Stakeholder Interviews 1 Time & Motion Study / 3 Farm Tours Producer Survey	Process assessment & validation Solution Ideation Workshop Technology Scan Solution Validation Workshop	In-person solution development workshop Visual communication asset development Draft report Final report Project close meeting
Outputs	**Outputs**	**Outputs**	**Outputs**
Project Intent Research Protocol	Producer Segments & Archetypes Process Maps Research Report	Critical Control Point (CCP) Design Criteria Global Case Studies Technology Solutions & Labour Best Practices	Third PRG meeting Draft report Final report

Methods

13	4	6	12
In person interviews	Farms Toured / Time and Motion Study	Grower assessed Problem Statements	Grower Verified Solutions

Solution Discovery to uncover the various existing solutions options encompassed research methodologies outlined *below*, as well as a design methodology; idea generation and refinement process outlined *on pg 24*, "Solutions Pipeline Summary". Solutions considered either had a direct link to the problem statements on *pg 15-21* or were transferred from existing industries.

- Desktop research
- Open-ended & informal interviews with growers and technology providers
- Expert consultation
- Industry surveying at agriculture and agtech conference attendees and exhibitioners
- Grower survey

Development of solutions to get to usable solutions and grower assessed priorities and recommendations flows through the Explore, Validate and Deliver phases.

First the team developed problem statements with the insights from 13 grower interviews, then undertook a solution discovery process that linked the problem statements to potential solutions. During the validate phase, the team ran validation workshops to engage growers and sort the viable solutions from unrealistic or unpractical ones. Then once solutions were deemed valid, we asked growers to assess the solutions after being provided with all the relevant information and opportunities to speak to the solution providers in the final workshops.

The solutions presented in this report contain the research that outlines what the solutions and potential are as well as information from the assessment of a 9 attendee grower workshop in tasmania, made up of the largest growers in australia and key Tasmanian rubus grower for primary suppliers.

Desktop research consisted of a review of literature, industry papers and available industry data. This provided the project team with a baseline knowledge of practices employed by growers, an overview of the industry and a set of assumptions that were tested through grower interviews and informal conversations with industry experts. This information has provided greater fidelity to the project focus and is captured in the Background information section of this document.

Grower interviews with individuals from 12 medium- or large-sized rubus business gave the team specific information about their processes and methods of production. These interviews also provided the project team insight into the ways in which resources are employed and organised in these companies, their attitudes and motivations, as well as their perceived obstacles.

The research team was able to conduct **contextual interviews** with growers at **site visits**. This was critical for the creation of the process maps included in this report since it provided a solid practical understanding of the diverse practises used on farms of various operation sizes. Additionally, during our site visits, we recorded time tracked video for the **time & motion analysis**.

A **survey** was also distributed to a wide range of growers to help inform the development of an Australian rubus grower 'footprint'. The project team was able to aggregate information across 35 farms to support this footprint and will continue to build upon this dataset throughout the duration of the project.

The core **research limitations** were varied and included:

- Limited availability of individuals
- Varied harvest seasons
- Commercial confidence and privacy

Focus Areas

This research is divided into 5 Primary focus areas, while not all of these areas are critical in the primary scope of this research report, they have a great impact on the labour effectiveness and are within the primary labour concerns for growers. The team felt it was important to capture data that emerged in each focus area.

The focus areas were developed in collaboration with an expert Reference Group (RG). These experts are made up of primary rubus growers from multiple states, industry development officers from Berries Australia, a Hort Innovation project coordinator and additional industry expert consultants.

Focus Area 01. Workforce composition & management
Who makes up the harvest workforce and what are the factors to consider? The characteristics and motivations for different parts of the workforce and the range of hiring/contracting options available to growers.

Labour management techniques, training best practices, tools and educational resources, worker retention.

"Nothing else that we do in the next three years in this area will deliver as much productivity input and uplift as the ability for me to retain a worker from one year to the next"
- RG Member

Focus Area 02. Crop profiling
Managing the accelerated production curve in rubus when compared to strawberries or other crops. For example, Rubus has a steep increase in production in the first 1-2 weeks.

Trying to forecast and predict when a harvest window will be. Developing or utilising a sustainable cropping profile to do these.

Focus Area 03. Harvest efficiencies
Movement of product, reducing inefficient practices, understanding the differences that picking process, types, and marginal changes can have on harvest efficiency.

Focus Area 04. Non-harvest labour
Labour outside the harvest window contributes to total costs and makes up a sizable amount of labour.

Focus Area 05. Crop production & waste
Crop design involves several variables including supplier genetics that will influence production yields. This in turn directly affects picker efficiency as well as waste that is also directly correlated with labour efficiency.

02

Background

The Rubus Plant & Industry

The Industry

Rubus is a perennial plant with biennial canes. Varieties of rubus produce fruit including raspberries, blackberries, and hybrids such as loganberries, boysenberries, marionberries, and tayberries. At present, only raspberries and blackberries are grown in commercial quantities in Australia. The industry is made up of 120 growers as of 2019/20, producing 9,932 tonnes or raspberry and blackberry, as stated in Hort innovation' s *Berry Strategic investment plan.* Of this, raspberries and blackberries supplied fresh to the market comprise the majority of rubus grown in commercial quantities.
Processed and frozen berries within Australia are dominated by cheaper international imports that Australian growers cannot compete against on a pricing basis. Fruit that is sold into frozen and processed markets is typically growers' second-quality fruit that is sold as a means for cost recovery and is not considered a core revenue stream. The only known exception to this is one farm based in Tasmania that supplies specific fruit varieties to the processed market as a premium product, leveraging the Australian-grown brand.

The value of the industry according to the Berry Strategic Investment Plan 2021-26, is $216 million, with growers are located across all Australian states with the exception of the Northern Territory. 77% of Australian rubus production is grown across New South Wales (23%), Victoria (26%) and with the highest proportion of rubus in Tasmania (28%). The growing season is at its most productive between December and April when Tasmanian and Victorian farms are harvesting. However, year-round supply is achieved through growers based in northern New South Wales enabled by advanced growing practices, genetics and environmental conditions

The Challenge

Growers who supply fresh Rubus face various interrelated challenges to ensure the sustainability of their operations, with managing labor costs being a critical factor. Compared to other berries and produce, Rubus production presents a unique challenge in optimizing labor use due to the fruit's high perishability and fragility.

As a result, known automation solutions for many processes are either impractical or not financially viable to implement while still maintaining the necessary quality control standards to meet consumer expectations. Overripe, bruised and fruit exposed to extended warm temperatures once picked are more susceptible to perishing faster than existing supply chains can manage. Underripe fruit will not develop in flavour once picked, and collapsed or broken fruit will fail to meet consumer expectations from rubus as a premium product.

Current Harvest Practices

Practices adopted by growers in handling the fruit aim to navigate these challenges. To date, picking by hand has been the only feasible approach due to the dexterity required for handling the fruit without damaging it, but also picking at a speed that meets supply demands and crop viability. Handling of the fruit once picked is kept to a minimum with fruit going into the retail punnet within 2-3 touchpoints. Processing lines that can support the fragility of the fruit once picked are either not available or not publicly known.
In supporting the shelf life of the fruit as it makes its way to the consumer across the country, growers endeavour to cool the fruit once picked as quickly as possible. The acceptable timing will vary from grower to grower depending on the extent of their supply chain but for many 60 minutes is the norm. For larger growers ensuring this may entail further labour expense in the form of dedicated staff for transport of fruit between crop and cool room.

The Rubus Plant & Industry Continued.

Growing Rubus

The specific techniques adopted for growing rubus vary by location and farm. The majority of growers, however, will use some form of trellising system and grow within tunnels. There are several varieties currently being grown. These varieties are usually the developments of marketing and supply chain organisations such as Driscoll's, Berryworld and Perfection. These organisations dedicate considerable investment to the advancement of genetics to support flavour, yield, harvest window, appearance and handleability. Commercially focused growers will also typically approach growing their crops in one of two ways (though they may use a combination across their site). The first is double cropping. Double cropping entails growing primocane fruiting varieties that will fruit on the primocane (first cane) later in the season with its floricane (second season cane) fruiting earlier in the season. The other approach that is continuing to gain traction amongst growers is long-cane production. Long-cane production involves growing primocanes and artificially inducing a winter on them by removing all foliage and placing the canes into cold storage. This allows for the staggered re-planting of the canes to overlay production curves of crops to ensure greater consistency in production.

Industry Ecosystem Map

The diagram below, shows a high level overview of the rubus market. It demonstrates the various business models adopted, with large conglomerates , partnerships and a combination of vertically integrated and with third-party growers/operators.

The industry structure is significant to the project. Supply partners (ie Driscoll's, Perfection, Berryworld) provide genetics to the grower and determine punnet size and design. This affects the grower's operations as a set of fixed variables they must navigate.

03

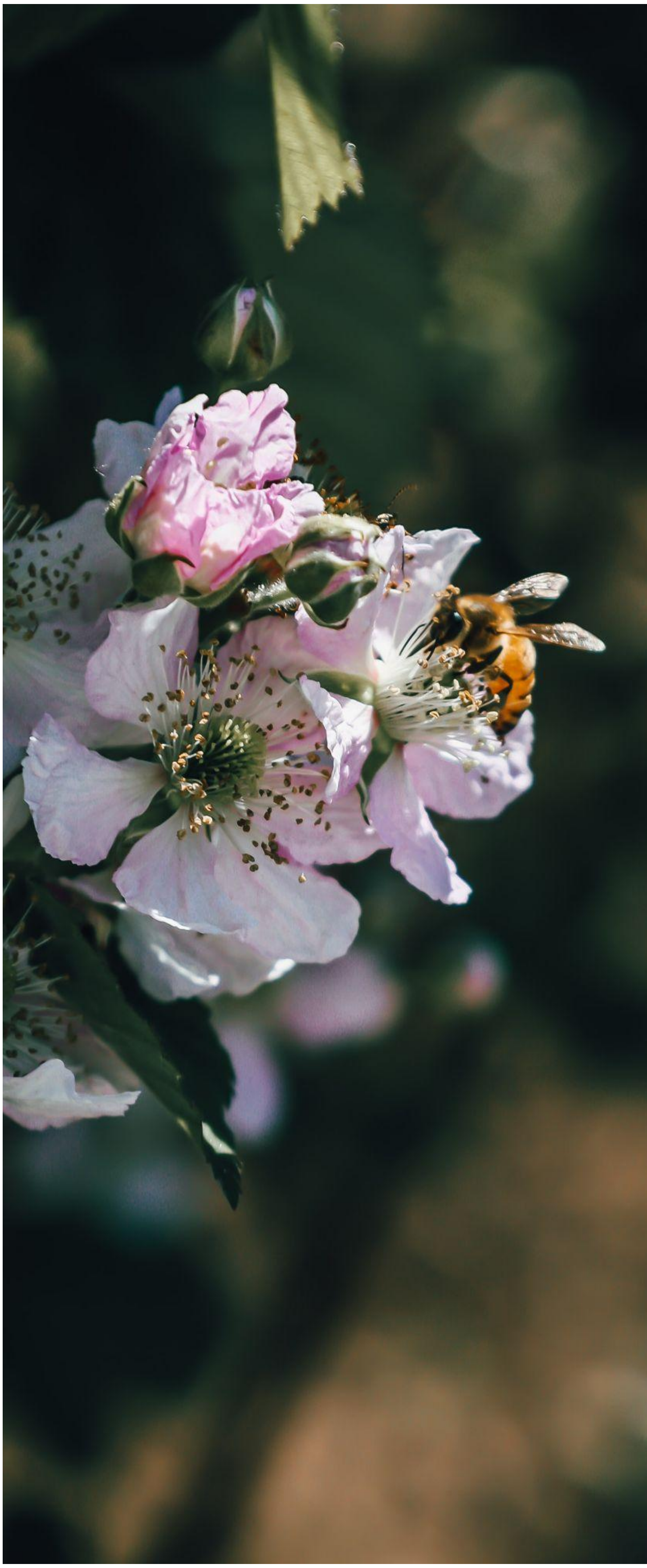
Problem Statements

Problem statements

The problem statements outlined throughout the following section encompass the most important labour efficiency challenges for growers. The shortlist of five articulated problem statements is not exhaustive but rather reflects the greatest opportunities for the advancement of labour efficiency by growers engaged throughout the project. The development of the problem statements was done in close consultation with the industry to ensure the resulting statements sufficiently frame the problem to enable solution discovery.

Well-defined problems lead to beneficial solutions that can be adopted by industry. When organisations aren't sufficiently rigorous in defining the problems and articulating why those issues are important opportunities are missed, resources are wasted, and innovation initiatives are pursued that aren't aligned with their strategies.

These statements articulate critical points in the production process where labour efficiency is best able to be addressed. To develop these problem statements, we interviewed growers across Australia and followed up with one-on-one grower feedback interviews as well as a grower workshop to develop and refine. The following list provides an overview of the solutions presented throughout the following section.



Problem statements

More efficient harvest activities: picking: Improving picking speed by advancing pickers' capability and capacity.

More efficient harvest activities: non-picking: Supporting pickers through optimisation of ancillary activities such as transporting, packing and QA

Row & fruit quality assurance: Addressing labour inefficiencies associated with QA corrections of either picked & packed fruit or how clean a row has been picked

Crop presentation: Supporting the efficiency of staff conducting crop presentation as well as decision-making around human resource deployment

Cane selection & sucker removal: Supporting workers to conduct cane selection or sucker removal efficiently as well as supporting management in the deployment of human resources

More efficient harvest activities: picking

What is the problem?
So-called "good pickers" possess a unique blend of physical characteristics and abilities, sufficient experience, and the right attitude. Inexperienced or unsuitable pickers represent a disproportionately high cost to growers because they are unlikely to pick at a rate that exceeds the minimum award.

For any new picker, several weeks of on-the job training is required before they achieve strong proficiency. This poses a challenge for growers in ensuring that they have suitably sized picking teams for harvest. A high proportion of inexperienced pickers, high staff turnover, and the high expense associated with bringing foreign workers into country make finding a reliable source of good pickers a significant industry-wide challenge.

Problem in detail
Achieving proficiency in picking raspberries and blackberries requires on-field experience to learn the feel and rhythm of the task. Some new pickers learn the feel and rhythm quicker than others and some are inherently more motivated to maintain a high-pace in the repetitious task of picking for longer periods of time.

New pickers are typically supported with some basic training and supervision as they get started but this is insufficient to enable proficiency. Candidates from overseas may be subject to some basic physical testing requirements prior to being brought to Australia for the season.

On average it takes a new picker 2-3 weeks to achieve basic proficiency. Experienced pickers with one or more years experience will pick at a rate nearly double that of a new picker. The proportion of new pickers will vary with the time of year and farm location. Some growers indicate that up to 30% of their workforce may not have had previous experience picking raspberries or blackberries.

This makes finding suitable workers from a local workforce particularly challenging for growers. Local workers have much lower barriers to entry to picking and lower barriers to exit, in comparison to selected overseas worker pools, leading to higher employee turnover. Local workers are rarely considered as part of a growers recruitment.

Experienced pickers are often in short supply, forcing the Australian rubus industry to take a risk on selecting and training new pickers.

What is the impact?
Inexperienced pickers cost growers in make-up-pay when they fail to pick above the minimum award rate. Once picking above the minimum award, slower pickers represent an inefficiency within the harvest process. In instances where a suitably sized or experienced workforce cannot be found, this costs the grower in productivity losses represented by ripe fruit going unpicked. The time taken to pick 1 tonne of produce for an experienced versus and inexperienced picker is approximately 100 hrs vs 140 hrs, respectively.

Solutions
Solutions may make use of digital technologies such as augmented reality and/or embed gamification principles in motivating pickers to obtain and maintain a high proficiency. Alternatively, solutions may support growers in identifying the "ideal" picker, that have the capabilities to pick proficiently. This may include a set of physical requirements such as, height, reach, build and vision. Other characteristics of interest relate to personality and behaviour that have a higher likelihood for maintaining motivation in a highly repetitive task. The industry is also interested in cobotics and other machine assistance that might increase efficiency. Full automation of picking is not of interest due to the task complexity, and high input variability amongst growers.

How will we judge success?
Solutions should consider the human aspect of this skilled and repetitive task,demonstrating how a path to increased overall picking productivity is possible without negatively impacting other parts of the production process.

Potential solutions will take account of:

- Rapidly advancing the performance of inexperienced pickers
- Improving the reliability in the selection and retention of high performing pickers.
- Improved job satisfaction of picking teams
- Financial cost of the solution including capital expenditure. An estimation of investment payback period is recommended.
- The simplicity of adoption and integration.
- Adaptability of the solution to different types of growers.

Questions for thought - How might we...
Gamify the picking process to motivate pickers and increase performance?

Understand key picker traits and attitudes that are common in good pickers?

Use realistic training (eg augmented reality) to support pickers to learn the feel and rhythm of picking prior to coming on farm?

More efficient harvest activities: non-picking

What is the problem?

Rubus pickers spend up to an estimated 40% of their time during harvest on non-picking activities such as walking to and from the job location, packing, and transporting fruit. Time and motion studies conducted on a typical farm indicated walking constitutes 10-20% of labour time and packing 20-30% of harvest labour time, with the remainder dedicated to picking. If picked fruit quality is low or fruit is damaged whilst being transported to or during packing, the time spent on packing can exceed 30% of total labour time.

Problem in detail

Non-picking activities and the amount of a pickers time they consume will vary between growers and their harvest processes. Some may opt for a pick direct to punnet process, whilst others may pick into a bucket before packing to the final punnet in the field. Regardless of process adopted, once the fruit has been picked, fruit must be transported to a cooling facility, usually within 60 minutes, to ensure shelf-life and quality. The timing and quantity of fruit being moved is subject to a range of variables, especially climatic conditions. On hotter days there is greater pressure to cool fruit quicker and demands smaller amounts being picked per bucket to prevent fruit damage.

Pickers are held to account for the quality of their picking and handling of fruit via a piece-rate wage structure. Consequently, growers typically have the picker responsible for packing the fruit into its final punnet, assessing the punnet to ensure it is within weight and quality specifications. Time spent by pickers on packing and transporting fruit takes time away from picking. Since picking is considered a more complex task involving skill, visual assessment, and a high amount of dexterity, non-picking tasks seem to represent a good opportunity for automation solutions.

What is the impact

It has been estimated that harvest activities represent 30% of costs to the Australian rubus grower, mainly in labour costs. Picking is a critical harvest activity and there is a clear benefit of having experienced pickers focussed on that job. Non-picking activities are essential and are performed by the same people.

The effects to business and workers when disproportionate time is spent on non-picking harvest activities include; inexperienced pickers are unlikely to meet the picking targets. Experienced pickers capable of meeting the picking targets (financial reward), time spent on non-picking activities can be frustrating and leads to lower overall pick rates.

Solutions

One approach trialled in industry was to create **task specialisation,** whereby some workers were responsible for only picking, and others took care of non-picking activities. The concept was to improve the performance of each activity to gain overall labour use improvements, however this approach has generally been regarded as unsuccessful. Negative consequences experienced in this trial included higher levels of poor-quality fruit being sent to packing (incentivised by piece rate picking contracts), increased burden on QA, and higher friction between workers. Regular changes in worker attendance and variations in fruit quality, placed additional stress on the work teams, leading to production bottlenecks and lower picking efficiencies. Task specialisation could form part of a solution, but would need to address the negative consequences experienced in the example above.

The Australian rubus industry is particularly interested in technology and automation options that reduce the number of workers and/or increase the effectiveness and efficiency of non-picking harvest activities.

How will we judge success?

Solutions should consider both the diversity of production methods and harvest processes used by growers holistically. Solutions will need to be reliable and take into account the available space in tunnels, terrain and conditions on the farm

Potential solutions will take account of:

- Financial cost of the solution including capital expenditure. An estimation of investment payback period is recommended.
- A target grower segment with a reasoned plan for the solution adoption and integration into operations.
- Evidence or anticipated effect on harvest yield and other harvest operation costs.
- Evidence or anticipated effect labour utilisation or other production efficiencies.

Questions for thought - How might we...

Better utilise our labour mix to maximise the time spent by experienced workers picking fruit?

Transport fruit and/or people differently?

Reduce the time required in non-harvest activities?

Row & fruit quality assurance

What is the problem?
Row & fruit quality assurance (RFQA) is a manual process conducted by support staff via visual assessment of rows of fruit on the vine, and picked fruit. This is a process to ensure fruit of the required quality is supplied to customers. In this way, RFQA is a "safety net" task to ensure picking crews are cleaning the rows of fruit effectively, picking fruit within customer specifications, and fruit handling does not cause damage whilst being moved or packed. QA tasks represent additional labour costs to growers.

Problem in detail
Typically, RFQA is done at the same time with one QA supervisor conducting both row and picked fruit quality inspections. Row QA is undertaken during harvest to ensure pickers are picking effectively by visually assessing each row for missed ripe fruit as well as any damage to plants from picking. When ripe fruit is left to spoil on the cane, this represents a financial loss as well as a potential pest and disease risk to the crop.

Typically, the role of a QA supervisor will involve;

1. Identifying under-picked rows and requesting that pickers return to clean rows of ripe fruit
2. Monitoring of undesired picking behaviours such as picking that favours well-presented fruit and leaves fruit less obvious or accessible on the plant.
3. Monitoring of undesirable picking behaviours such as to pick & pack under/over ripe fruit or leave foreign objects such as pests and plant matter in the punnet

RFQA may hinder picker productivity when pickers are requested to return to a row or to re-pack their punnets to rectify an issue. For fast pickers that are capable of picking well above the minimum award, this will reduce overall yield. For slower pickers, QA intervention will hinder their capacity to pick above the award rate.

The effectiveness of staff to assess a row or packed fruit, the speed at which they do the assessment and the judgement calls on sending a picker to rectify a row or punnet will vary from person to person. The subjective nature of RFQA is a challenge to achieving consistency.

What is the impact
RFQA is a variable cost to growers that increases with picking crew size and the level of intervention in the production process. It is estimated that most growers will use the equivalent of one person full day labour for every 10 pickers. For a grower with a 6-month harvest window, this represents a cost of approximately $25,000 for every 10 pickers they have active.

Poor judgement calls by row QA personnel can reduce the labour efficiency of pickers. Conversely, decisions not to intervene creates an increased risk for pests and disease, and reduced production yield.

Solutions
Solutions that transform this task from subjective to objective are of interest. Solutions may incorporate advanced sensing and analysis technology such as machine learning, vision processing and artificial intelligence.

Other solutions may incorporate features such as real-time feedback to pickers on how clean they are picking their rows, quantitative analysis of packed fruit or autonomous row QA.

How will we judge success?
Solutions to support labour optimisation related to RFQA should consider how to best:

- Incentivise pickers to pick rows cleanly
- Reduce labour use in the process of quality assurance,
- Empower objective decision-making in real time
- Improve the pick-pack process within set customer specifications.

Ideal solutions will reduce labour requirements dedicated to RFQA and increase picking effectiveness and efficiency..

Questions for thought - How might we...
Incentivize desirable picker behaviours to produce measurable improvements in picker effectiveness and efficiency?

Objectively quantify QA in the field?

Introduce tools and visual inspection technologies that reduce or eliminate the need for additional labour in the role of QA?

Crop presentation

What is the problem?
Crop presentation is a labour intensive non-harvest activity that involves the tucking of cane laterals, positioning canes within the trellis system and occasional pruning to present the fruit ready for picking. Crop presentation is a necessary set of maintenance tasks that is currently performed manually by a skilled labour force.

Problem Detail
Crop presentation tasks are performed several times over a plants growth cycle, usually by a small team of workers on a casual contract. It is important to get the right timing on labour deployment because vine laterals that are left to grow too long are more difficult to handle and are prone to damage. If done too soon the working crews may need to be deployed more often to correct new growth.

Second year canes, known as floricanes, require more intensive management than primocanes, and therefore represent a higher labour cost to growers.

Crop presentation crews are usually only equipped with a pair of gloves for handling and rely on their training to identify laterals to be moved and an ideal new location. The range of movements by the worker are varied as plant laterals could exist in any direction, and work is focussed from waist height to above head.

Good crop presentation is essential to ensure optimum crop yield by exposing flowers to adequate sunlight. Picking performance is also impacted by the task since good crop presentation makes fruit picking more efficient.

What is the impact?
Crop presentation is a direct labour cost to growers. For a row spacing of 2.35m, the labour cost is estimated at $3000-5500/hectare, which may be required three times per annum ($16,500 per hectare per year). There is also an associated training and development cost for growers to upskill the labour force to perform the task at the desired standard.

Poor crop presentation due to inexperienced workers, or carelessness will impact crop yield as well as inhibit picker efficiency.

Solutions
Potential solutions may include the use of tools or infrastructure (such as new trellis systems) that simplify or reduce the labour time required for crop presentation work.

Best practice and workforce training solutions that have clear benefits to upskill and improve crop presentation performance of workers are of interest.

Tools and infrastructure that target improved ergonomics and can demonstrate better job effectiveness and efficiency are of interest.

Crop analytics solutions that offer support to management to make resource deployment decisions are also of interest.

New plant genetics which may have an impact on crop presentation are out of scope.

How will we judge success?
The following have been identified as key success criteria for solutions to be assessed against.

- Improved labour use;
    - Increase in worker efficiency
    - Reduced labour need
    - Improved task effectiveness as assessed by the quality of crop presentation, crop yield and business feedback
- Economics - Capital costs and payback period
- Ease of change - Simplicity to implement and applicability across different varieties, genetics and growing practices

Questions for thought - How might we...
Provide data and inform growers in advance on the deployment of crop presentation crews?

Improve the efficiency of crop presentation crews through the use of existing or specially designed support tools or systems?

Remove or relocate labour from crop presentation through the innovative design of trellising systems or automation?

Increase the quality and speed of worker education and practical performance in crop presentation?

Cane selection & sucker removal

What is the problem?
Cane selection(sometimes referred to as spawn selection) is the process of choosing the best early growth canes as a plant develops and removing the unwanted canes. This process is performed manually using secateurs and requires knowledge and care to select the right canes and remove unwanted canes without damaging others.

The task of sucker removal is a similar manual process to cane selection and refers to removing unwanted early stage propagations ('suckers') from coir. This task is performed manually, multiple times over a growing year during plant growth periods. Unwanted suckers must be addressed in a timely manner to ensure optimum crop yield. Both activities represent a significant use of non-harvest labour.

Cane selection and sucker removal are similar manual processes that are anticipated to attract solutions that could apply to both tasks. Human solutions should target increased labour efficiency and effectiveness including approaches to better identify and plan the deployment of personnel.

Problem in Detail
Removal of spawn from coir happens in one of two contexts:

1. For growers that are using a double-cropping technique, at a point during the growth cycle, small labour teams are required to select emerging spawn to become the primocanes for the next fruiting cycle and remove excess through the cutting of others at the base. This is a time-consuming process that can take a worker approximately 2 hours to complete a 100m row.

Cane selection also requires training and expertise to ensure workers are selecting the best new plants to grow.

2. Sucker removal should occur as early as possible to avoid energy and nutrients from the plant being misdirected. It is an activity common to all the main cropping techniques (long-cane production, double-cropping and single-cropping).This requires low to semi-skilled workers as it is a relatively simple task that involves waiting until about 300mm of growth has occurred.Workers will typically use a set of secateurs or sheers to cut them off at the base at ground level.

What is the impact?
Cane selection in Raspberry cropping is a task typically performed by workers on a casual hourly contract and thus represents a direct variable cost to the grower. Cane Selection is estimated to take 170 hours per hectare to complete, representing a cost to the grower of approximately $4,200 per hectare and may be conducted twice per growing cycle.

Manual sucker removal for Blackberry cropping can take up 200 hours per hectare, per growing cycle. This represents a cost of approximately $5000 per hectare.

Poorly managed suckers will also directly impact yield and subsequent picker efficiency.

Solutions
Potential solutions may include the use of tools or infrastructure that simplify or improve the results of the task. Furthermore, tools and infrastructure that target improved ergonomics and can demonstrate better labour efficiency are of interest.

Sensing and data analysis of spawn emergence to better inform business and resource decision making are also of interest.

Use of herbicides in specific instances that do not harm the main plants are already known to save significant time, though is not universally implemented. Solutions in this area are of interest.

How will we judge success?
The following have been identified as key success criteria for solutions to be assessed against.

- Improved labour use;
  - Increase in worker efficiency
  - Reduced labour need
  - Improved task effectiveness as assessed by crop yield and business feedback
- Economics - Capital costs and payback period
- Ease of change - Simplicity to implement and applicability across different varieties, genetics and growing practices

Questions for thought - How might we...
Integrate advanced imaging and sensing tools into the production process to identify the emergence of spawn?

Use mechanical assistance (eg exoskeletons) to support worker efficiency and effectiveness?

04

Solutions

Solution overview

The subsequent section outlines a variety of potential solutions aimed at addressing one or more of the Problem Statements. These solutions were identified through diverse channels, such as TGD's engagement with its network of inventors, researchers, and technology providers. The solutions were then developed in consultation with prospective technology providers and validated and improved through interactions with growers, including interviews and a dedicated grower workshop. The solution pages act as living documents that may be continually updated, they provide an overview of their potential and the course of action required to advance them.

1

Autonomous collaborative robots (ACR)

ACRs are autonomous transport platforms that carry produce or other material around without the need for programming.

2

Advanced recruitment assessment

Testing and assessment tools that assess the capabilities, skills and motivation of potential new hires.

3

Data empowered resource planning & deployment

Utilising innovative data capture mechanisms to inform the decision making process for planning and deployment of resources.

4

VR training & Assessment

Using virtual reality hardware and training modules to train workers and assess aptitude in prospective hires.

5

Ergonomic picking equipment

Altering picking equipment such as buckets and trays to make them more ergonomic and easy to use for pickers

6

Computer vision quality assessment

Assessing the state and quality of crops or picked fruit using computer vision on a range of hardwares

7

Exoskeleton for workers

Wearable exoskeletons that reduce the strain on the body of specific repetitive and strenuous activities

8

Gamification in AR enhanced picking

Enhancing picking skill uptake and reskilling for pickers through the use of augmented reality hardware and training modules.

9

Packing equipment

Reducing the time spent weighing picked fruit by designing a more efficient scale with enhanced usability features.

10

Harvest team reconfiguration

Reconfigure the structures of harvest teams to make team more agile and priortised.

11

In-field cooling system

Starting the coolchain earlier by brining a cooling process into the field, increasing the shelf life of berries in retailers.

12

Improved trellising

Utilising more advanced trellises or a different trellising practice that reduces time spent on adjustments and alterations and is less likely to damage fruit.

13

Digital language translation

Digital tools for overcoming language barriers to support training and communication of on-field tasks

Solution overview

Procedure for solution discovery, validation and assessment.

Discovery

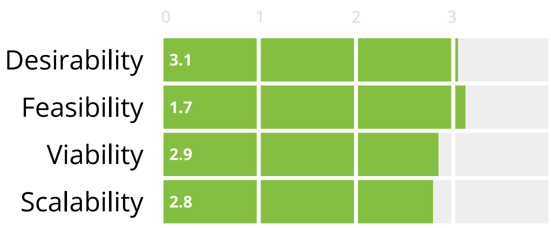
This discovery process is further outlined on pages 8 and 9 in ***01 Project overview***.

1. Solution were aligned with problem statements and discovered through research methods outlined in ***03 Problem Statements***
2. Growers were engaged in a solution ideation workshop to review and come up with new approaches
3. Solution profiles were refined by the team and providers were contacted and verified.
4. A full-day solution workshop was conducted in Launceston with primary raspberry and blackberry growers to review the solutions, understand and assess their suitability to their contexts and speak to the technology providers for some of the solutions.
5. Solution assessment rubrics form the solutions workshop were used to calculate scores for the Desirability, feasibility, viability and scalability.

Solution Scoring

The below chart is not a definitive assessment but provides general context around how a solution is positioned against the four characteristics that make a good solution.

To show these scores, we used the rubrics filled out by growers at the solution workshop (In **Appendix F Solution Assessment Rubric**), answering multiple choice questions along interval scales, that relate to each field. Solutions with higher scores (out of 4), translate to solutions that growers have positively assessed against the rubric. This scoring is not a definitive assessment, but provides general context around how it sits in comparison to other solutions and relates to growers that participated in this project.

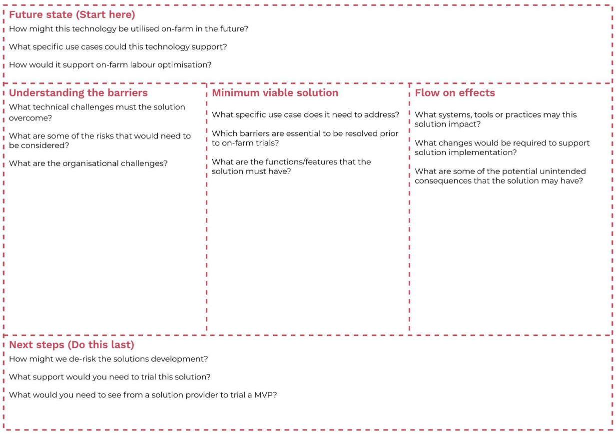


Example of solution score chart.

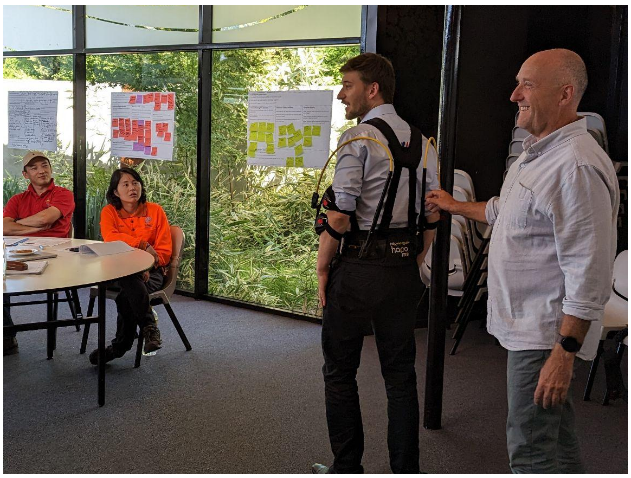
Solution Exploration Canvases

Lead by a facilitator in the solutions workshops, growers used a canvas designed to explore key questions related to these solutions.

The Canvas as shown below is made up for 5 sections: Future State, Barriers, Minimum Viable Solution, Flow-on Effects and Next Steps:



These completed canvases influence the recommendations and findings outlined in the solutions and can be reviewed in more detail on page 102 in the appendix.



Solution overview

By conducting assessments of solutions with growers, we were able to evaluate their potential to address multiple problem statements. The table presented below highlights the solutions that exhibit potential impact across different problem statements. Although this assessment is qualitative in nature, it provides valuable insights that can guide the prioritization of solutions to cater to individual grower requirements.

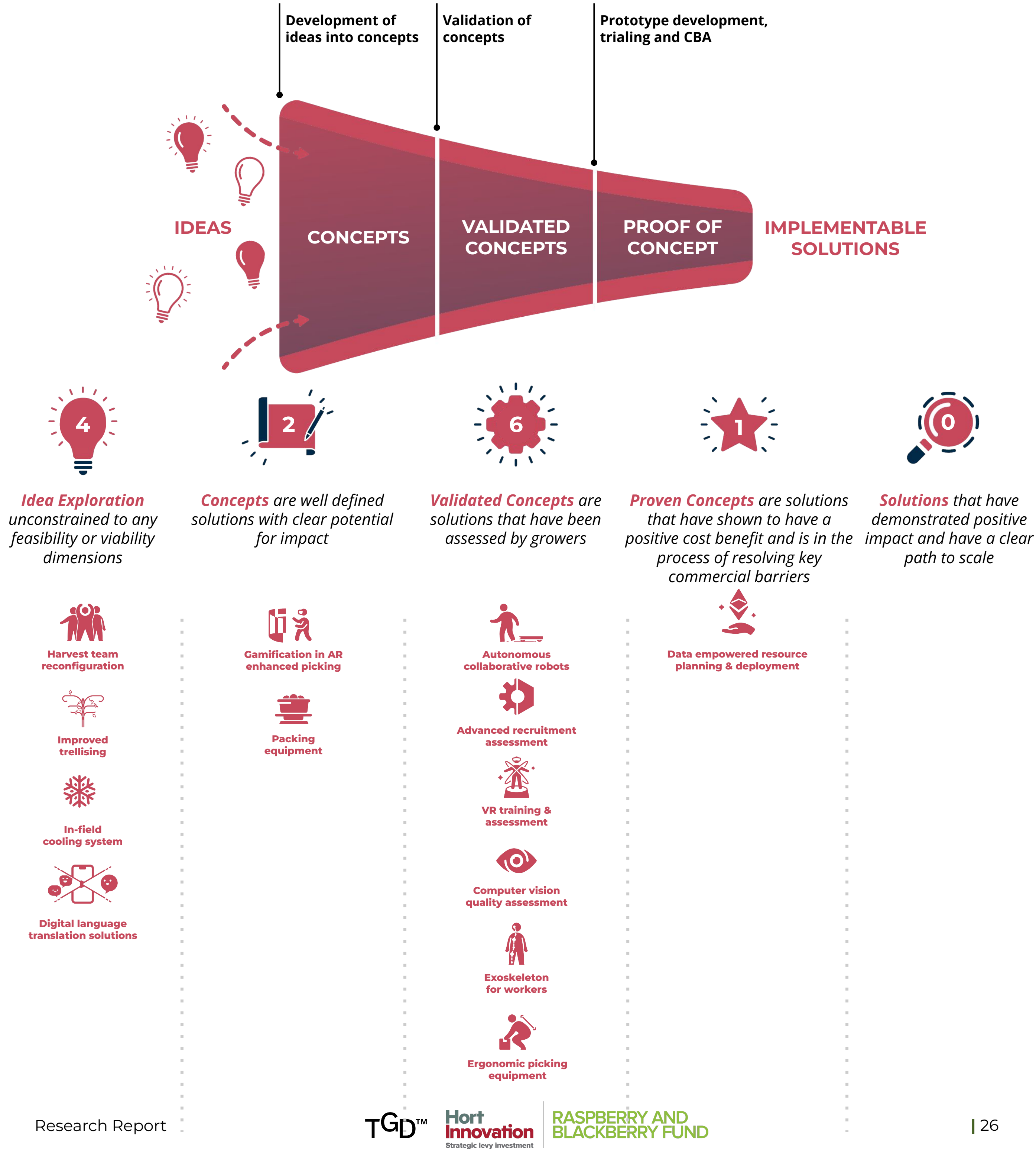
	More efficient harvest activities: picking	*More efficient harvest activities: non-picking*	*Row & fruit quality assurance*	*Crop presentation*	*Cane selection & sucker removaL*
Autonomous collaborative robots		High			Moderate
Advanced recruitment assessment	High	High		Moderate	Moderate
Data empowered resource planning & deployment	High	High	High	Moderate	Moderate
VR training & assessment	High	High		High	High
Ergonomic picking equipment	High				
Computer vision quality assessment		High	High		
Exoskeleton for workers	High			High	High
Gamification in AR enhanced picking	High	Moderate			
Packing equipment		High			
Harvest team reconfiguration	High	High			
In-field cooling system	Moderate	Moderate			
Improved trellising	Moderate	Moderate		High	
Digital language translation	High	High		Moderate	Moderate

High Potential
Moderate Potential

Solutions Pipeline Summary

The solution pipeline offers an overview of the progress and status of various solutions identified throughout this project, as well as a representation of the methodology employed by TGD in discovering and cultivating these solutions. This process commences with the inception of preliminary ideas, which subsequently evolve into well-defined concepts through the delineation of distinct solution components. These concepts then undergo validation through testing with growers, followed by prototyping & testing, ultimately leading to proof of concept – solutions that effectively address technical challenges while demonstrating favorable cost-benefit outcomes.

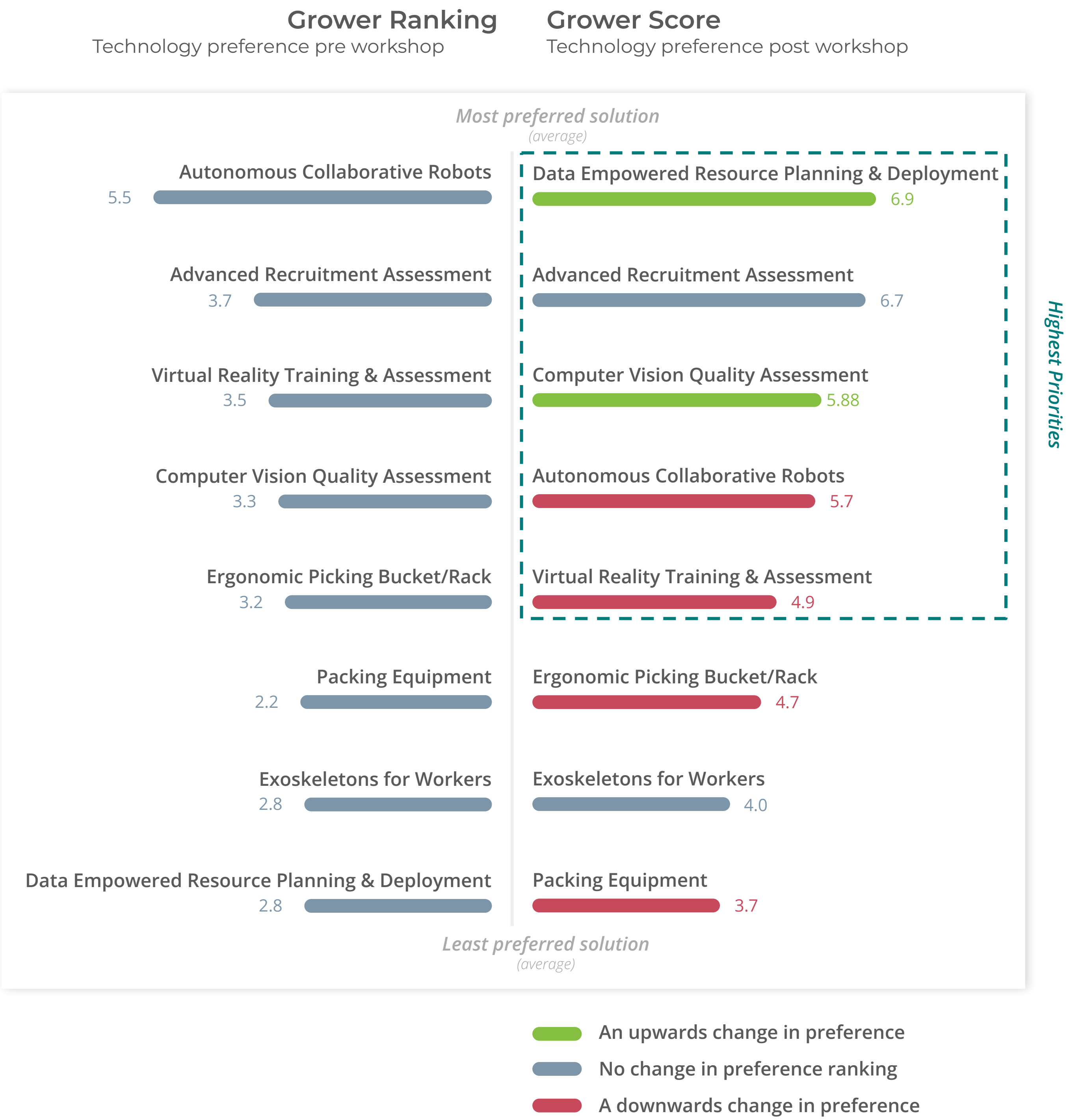
As solutions advance through this process, some may require suspension or iteration, necessitating a step back to refine and improve upon them. A notable example of this is the Packing Equipment solution, formerly known as Scale Array. During the grower workshop, it became apparent that the initial solution was too narrowly defined, prompting a reversion to the conceptual stage for further work. The ultimate objective of the process illustrated in this diagram is the generation of 2-3 viable solutions for commercial development and widespread implementation among growers.



Solution Sentiment

The below diagram shows the results of workshops participants asked to rank their solution preferences at the beginning and again at the end of a workshop. The workshop provided the opportunity for growers to identify and explore barriers to adoption of the solutions in their business and was supported by technical, intellectual property, and commercial experts.

This diagram illustrates how growers felt initially about each solution (on the left) and how this changes when they think critically about each solution after being informed and better understand which challenges they address.



Autonomous collaborative robots

Problem(s):
More efficient harvest activities: picking
More efficient harvest activities: non-picking

What it is & How it works: Autonomous Collaborative Robots (ACRs) utilize computer vision, precision GPS, and artificial intelligence to navigate between locations for various in-field tasks such as crop scanning and transportation. This innovative solution can support on-farm labor optimization in multiple ways, including:

Transportation of picked fruit: The ACR can collect picked and packed fruit and transport it to the designated in-field drop-off point, freeing up pickers to focus on their primary task of picking. To accommodate the transportation of rubus fruit, modifications may be necessary, such as integrating space for supplies like punnets and trays or adding scales for pickers to perform quality assurance by weighing fruit while packing punnets directly on the ACR.

Other applications: ACRs can be used for a range of other on-farm tasks, including mowing rows, crop scanning for forecasting, or clearing debris from rows during pruning. These applications can further support the viability of ACR implementation in agriculture.

Estimated Efficiency Gains: By eliminating time spent by pickers in transporting picked fruit and for collection of supplies, a potential labour saving of up to 20% across picking crews is possible. Additional benefits may include improvement in picker speed by increasing the pickers' time focused on picking.

Costs: The initial capital outlay is expected to be high as ACR's are a relatively new technology. Suppliers such as Burro have a per unit cost of approximately $20,000. The operating expenses Medium, ACRs require maintenance and management adding cost in skilled labour, parts and electricity

Segment relevance: Large Corporate & Established Commercial - Larger growers are more likely to have the capacity for the capital outlay on these type of solutions. Larger operations may also distribute any associated risk across a larger fleet of robots.

Burro, 2022

Solution snapshot

Grower Ranking	
Solution stage	Validated concept
Solution Horizon	2 - 5 years
Cap-Ex	High
Segment	Larger growers
Desirability	3.1
Feasibility	1.7
Viability	2.9
Scalability	2.8
Recommended Action	Further analysis and scenario modeling required before moving to in-field trials
Technology owners	Burro.ai, Naïo Technologies

*preliminary assessment based on grower perception during solution workshop and review by project team

Solution horizon: The use of collaborative robots for agriculture is rapidly expanding, and new market entrants are expected in the near future. Although the use of ACRs in agriculture is still in its emergent stage, some businesses in the blueberry and grape industries have already successfully deployed ACRs to assist with harvest activities. Additionally, AgPro Robotics has a commercially available solution for field strawberries. However, several feasibility and viability barriers need further development to ensure the adaptability of an ACR system for the specific needs of rubus growers.

Autonomous collaborative robots

Barriers:

1. ACR's must be able to transport picked fruit across variable terrain without impacting fruit quality due to bumps and vibration.
2. ACR mobility may not be limited in fields with poor drainage that results in puddles and ruts too deep for the ACR to navigate.
3. Design of a new picking process that translates across growers, supports picker buy-in and behaviour change and demonstrates viability of ACR integration.
4. Evaluating potential changes to in-field infrastructure to support access for ACRs, including row width, tunnel design for valley access, or integration of cross-row access at intermediary points.
5. Developing a system to attribute punnets/trays to a picker for piece-rate pay and quality assurance.
6. Considering the capital expenditure required to integrate the system into on-farm practices, which may limit adoption by some growers. A pathway for scaling the solution in operations is necessary.
7. Designing the ACR platform to support packed trays, digital scales, and picker supplies.

Risks: The implementation of ACRs can introduce complexity to the picking process, which must be effectively managed to avoid adverse impacts. These risks may include a dependency risk, where the picking process may not work optimally if sufficient ACRs are not available to service all the pickers. Additionally, there are financial risks associated with the large capital expenditure required to establish a fleet of ACRs to service picking crews. Conducting a cost-benefit analysis may also not adequately account for poor-yielding subsequent seasons.

Recommendations: ACRs hold significant potential for supporting growers to improve on-farm labor efficiency and warrant further development. To advance this solution, we recommend the following next steps:

1. Picker data capture: Further investigation to gather nuanced data on picker movements and speed with relation to crop density. This data will enhance the information collected in the time and motion studies conducted in this project, and support the modeling of various picking process configurations and the design of hardware modifications to the ACR to ensure they support good ergonomics. Additionally, this work will include the capture of essential data on impact force limits to retain fruit quality, taking into account fruit ripeness and air temperature, and to investigate the realistic forces that the fruit is subjected to in practice during picking and transportation.

2. ACR scenario modeling: Perform computer modeling to test hypotheses on optimal configurations for ACRs, picking crews, and tunnel design. This modeling will help establish a minimum payload of picked fruit that the ACR must be able to transport, guide the design of modifications such as means for stacking punnet trays, and inform how to set up picking crews to ensure optimal ACR to picker ratio and in-field access requirements.

3. In-field trials: Using the work collected in items 1 and 2, In-field trials should be conducted where physical hardware prototypes of ACR and access configurations will be trialled. The trials will test the modeling data and include a cost-benefit analysis that provides growers and suppliers with a clear business case, informing the next steps regarding adoption.

All activities will be conducted in partnership with both at least one volunteer grower organisation interested to further progress technology assessment and the technology owners themselves.

Advanced recruitment assessment

Problem(s):
More efficient harvest activities: picking
More efficient harvest activities: non-picking

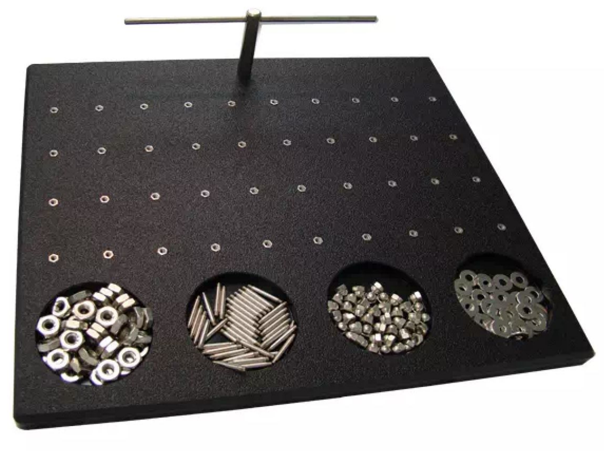
What it is & How it works: As part of the recruitment process, a set of specialized assessment tools can be utilized to identify candidates with the best potential for picking proficiency and behavioral characteristics that are conducive to maintaining high motivation in repetitive tasks. The tools would assess basic physical attributes, fine motor skills, hand-eye coordination, and psychological fit.

Existing research-based tools, such as the Minnesota Manual Dexterity, Pegboard test, and Roeder Manipulative Aptitude Test, can be adapted or customized for the assessment of Rubus workers. These tests are designed to evaluate hand, arm, and finger dexterity and speed. Additionally, psychological tests, including the Myers Briggs Type, DiSC, and the SHL Occupational Personality test, can be used for candidate assessment and selection.

Other potential tests for a recruitment system may include a color blindness test, assessment of basic physical attributes, and evaluation of hand-eye coordination or peripheral perception.

There is potential for these assessment tools to be integrated into the recruitment process by growers who self-manage their recruitment or those who outsource the job to labor-hire companies involved with the Seasonal Worker Program or the Pacific Labor Scheme.

Estimated Efficiency Gains: Improved pre-hire assessment of pickers can benefit growers by reducing hiring risks and improving the time it takes for new pickers to become proficient. Currently, it can take 2-4 weeks for a new picker with no prior experience to achieve basic competency, and it can take between 6 months to multiple years to become highly proficient. This can be a significant challenge for growers with inexperienced workforces, where improving pre-hire assessments has the potential to reduce labor needs significantly.



Lafayette, 2022

Solution snapshot

Grower Ranking	
Solution stage	Validated concept
Solution Horizon	1 - 3 years
Cap-Ex	Low
Segment	All grower segments
Desirability	3.1
Feasibility	2.9
Viability	3
Scalability	3.4
Recommended Action	Consult labour hire companies and determine optimal minimum viable solution
Technology owners	Lafayette Instruments, SHL

*preliminary assessment based on grower perception during solution workshop and review by project team

Costs: The proposed solution is expected to be cost-effective for growers, especially if existing assessment tools can be adapted to meet their needs. Some of the test devices listed are priced below $1000 AUD, which should be affordable for most growers. However, if customised physical testing tools are required, the initial capital outlay may be higher, although the exact cost cannot be determined at this stage. The main operational costs will be associated with the additional time required to conduct the tests during the recruitment process.

Advanced recruitment assessment

Segment relevance: This solution may be well-suited for large corporate and established commercial growers who manage their own hiring and workforce. However, smaller independent growers and those who rely on external third-party labor-hire companies may require a strong value proposition for integration. This solution may also be more applicable for growers with multiple crop types, allowing for greater flexibility in worker positioning across operations.

Solution horizon: A minimum viable solution could be achieved within 12 months, with some components viable for experimentation now. However, a fully-realized solution may take 2-3 years for optimal effectiveness. Fine motor skill and hand-eye coordination assessment tools are commonly used in physical rehabilitation and employee assessment for occupational jobs, while psychological tests for employee aptitude are widespread across various industries. This simplifies their adoption or adaptation for use in assessing rubus workers.

Barriers:

1. Further investigation is necessary to understand the legal constraints related to candidate assessment, such as discrimination laws.
2. The value proposition for labour hire companies to adopt the assessment tools needs to be explored, which may be challenging given the current high demand and short supply of pickers and on-farm labor.
3. Before developing the tests, a clear understanding of the ideal characteristics of a picker, including physical and mental attributes, is required.
4. Establishing a positive correlation between test results and picking proficiency, as well as determining the time required to conduct the tests, is crucial to prioritize tests based on the financial return for the time invested in them.

Risks: This solution has been broadly considered to be low risk. However, it is worth noting that recruitment assessments have potential for splintering friendship groups which are conducive to strong picking crew culture.

Recommendations: Advanced recruitment assessment represent a low risk solution that has potential for impact across a broad section of growers. We recommend the following actions be considered for the advancement of this solution.

<u>1. Scope & define constraints</u>
As a first step it is essential to establish a baseline understanding of the constraints that assessment tools must adhere to. This should include legal requirements and time or access constraints at differing points of the recruitment process or locations ie. onsite vs offsite.

This investigation should also establish an understanding of labour operations and practices to ensure solutions provides a strong value proposition to these stakeholders.

<u>2. Scope & define dimensions and measures</u>
To design and develop effective assessment tools, it is critical to identify the most important dimensions and measures of a successful picker. This involves analyzing the movement patterns and characteristics that distinguish proficient pickers and considering factors such as peripheral perception and hand-eye coordination.

<u>3. Design and trial MVP</u>
After identifying the crucial dimensions and measures, various tools and methods should be explored and developed to create a minimum viable product (MVP) that has strong likelihood for adoption by labour hire companies. This MVP may be further developed and expanded upon to include assessment tools.

Data empowered resource planning & deployment

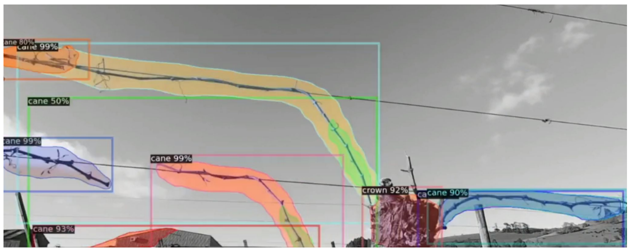
Problem:
More efficient harvest activities: picking,
More efficient harvest activities: non-picking,
Crop Presentation,
Cane Selection & Sucker Removal,
Row & Fruit Quality Assurance

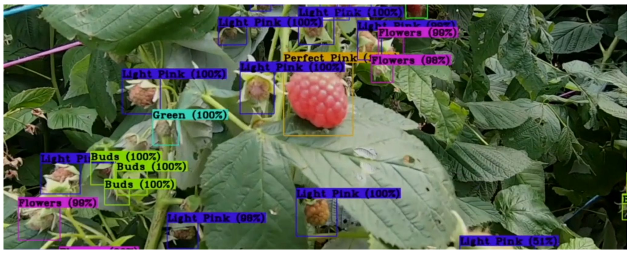
What it is & How it works: Using visual data capture and machine learning to improve labour forecasting and deployment.

Data capture & analysis tools are commercially available to raspberry and blackberry growers to scan and analyse their crops for improved planning and deployment of picking crews. The application of this technology, however, may also be adapted to support decision making on resource deployment across a multitude of different on field tasks including crop presentation, sucker removal or identification of pests & disease.

Solution providers such as Bitwise utilise footage captured through digital cameras such as GoPros. This footage is then uploaded to an online platform for crop analysis through their machine learning neural network. At present this is only being offered for crop forecasting in raspberries and blackberries, however, the grape industry is using the same information to improve planning on a range of other crop activities. For example, the neural network may be trained to assess lateral growth or flower distribution to identify the optimal timing for deployment of human resources to engage in crop presentation tasks. Likewise, the neural network may be trained to identify the emergence and density of spawns/suckers for either removal or floricane selection, or for the early identification of pests and disease.

Future application of the technology could also support row quality assurance whereby picked rows could be analysed in real time to assess how effectively a row is picked. This would reduce labour associated with manual row assessment and avoid unnecessary redeployment of a picker to a row.





Bitwise Ag, 2021

Solution snapshot

Grower Ranking	
Solution stage	Validated Concept
Solution Horizon	Now - 2 years
Cap-Ex	Medium
Segment	Medium to larger growers
Desirability	3.4
Feasibility	3.4
Viability	3.5
Scalability	3
Recommended Action	Development of business cases for further system development, cost-benefit analysis
Technology owners	Bitwise, Clarifruit, Lincoln Agritech, Croptracker: Harvest Quality Vision 3.0 (HQV 3.0).

*preliminary assessment based on grower perception during solution workshop and review by project team

Estimated Efficiency Gains: The impact in efficiency gains through empowering resource deployment decision-making through data is likely to vary between growers. Experienced growers who consistently deploy resources efficiently may experience less of an impact than those who are less effective in resource deployment. According to Bitwise, the average return on investment is expected to be approximately 300%.

Data empowered resource planning & deployment

Costs: The initial outlay for the Bitwise solution mainly consists of the cost of purchasing GoPros for crop scanning. Other solution providers with proprietary scanning hardware may have higher initial costs. Ongoing operational costs will include subscription services for the analysis platform and labor costs associated with crop scanning and data handling. Bitwise solutions are currently priced competitively in the market, starting at $5,000 per year for up to 30 hectares.

Segment relevance: Solution has potential to be viable and feasible across most commercial grower segments with 10+ acres dedicated to rubus and/or other berry crops.

Solution Horizon: Computer vision for crop assessment is already implemented in commercial raspberry farms in Australia for yield forecasting. In the grape industry the technology has been adapted to advance its application to other crop tasks including pest/disease identification, shoot identification & assessment and hail damage assessment.

Future development of the technology to suit other applications can likely be rolled out to growers within a 12 month period provided there is a strong enough business case for the development.

Barriers: The following barriers relate to further expansion of computer vision solutions to other applications.

1. Understanding in greater detail the cost-benefit of the solution in planning picking crews
2. Understanding the potential labour benefits in optimal deployment of resources across other on-farm tasks such as crop presentation and sucker removal
3. Advancements in neural networks and connection speed to support real-time analysis and feedback

Risks: It is important to note that neural networks and decision-making algorithms are only as effective as the data they are trained on and the quality of the data input. This may present limitations or risks, especially since weather is a key variable for analysis that is inherently difficult to predict at longer ranges. The accuracy of these technologies is heavily dependent on the quality and accuracy of the data that is being used for analysis.

Recommendations: Computer vision solutions have the potential to positively impact how growers plan and deploy their human resources. Solution providers such as Bitwise already have a solution available for growers to adopt now. There is further potential applications for rubus growers that have yet to be fully explored. Given the current status of this solution we recommend the following

<u>1. Independent trials & cost-benefit analysis</u>
We suspect there would be value for growers in supporting independent trials and cost-benefit analysis of Bitwise solutions in their current state. Trials should target different grower segments with analysis that surfaces the variables that impact the return on investment. This will support to make informed decisions on when and how to implement as part of their growth strategy.

<u>2. Opportunity discovery</u>
Applications for computer vision analysis beyond crop forecasting should be further explored to identify promising business cases. From our engagement through this project, crop presentation may be an opportunity for future application but could also include sucker identification or pest & disease identification.

Virtual reality training & assessment

Primary Problem:
More efficient harvest activities: picking,
More efficient harvest activities: non-picking,
Crop Presentation,
Cane Selection & Sucker Removal

What it is & How it works: The use of "Virtual Reality (VR)" is becoming increasingly popular in the field of horticulture, providing workers with immersive and engaging training experiences. VR technology has the capability to simulate a wide range of horticultural scenarios, including identifying pests and diseases, pruning techniques, and plant propagation. Furthermore, it can be used to enhance decision-making in designing horticultural facilities like greenhouses and nurseries.

There is immense potential for VR to revolutionize fruit picker training. VR simulations offer a safe and controlled environment for new workers to acquire the necessary skills and techniques for fruit picking. Additionally, VR can replicate the variability of different fruit types and growing conditions, allowing workers to gain experience without damaging crops. Furthermore, VR training can reduce the time and costs associated with traditional training methods, by providing training off-site and out of season, as well as lowering the need for skilled trainers. Moreover, VR training can assist in overcoming language barriers when training international workers.

Virtual reality technology can also be adapted as an assessment tool to evaluate workers' performance and proficiency off-site and off-season. Although no known examples exist in agriculture, VR has been employed in manufacturing to simulate different assembly line scenarios and tasks for worker evaluation. The aviation industry utilizes VR simulations to assess pilot skills and proficiency for safe and controlled performance evaluations. In healthcare, VR is being used for medical training and skill assessment, such as in surgery and patient care.

Think Digital, 2020

Solution snapshot

Grower Ranking	
Solution stage	Validated Concept
Solution Horizon	1 - 3 years
Cap-Ex	Medium
Segment	Medium to larger growers
Desirability	2.7
Feasibility	2.5
Viability	2.7
Scalability	3
Recommended Action	Identify current and future opportunities and develop CBA
Technology owners	

*preliminary assessment based on grower perception during solution workshop and review by project team

Estimated Efficiency Gains: In a training application growers can expect to benefit from improved proficiency of inexperienced pickers due to them receiving training off-site and off-season. Several studies suggest that VR has the potential to reduce training time by up to 60%. Researchers also argue that VR education provides a 75% learning retention rate, beating lectures (5%), reading (10%), and audio-visual learning (20%) [1].

1. Educating tomorrow's engineers: Reinforcing engineering concepts through Virtual Reality (VR) teaching aid. O.T. Laseinde, et al., 2015

Virtual reality training & assessment

Estimated Efficiency Gains cont.
Virtual reality technology can also serve as an assessment tool to screen potential fruit pickers by evaluating them against functional movement patterns, hand-eye coordination, and peripheral perception in a variety of scenarios. This can assist growers in identifying the most capable candidates and placing them in suitable roles and crops.

Costs: Creating a VR training and assessment module will require an initial investment of around $100K. The cost per headset is approximately $1K, and there will be an ongoing hosting fee of roughly $2K per year. The total cost of setting up the module is expected to be approximately $5-10K per trainee, which includes other expenses like onsite setup and support. In a training application, it is likely that candidates will need to spend 6-10 hours in the training environment for it to be effective.

Segment relevance: This solution may be particularly relevant for large corporate and established commercial grower segments. However, smaller independent growers could also benefit from the technology by accessing training as a service through a third party or labor-hire companies.

Solution Horizon: Developing a minimum viable solution for a single training or assessment module could be completed within 12-18 months, while additional modules could be added as required to create a fully optimized solution within 3-4 years. The necessary components for this solution are commercially available, and similar solutions already exist in other industries, such as warehousing and manufacturing. For instance, Walmart trialed VR training across ten of its stores in 2018, reporting improved confidence and retention among employees, as well as a 10-15% boost in test scores and a 96% reduction in training time. [2]

Barriers:

1. Current costs associated with VR training of pickers are too great for it to be viable for many individual growers. Cost-sharing across the industry may need to be explored to address this issue..
2. There is a need to determine the ideal characteristics of a picker by developing a series of key performance indicators (KPIs) and prioritizing them to support the identification of a minimum viable solution.
3. The optimal uses of VR training that provide clear advantages over other training methods need to be identified. These use cases should consider situations where group training is not possible to ensure the best return on investment (ROI).
4. Haptic feedback, which is the sense of touch, is essential in rubus fruit picking. However, current VR simulations can provide limited haptic feedback, which may affect the effectiveness of the training. Efforts should be made to improve haptic feedback in VR simulations to make the training more realistic and effective.

Recommendation: Based on the potential of VR training and assessment in the fruit picking industry, we recommend taking the following actions to ensure that the solution is viable and scalable:

<u>1. Identify optimal use cases</u>
Conduct a scoping exercise to identify potential use cases that can provide a strong cost-benefit to growers. This should also consider potential business models for implementation to support cost sharing.
<u>2. Scope & define dimensions and measures</u>
To design and develop VR tools, it is crucial to establish an understanding of the most critical picker dimensions and measures. This would involve a range of assessments of pickers to establish how their characteristics differ and which ones are strong indicators of picking proficiency. This would include more in-depth analysis of movement patterns that pickers need to perform, as well as peripheral perception and hand-eye coordination.
<u>3. Design and trial</u>
Partner with a VR developer such as Think Digital to develop and trial a minimum viable solution. Real-world results from this trial should then be used to prepare a more detailed cost-benefit analysis.

2 How VR is Transforming the Way We Train Associates. Walmart Newsroom J. Incao, 2018

Ergonomic picking equipment

Primary Problem:
More efficient harvest activities: picking.

What it is & How it works: This solution seeks to increase efficiency, reduce physical strain, improve fruit quality, ensure consistency and adaptability to changes in the industry through the design of improved picking equipment.

Designs could include the development of new vessel and harness systems to replace the existing rudimentary waist belt and bucket configuration. Alternatively, designs could be developed to support the carriage of punnets. In either case, the design of equipment should be informed through detailed analysis of picker movements, as well as other variables such as maximum berry compression forces at varying temperatures.

An ideal design would enable a picker to cover more ground and pick more fruit in less time through increased vessel capacity, reduce picker fatigue and strain through better ergonomics, improve the quality of fruit by reducing damage to the fruit, improve picking method consistency, making it easier to train new pickers, and enable greater adaptability to different picking conditions (e.g., primocane vs. floricane).

Estimated Efficiency Gains:
Laboratory and field tests conducted on strawberries, provide evidence that preventing overload on a given pickers body and safeguarding pickers from musculoskeletal injuries will improve the quality of fruit picked *[1]*. This is critical to rubus due to soft, delicate nature of the fruit.

"If picking bags are used for harvesting it is essential to have well maintained equipment that is ergonomically designed."
[2] APAL (2017)

This focus on picker experience has flow-on, improving workforce retention.

Terrateck, 2022; Harvest Ware, 2022

Solution snapshot

Grower Ranking	
Solution stage	Validated Concept
Solution Horizon	1 - 2 years
Cap-Ex	Medium
Segment	
Desirability	2.4
Feasibility	2.2
Viability	2.2
Scalability	3.2
Recommended Action	
Technology owners	Terrateck, Harvest Wear, Wells and Wade, Various Industrial design & engineering firms

*preliminary assessment based on grower perception during solution workshop and review by project team

Improved ergonomics points to improvement in working conditions and process by reducing the amount of movements performed by a picker, this study shows an increase of up to 60% in productivity in citrus harvesting *[3]*. While potential efficiency gains will depend on the solution developed, this shows promise.

1 Evaluation of Picker Discomfort and Its Impact on Maintaining Strawberry Picking Quality. Komarnicki P, Kuta Ł. 2021 https://doi.org/10.3390/app112411836
2 Labour-saving harvest techniques. U. Kerer. 2017 https://apal.org.au/labour-saving-harvest-techniques-2/
3 An ergonomics approach to citrus harvest mechanization. 2012. S. E. A. Costa & J. A. F. Camarotto https://doi.org/10.3233/WOR-2012-0794-5027

Ergonomic picking bucket system

Costs: Implementing this solution would likely incur an upfront cost of approximately $200-300K for industrial design and prototyping. As part of the design development, the leading industrial firm would need to consider the unit cost in the design to ensure viability for the grower(s). This optimal unit cost would need to consider the scale of production, life of the product, and expected efficiency gains..

Segment relevance: For the larger growers this solution may be viable to implement with a customised design that aligns with their own unique requirements, as they will likely have the required scale across their large picking crews (500+ pickers). For the rest of the industry a collective effort around development would be required but resulting products would be accessible to most growers regardless of scale.

Solution Horizon: A custom picking equipment solution is expected to take approximately 12-18 months for the development of a proof of prototype. Full scale production, requiring the development of manufacturing tooling is expected to add a further 12 months.

Barriers:

1. Understanding and aligning growers around a common set of design requirements including cost and various functional features.
2. Design of a solution that addresses the following interconnected criteria
    a. Optimising vessel capacity
    b. Ensuring fruit quality through reduced impact and loads applied to picked fruit
    c. Picker ergonomics and functional movements ie fruit cannot spill from vessel and must provide net efficiency gain
    d. Median picker measures such as height and compatibility across sufficient cross section of pickers
    e. Compliance with AS/NZS hygiene requirements
    f. Any intellectual property encumbrances
3. Understanding the size of the market opportunity in rubus and adjacent industries that may have an interest in resulting equipment

Recommendations: We believe that ergonomic picking equipment is a relatively low-risk solution that will likely have benefits to growers extending beyond labor efficiency. Given that growers are unlikely to have the capacity for bespoke designs, the following recommendations center on development for manufacture and retailing by a third party. This may entail the licensing of intellectual property developed by the industry to the manufacturer.

<u>1. Business case development</u>
As an initial step, we suggest creating a compelling business case for a manufacturer to undertake the manufacturing and distribution of the proposed solution. This should encompass market sizing, both locally and globally, as well as identifying potentially adjacent industries that may benefit from the solution. Additionally, conducting a preliminary cost-benefit analysis with expert guidance to identify potential efficiency gains would be required to support further investment.

<u>2. Preliminary research & design brief</u>
An in-depth study of picker movements and human dimensions should be undertaken. This insight will guide vital ergonomic constraints and criteria for the design. This information should then be presented to a consortium of growers to co-design a design brief for the design and prototyping of the equipment.

<u>3. Design development, prototyping & testing</u>
An industrial design consultancy, in close collaboration with the industry, should conduct a series of development iterations to explore, design, and test a range of solutions. This process should aim to narrow in on the most promising solution, and tests should be designed to ensure consistency and produce reliable datasets that can support in-depth cost-benefit analysis. Any intellectual property developed through design development should be recorded and owned by the industry.

Computer vision quality assessment

Problem(s):
More efficient harvest activities: non- picking, Row & fruit quality assurance

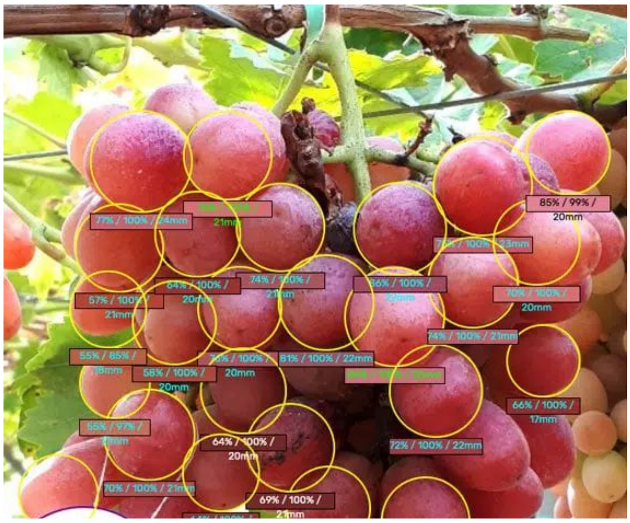
What it is & how it works: Utilizing visual data and machine learning to provide a quantified assessment of fruit quality during harvest, a digital camera is used to capture picked and packed fruit, which is then uploaded to an online platform for assessment and real-time feedback. This may incorporate semi-fixed hardware such as digital cameras and traffic lights for feedback or leverage smartphones' camera, interface and connectivity. The solution aims to reduce the embedded labor in QA rejected fruit and decrease the amount of time associated with manual grading.

This solution can be implemented at multiple points in the picking process and will vary depending on the picking methods adopted by the growers. For instance, the solution may be implemented in the row at the trolley or at the chariot/drop-off point. Generally, the earlier in the process that it is implemented, the greater potential for labor efficiency improvements.

The use of computer vision for QA can also improve the culture amongst picking crews by deferring quality assessment to an algorithm, avoiding potential tensions between supervisors and pickers or between pickers. Improved culture can support picking efficiency as well as staff retention.

Estimated efficiency gains: Computer vision quality assurance may benefit growers on-farm labour usage by reducing the labour costs associated with manual grading, increasing the throughput of packed fruit and reducing waste associated with defective quality fruit detected later in the supply chain. Furthermore, waste data may support better operational decisions that optimise waste.

Providers such as Clarifruit claim an improvement in QC labour of up to 50%. They have also suggested a conservative improvement in wastage occurring at the distribution centre of 10%. These figures however, are expected to vary significantly between growers.



Clarifruit, 2022

Solution snapshot

Grower Ranking	
Solution stage	Validated concept
Solution Horizon	2 - 5 years
Cap-Ex	Medium
Segment	
Desirability	3
Feasibility	2.7
Viability	3
Scalability	3
Recommended Action	
Technology owners	Clarifruit, Bitwise

*preliminary assessment based on grower perception during solution workshop and review by project team

Costs: The main upfront cost of implementing this solution is related to hardware and solution design, which includes the cost of the digital camera, feedback interface, and effective system design. Additional costs may arise from retrofitting these devices to existing tools, such as picker trolleys or the chariot, to ensure consistency and ease of use.

Computer vision quality assessment

Segment relevance: This solution has the potential to be applicable across most commercial grower segments. We would anticipate the scale by which it is implemented to vary between growers depending on their capacity ie provision of equipment to pickers versus supervisors or other QC/support personnel.

Solution horizon: Computer vision quality assessment solutions are commercially available through Clarifruit and in use across several horticultural sectors but are not currently offered for raspberries or blackberries. Development associated with training of the neural networks to support use in raspberry and blackberries may take 6-12 months to develop.

Bitwise also have the capability to provide a solution competitive to Clarifruit but have yet to develop a solution in this space.

Barriers:

1. Shifting on-farm practices from reactive to proactive may present several behaviour change challenges.
2. Internet connectivity that may represent a challenge for more remotely located farms.
3. It is unclear how well these systems can adapt to light variability and climate
4. An understanding of the optimal level of detail for feedback on quality and to whom ie a picker will likely need less detail than the supervisor etc
5. Punnet and other packing vessels/equipment may limit how effectively visual data on fruit can be captured.
6. The size of the industry, may make it challenging to create a strong business case for the development of neural networks and may require global buy-in

Risks:

- Neural networks used for the analysis of footage are only as effective as the data that they have been trained from. This may present some nuanced challenges around new genetics.
- Implementation of a computer vision system adds a level of complexity to the harvest process. It creates a dependency on stable internet connectivity to ensure no disruption to harvest
- Long term data could collect defect trends overtime, exposing systematic flaws

Recommendation: Computer vision quality assessment has the potential for positive impact beyond labour efficiency and has potential to be an obtainable solution for most growers. We recommend the following actions to be considered in advancing the solution.

<u>1. Rubus MVP & business case development</u>
Through consultation with a provider such as Clarifruit a greater understanding of the barriers to addressing rubus growers should be developed. Considering these barriers a minimum viable product should be defined along with a business case for its development. The business case may want to consider industry support on development costs and include a cost-benefit analysis for growers.

<u>2. Development & testing</u>
Provided development of neural networks required for the solution can demonstrate a positive cost-benefit, the solution should progress to development and testing. We would recommend that development involve engagement of a minimum of two growers for testing and be supported by an unbiased third party that support on farm testing, development and verify results.

Exoskeletons

Problem(s):
More efficient harvest activities: picking
More efficient harvest activities: non- picking

What it is & how it works: Exoskeletons are wearable devices that augment the movement and strength of the user's limbs. They are typically composed of a frame that attaches to the user's body, providing mechanical support, and may include motors or actuators to assist with movement in more advanced designs.

Exoskeletons can be useful for raspberry and blackberry growers in various roles such as picking or crop presentation. They should be primarily used in applications where it is not feasible or practical to change the environment to better suit normal human movement patterns or ranges. For instance, it may not be possible or practical to present fruit within a limited vertical range.

Exoskeletons can improve on-farm labor by reducing fatigue and discomfort associated with repetitive tasks. They can also potentially increase productivity by reducing physical strain and supporting workers to move more efficiently. Exoskeletons may also indirectly benefit growers by reducing the risk of injury and improving staff retention.

Estimated efficiency gains: The potential efficiency gains of exoskeletons for on-farm labor use are difficult to infer from other industries as this solution is specific to unique movement patterns. For picking tasks, exoskeletons may support shorter stature pickers to work for extended periods with their arms above head height, which could result in improved efficiency gains depending on the percentage of workers falling into a suboptimal height range and the amount of fruit occurring above head height. While the application of exoskeletons in other on-farm roles such as cane selection is likely to have benefits, these may not make a significant impact on labor efficiency.

Exxovantage, 2022

Solution snapshot

Grower Ranking	
Solution stage	Validated concept
Solution Horizon	2 - 5 years
Cap-Ex	Medium
Segment	
Desirability	2.7
Feasibility	2.6
Viability	2.5
Scalability	2.4
Recommended Action	
Technology owners	Exxovantage, Skelex, Laevo, Levitate technologies

*preliminary assessment based on grower perception during solution workshop and review by project team

Costs: The initial costs associated with implementing an exoskeleton solution include the cost of a movement study to determine the correct product or inform the design of a custom solution. This study typically costs between $40k - $60k. The cost for passive exoskeletons, such as the Hapo by Exxovantage, is currently around $5k per unit. However, this cost is expected to decrease over time as exoskeletons become more widely adopted and economies of scale are achieved.

Exoskeletons

Segment relevance: Larger growers are expected to benefit more from this solution as they will have greater capacity to invest in it. Larger growers are also in a better position to ensure that the exoskeletons are efficiently utilized and not left unused for long periods.

Solution horizon: While there may be some potential applications for commercially available exoskeletons among rubus growers currently, the unit costs would need to decrease significantly for them to have a substantial impact on on-farm labor optimization. We anticipate that a sufficient drop in unit costs could be achieved within 2-5 years if the industry continues to grow on its current trajectory.

Barriers:

1. It is unclear whether exoskeletons can significantly enhance worker movement patterns, leading to notable improvements in ergonomics and efficiency
2. The current unit costs of exoskeletons are unlikely to be viable for a solution that can demonstrate a positive cost-benefit analysis with a focus on labor efficiency
3. Equipment design must ensure the units can be
    a. Easily cleaned given the outdoor environment subject to mud and dust
    b. Meet hygiene standards and pose no risk of foreign objects entering fruit punnets
    c. Maintained and repaired
    d. Designed to provide no safety risk to the user from components breaking or getting snagged on plant limbs or trellises.

Risks:

- Workers may develop a dependency on equipment that then needs to be maintained
- Supporting certain movement patterns inhibits others
- Sense of equity between those workers who receive a exoskeleton and those that don't. Especially with pickers who are paid on a piece-rate

Recommendations: Exoskeletons can enhance the ergonomics of workers in situations where modifying the work environment is not practical. However, due to their high unit costs, exoskeletons may not be viable for most growers in the short term, particularly for use in picking crews, where they have the greatest potential for improving labor efficiency. Despite this, we suggest that the following measures be taken into account to investigate the feasibility and viability of this solution further.

<u>1. Conduct an in-depth movement analysis</u>
To gather data on the movements of pickers or other workers, a series of sensors can be placed on them. This data can then be analyzed to help growers make changes in the work environment, process, or equipment to better support ergonomics. If simple changes are not feasible, this data can aid in identifying potential exoskeletons that can provide benefits.

<u>2. In-field trials</u>
Aside from improving labor efficiency, exoskeletons offer numerous benefits. Therefore, there may be an interest in utilizing exoskeletons in various ways. If there is a grower willing to participate, we suggest that the industry supports in-field trials of the equipment, encompassing a broader range of assessment.

Augmented reality enhanced picking

Problem(s): More efficient harvest activities: picking

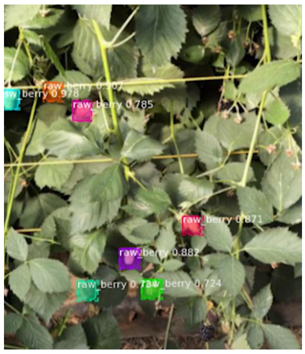
What it is & How it works: The introduction of automation and cyber-physical systems to low-tech industries and roles through Industry 4.0 is advancing rapidly. Augmented reality is a technology that integrates digital information with the user's environment in real time and can be used in a variety of applications. For rubus growers, this technology presents an opportunity to improve the efficiency and proficiency of their picking crews in several ways.

In-field training: Augmented reality could be used for in-field training, providing new or slower workers with prompts through a set of augmented reality glasses. This would help them identify ripe fruit, guide hand movements, improve peripheral perception, and maintain pace.

Gamification of picking crews: Gamification is a psychological technique that can be used to motivate employees in a "game-like" digital environment where pickers are rewarded for meeting performance targets. Each picker would wear AR glasses and be supported through a range of prompts and feedback, including pace, fruit ripeness, the amount they have picked, their rank compared to others, and how cleanly they have picked their section. This has the potential to create new interest in activities that may otherwise be considered repetitive and monotonous, leading to improved job satisfaction and retention rates.

Estimated Efficiency Gains: Gamification of picking in a warehouse environment has resulted in up to 9% increased productivity, along with improved motivation and job satisfaction (Van Den Berg, 2017). In the case of an AR-based application with additional prompts and feedback, this may present an opportunity for further improvements.

In terms of a training application, there is potential for AR to result in similar or potentially better improvement in picking proficiency compared to VR training. However, there is currently insufficient data to draw conclusions on the potential impact of AR in an agricultural context.

NIAB 2022

Solution snapshot

Grower Ranking	N/A
Solution stage	Concept
Solution Horizon	4 - 7 years
Cap-Ex	High
Segment	Larger growers
Desirability	2.7
Feasibility	1.4
Viability	2.7
Scalability	3
Recommended Action	Plan & prepare
Technology owners	Bitwise, Teamviewer, Lucas, Logistiview, Google, Microsoft, Lenovo

*preliminary assessment based on grower perception during solution workshop and review by project team

Costs: While AR technology holds significant potential for improving on-farm labour efficiency, it is currently considered unviable for the short to medium term due to high implementation costs. AR glasses can cost between $1000 and $5000 per set, and custom software to suit rubus growers' needs would need to be developed for both in-field training and picking gamification. This software development is likely to cost over $100K, although industry investment may be attracted. In addition, ongoing costs for a system subscription are expected to be over $10k per year.

Augmented reality enhanced picking

Segment relevance: Large Corporate & Established Commercial growers segments are more likely to have the capacity for the capital outlay on these types of solutions as they become feasible.

Solution Horizon: The implementation of AR technology for rubus fruit picking is still in its early stages and requires further development before it can become a viable solution for growers. While the technological components of this solution are commercially available, there is currently a lack of field applications in fruit picking. However, there is evidence of growth in AR application within warehouse environments. For instance, sportswear company Peter Millar has successfully implemented the technology in their warehouses to guide their pickers to the products they need through visual and audible cues, enabling them to find items or locations faster. Despite this, the solution is not expected to become viable for the short to medium term, with a horizon of 4-7 years, due to the high costs associated with implementation.

Barriers:

1. To be effective for in-field applications in real-time, AR technology must analyze visual inputs and provide immediate feedback to the picker. However, neural networks have not yet achieved the required speed, and internet connection speed can be a challenge, particularly in remote locations.
2. Current generation AR glasses are most effective for indoor applications, as direct sunlight and bright conditions can make the feedback difficult to read.
3. The initial capital outlay required for AR glasses alone may be too high for many growers to be viable, especially for smaller operations.

Risks: To ensure that "gamification solutions" produce the desired "behavioural outcomes", it is important to design and execute them properly. Poor game design can result in participants becoming too reliant on rewards, which may cause the benefits of gamification to diminish over time. Additionally, cultural risks may arise when using gamification, particularly with leaderboards. These can create problems related to pride and public humiliation, which can lower a participant's self-worth if they continually place last. Moreover, gamification may be viewed as manipulative or exploitative.

Recommendations: Augmented reality is a solution that holds high potential for use in horticulture. At present the barriers that limit its feasibility and viability are likely too high to warrant focused investment. However, we recommend the following actions be considered.

<u>1. Prioritise VR and computer vision technologies</u>
Advancing VR and computer vision technologies will likely resolve many feasibility challenges in AR solutions. The development of VR training modules can provide insight on how people respond in cyber-physical environments as well as how to best prompt people coming from different cultural backgrounds. The development of computer vision solutions such as Bitwise will provide neural networks backbone for AR solutions to enable ripe fruit identification.

<u>2. Support fundamental research</u>
There is an opportunity to support advancing AR solutions through engagement with university researchers. Several universities including ANU are making focused efforts to advance AR solutions across a wide range of industries and including horticulture. The berries industry may leverage this for focused research into rubus harvest.

Packing equipment (previously Scale Array)

Primary Problem:
More efficient harvest activities: non-picking

What it is & How it works: This solution is designed for growers who use the pick-to-bucket picking process, which commonly results in pickers spending more than 20% of their time packing fruit into punnets. The proposed solution aims to improve the packing process by enhancing the rudimentary equipment and configuration currently in use.

The improved packing equipment should address the process holistically and may include configurations of components that allow pickers to weigh and quality control multiple punnets at once. Scales may also incorporate a traffic light system to allow for faster determination of whether a punnet meets the specified criteria from various angles. Additionally, more sophisticated fruit pouring trays that evenly distribute fruit across multiple punnets, thereby reducing fruit handling, could also be developed.

The implementation of improved in-field packing equipment could lead to several benefits for rubus growers, especially in enhancing labor efficiency. Firstly, it could directly increase productivity by reducing the time required to complete the task. Secondly, it has the potential to improve fruit quality by minimizing damage or bruising and reducing handling and impacts, which can lead to lower post-packing wastage.

Estimated Efficiency Gains: The proposed solution is both highly specific to rubus harvest and to the best of our knowledge does not have a precedent in adjacent industries that can support inference on the potential efficiency gains.

Given the rudimentary current setup and amount of time being spent in packing, in our professional opinion efficiency gains between 10 and 20% should be achievable. This would represent an overall efficiency gain for pickers of 2-4%. This estimate does not factor in any further gains achieved through reduced wastage.

Existing trolley, scale and punnet configuration 2022

Solution snapshot

Grower Ranking	N/A
Solution stage	Concept
Solution Horizon	2 - 5 years
Cap-Ex	Medium
Segment	
Desirability	2.3
Feasibility	2.2
Viability	1.8
Scalability	3.1
Recommended Action	
Technology owners	Clarifruit, Bitwise

*preliminary assessment based on grower perception during solution workshop and review by project team

Costs: The costs of implementing this solution should be flexible enough to accommodate a minimum viable product. For example, the number of scale platters for weighing multiple punnets can be adjusted to achieve an optimal cost-benefit ratio. In addition, the design and manufacturing method of other equipment can be customized to ensure optimal upfront and unit costs.
If there is a compelling business case, a third party may take on the manufacturing and distribution of any components, which could eliminate the need for upfront investment.

Packing equipment (previously Scale Array)

Segment relevance: The proposed solution of improved packing equipment is specifically designed for growers who use the pick-to-bucket picking process. Among these growers, larger corporate and established commercial growers are more likely to have the resources to support the initial costs of implementing the solution. However, the solution can also be made available to smaller growers if it can be offered as an off-the-shelf set of products, without the need for custom tooling or fabrication.

Solution horizon: It is expected that a minimum viable solution can be achieved within 12 months. However, more advanced solutions that involve customized scale systems and tooling may take between 18 and 24 months to develop.

Barriers:

1. Greater understanding of what the minimum viable solution requires and its cost-benefit.
2. Ensuring design is adopted by pickers may present a behaviour change challenge.
3. The design must ensure the solution
    a. Meets hygiene and health standards.
    b. Can be easily transported and stored.
    c. Withstands knocks and drops associated with handling out in the field.

Risks:

- Increased setup and maintenance skills where time negates benefit.
- New equipment creates a need for further training of pickers.
- Poor training results in lack of adoption or misuse by pickers.

Recommendations: Improving packing equipment could represent an easily addressable opportunity to make improvements in on-farm labour use. We recommend consideration of the following recommendations in advancing this solution

1. Create low fidelity prototypes & test

To explore potential designs and configurations, a series of low-fidelity prototypes would be created. These mock-ups are simplified versions of the designs that allow for basic testing of hypotheses through experimentation with different configurations and designs, involving pickers' interactions with the prototypes. Low-fidelity prototypes may consist of cardboard models or 3D printed components that are cheap and quick to build. This iterative process will result in multiple designs and iterations, ultimately leading to 2-3 standout prototypes for further development.

2. Design development

During design development the 2-3 standout concepts are further developed to address a range of criteria. This includes manufacturability, user experience and unit cost limitations. Resulting concepts should be able to demonstrate a positive cost benefit, support buy-in from pickers and ensure they can be produced at an appropriate scale.

Solution ideation

The table lists other solution concepts that have been raised with growers through interviews. These solutions will be further developed as complete one-page solutions, shared and prioritised through continued grower engagement. This process will include passing the complete solutions through the assessment rubric to identify adoption challenges and areas to investigate in future work.

Solution Description	Relevant Problem(s)
10 **Harvest team re-configuration**: The design of new labour configurations amongst harvest teams to make better use of inexperienced labour whilst supporting	More efficient harvest activities: picking, More efficient harvest activities: non-picking
11 **In-field cooling system**: Design of a scalable in-field cooling system that can be implemented across growers of varying capacities and designed to support maintenance of cool-chain. By bringing cold storage to the field it may afford picking crews greater flexibility and enable pickers to pick more before returning to drop-off point	More efficient harvest activities: picking, More efficient harvest activities: non-picking
12 **Improved trellising:** The development of trellising systems that better support the presentation of fruit within optimal human movement ranges. This would support pickers to pick at a higher efficiency. Improved trellising may also better support crop presentation crews to work at a higher proficiency or be deployed less often.	More efficient harvest activities: picking, Crop presentation
13 **Digital language translation:** The majority of growers utilise workers coming from pacific islands or other parts of Asia who will often speak little english. This presents a challenge for training and supporting these workers. A simple solution to this challenge would be to find an effective digital language translation solution, whereby a supervisor or trainer can translate and interpret in real time through a digital service.	More efficient harvest activities: picking, More efficient harvest activities: non-picking, Row & fruit quality assurance

05

Next steps

Next steps

This project has identified several technology-based solutions that can reduce on-farm labour or improve labour productivity in the Australian rubus industry. These solutions are can be applied across a broad spectrum of rubus growers and in other berry crops. What is presented in this report serves as a roadmap for the further development of these solutions through to active implementation with growers.

In advancing solutions identified for the Australian rubus growers, we have compiled a list of priority general actions that will be highly valuable to the advancement of all solutions. These are;

1.0 Baseline data

Several solutions presented in this report require additional baseline data on picker movement patterns and the resistance of fruit to impact forces. Baseline data requirements include the following two studies.

1.1 Picker movement study

Building upon the Time and Motion study results presented in this work, additional data would collect a digital capture and analysis of picker movements performing key tasks. In this study, a group of pickers of varying proficiency and anthropometry will have sensors placed on them that record their movements as they pick fruit and perform predefined job tasks. This data will be used to formulate a digital 3 dimensional baseline model for quantifiable assessment. Insight from the analysis will be utilised in the following solutions;

Autonomous collaborative robots

Design modifications to the hardware and software platform to support pickers.

Advanced recruitment assessment

Defining an agreed set of qualities and characteristics of proficient pickers.

Virtual reality training and assessment

Digitising an agreed set of qualities and characteristics of proficient pickers for training purposes.

Ergonomic picking equipment

Identification and optimisation of new equipment based on picker movements.

Exoskeletons

Selection of commercial exoskeleton options based on quantitative analysis of picker movement patterns.

A study of picker movement is estimated to cost $60-80K.

1.2 Fruit impact study

One of the most challenging factors in rubus harvest is the fragility of the fruit and the impact handling and weather conditions have on fruit quality. Poor quality fruit is characterised by loss of shape or form, bruising and diminished shelf life. Fruit quality aspects were out-of-scope for the current investigation and our desktop research was unable to identify any past studies that investigated this area.

Whilst it is understood that fruit impact thresholds will vary between genetics, a study that provides guidance on the facts that affect fruit quality and their relative impacts, would provide essential information for use with the analysis of the following solutions;

- Autonomous collaborative robots: understanding whether robots can move fruit between locations on variable terrain without causing damage. Identifications of equipment engineering modifications to stay below fruit damage thresholds.
- Ergonomic picking equipment: supporting the design of optimised vessels for pickers to place fruit into that balances capacity and compression forces of stacked fruit.
- Packing equipment: supporting the design of equipment that evenly distributes fruit across punnets such as pouring trays.

In designing this work, we recommend focusing on the most widely used industry plant genetics (i.e. from Driscoll's and Perfection). If this data already exists would negate the requirement to repeat the work. Discussions with genetic-owners should be conducted prior to the commencement of this study.

Next steps

2.0 Priority solutions
Of the 8 solutions that were identified and assessed as part of our grower workshop, 5 emerged as priority solutions for further industry investment.

The section below details the next steps required to advance the assessment of the 5 priority solutions. Additional details can be found on their respective solution pages in this document.

2.1 Data empowered resource planning & deployment
The primary benefit of this solution is that it provides assistance to growers in enhancing the optimization of their workforce. It is achieved by the utilization of crop data and analytics derived from video capture and analysis using neural networks. The solution was ranked the highest priority among growers, mainly due to its current commercial availability and positive stories of experimental use several growers.
Project approach:
- Levy-funded on-farm trials with a small cohort of growers who represent key grower segments in the industry.

Project objectives::
- Identify grower behavioural changes required for successful adoption.
- Design of action plan to support behaviour change.
- Refine and measure key success variables for grower adoption.
- Impact-focussed cost-benefit analysis to support grower business decision making.

Potential collaborators:
- Bitwise.

2.2 Advanced recruitment assessment
The primary benefit of this solution is to provide a tool that can reliably identify potential new employees with a high picking proficiency. This is achieved through identifying and measuring the performance of candidates in areas of personality and physical performance that are associated with high-performing pickers. The attractiveness of this solution to growers was based on a perceived low level financial risk and the ease of adoption (minimal interruption to current process).
Project approach:
- Technical solution development through testing of existing assessment tools with pickers. Support provided by subject matter experts.
- Exploration of implementation barriers and value proposition to labour hire companies through stakeholder engagement.

Project objectives:
- Identification assessment of existing recruitment tools.
- Selection or modification of existing tools for defined purpose.
- Small-scale trial to compare recruitment outcomes with existing methods.
- Cost-benefit analysis as input to grower business case
- Adoption pathway and progress assessment.

Potential collaborators:
- Labour hire company's, Universities

2.3 Computer vision quality assessment
This solution utilises computer vision for more rapid and reliable quality assessment of picked fruit. It also has the potential to identify quality issues earlier in the process, saving labour by eliminating repetitive quality checks which currently occur in the process. .
Project approach:
- Development of a business case to potential solution providers
- Feasibility study

Project objectives:
- Further detail to Identify technology barriers and limitations for use.
- cost-benefit analysis

Potential collaborators:
- Bitwise.
- Clarifruit.

2.4 Autonomous collaborative robots
Autonomous collaborative robots may facilitate pickers to concentrate on their primary task of picking by eliminating the ancillary activity of transporting the picked produce from the rows to the designated drop-off point. Although the adoption of this solution has significant barriers, it has the potential to significantly enhance picking proficiency.

Next steps

Project approach:

- Digital modeling of ACR and crop configurations
- Infield trials

Project objectives:

- Identification of field and robot configurations that can support the viability of the solution
- Cost-benefit analysis.
- Implementation pathway for varying growers segments.

Potential collaborators:

- Burro.
- Advanced Intelligent Systems.

2.5 Virtual reality training & assessment

Virtual reality tools may support the off-site and off-season training of workers, this would allow growers to identify workers with high potential for developing proficiency or supporting them to acquire appropriate skills so the hit the ground running when they arrive on farm.

Project approach:

- Collaborating with a VR solution developer to identify optimal use cases and create and test a MVP

Project objectives:

- Identifying opportunities
- Scoping and defining dimensions and measures that can be assessed or trained
- Designing and testing an MVP

Potential collaborators:

- Think Digital.

Closing remarks

This project has identified several high potential solutions to improve labour utilisation in the Australian rubus industry. We have identified two projects that could be commenced immediately to provide essential data that supports all project-specific actions plans. We think of these projects as “low hanging fruit”!

In addition to the research and development efforts described above, this report outlines specific plans for each of the grower-endorsed solutions. Many of these solutions are interdependent and synergistic, highlighting the need for a holistic approach to their development and implementation, with clear prioritization.

Furthermore, to maintain the momentum of the current work, continued investment is crucial to drive progress towards solution adoption.

TGD has demonstrated its award-winning end-to-end problem solving approach that has been responsible for the creation of tangible impact (financial, environmental, social, governance) across livestock, horticulture and food sectors in Australia. This process not only identified several promising solutions, but also provides a framework for the efficient and effective allocation of financial resources to conduct R&D on “wicked problems”. In addition to financially supporting the action plans in this report for the solutions identified, Horticulture Innovation Australia Ltd are strongly encouraged to identify opportunities to apply this same methodology and framework to more of the 37 levy-paying industries it represents.

06

Appendix

06 Appendix
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Appendix A

Research Insights

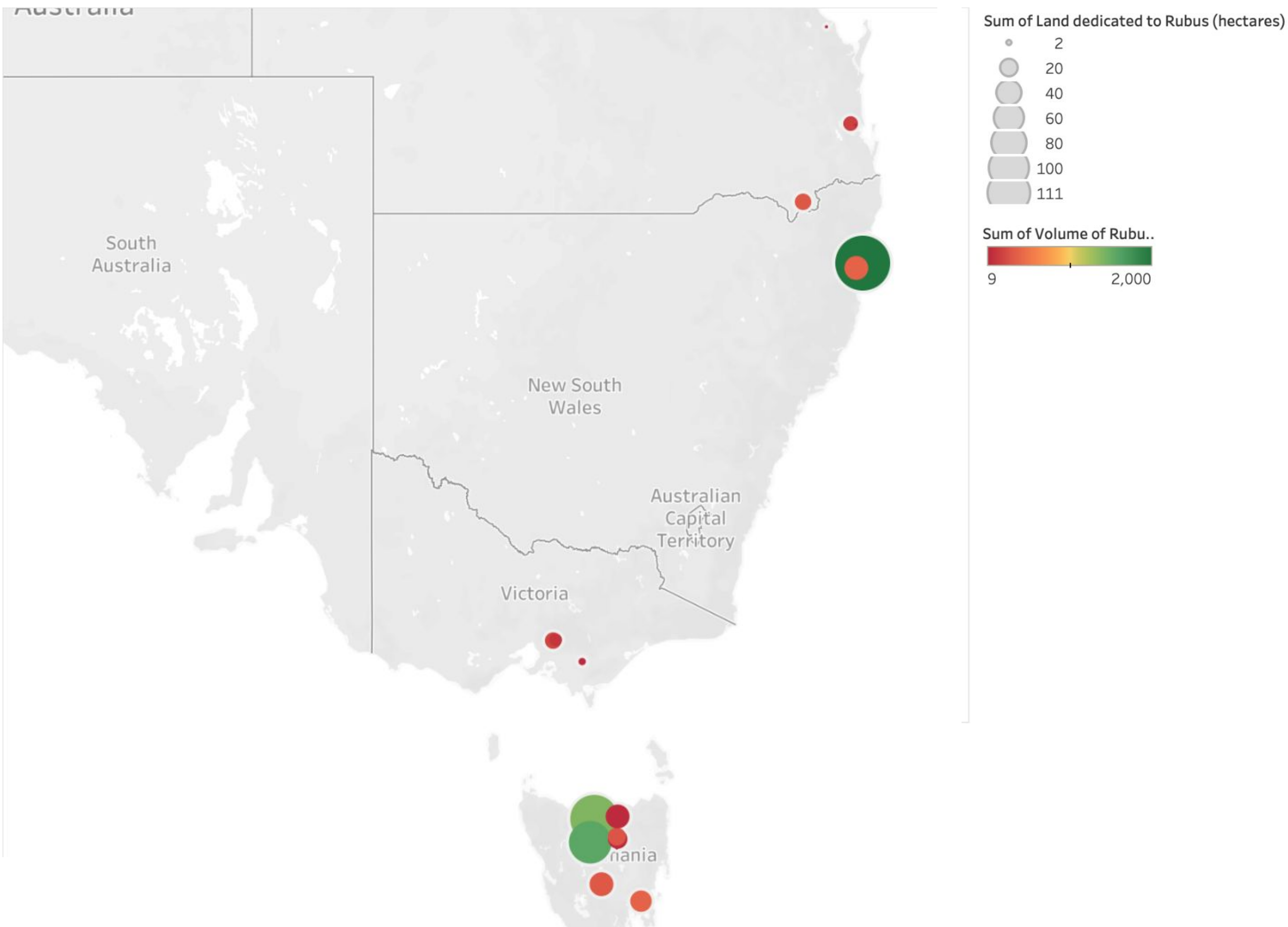
Grower Data

Through our grower engagements and survey we were able to profile approximately 22 unique growers across Tasmania, Victoria, New South Wales and Queensland. This data, that was collected through interviews, site visits, informal conversations and a survey extended to include dimensions and measures such as propensity to adopt technology and motivation to address labour optimisation. At a minimum we sought to obtain the postcodes of the farm, the volume in tonnes produced annually and land dedicated to rubus production in hectares.

At time of writing, our dataset of 22 growers has a median volume output of 98 tonnes per year and with 17 hectare on average dedicated to the production of rubus.

It is important to note that amongst this data set are three significant outliers representative of Australia's largest growers and producers. These outliers somewhat skew both our median and average values

Throughout the course of this project we will seek to build upon this grower dataset to establish a current and accurate depiction of the footprint of growers across the country. This footprint will support the industry toward future investments in labour optimisation or other grower related challenges to ensure they deliver optimal impact.



Research Insights

Introduction

Insights were generated through direct grower engagement and desktop research. They have been categorised through 5 project focus areas.

1. Workforce composition & management
2. Crop profiling
3. Harvest efficiencies
4. Non-harvest labour
5. Crop production & waste

There is some overlap in insights as the five main areas are interconnected. This shows how complex the problem area is. Solutions should be evaluated from a system-level perspective.

1.0 Workforce composition & management

1.1 | Disincentives associated with a changing award rate

Employing inexperienced personnel has become more challenging for growers due to the new minimum award. Growers are willing to invest in training, but they won't do so if there's a chance that the trainees will quit after only a short while, preventing growers from realising any return on their investments. Due to this, some growers are reluctant to provide job prospects to young or inexperienced local labour.

"The new award rate [has] made it impossible to hire locals - 90% of them leave after a couple of days."

1.2 | Sustainable worker retention

Obtaining and retaining the right people for picking has a huge impact on picking productivity. Therefore staff retention plays a significant role in the sustainability of a growers labour model.

1.3 | Extending the picking season and diversifying to offer long-term employment

Growers who aim to improve staff retention, achieve this in part through extending their picking season or diversifying to other crops to provide year-round or a longer/stable source of income to their employees.

1.4 | Self-regulating workforce performance

Growers are trending towards closer monitoring of worker performance to counter the profit losses that low productivity workers on minimum wage can create. Through performance indicators, growers can identify, improve or even remove workers who consistently underperform.

2.0 Crop profiling

2.1 | Forecasting effects on growers

The ability to accurately forecast the production curve of a given crop over the short to medium term directly impacts the ability of growers to forecast their labour use. This affects their ability to maximise profits through optimal crop efficacy, ensuring volumes align with demand and waste is kept to a minimum.

2.2 | Scale & latitude

The importance of crop forecasting varies between growers. Larger operations that have the scale to stagger crops to create an overlap in production curves achieve greater consistency that in turn simplifies the management of their picker crews. This is particularly the case for some of the larger growers in northern NSW with longer harvest windows. Comparatively smaller growers located throughout TAS with shorter harvest windows have less scope to move their picking staff.

2.3 | Forecasting approaches

Growers' approaches to forecasting differ significantly, with some relying on years of growing experience, to others using advanced Agtech solutions to assess and predict crop production. Whilst relying on experience may work for smaller growers this approach does not scale well for larger growers. Larger scale operations that forecast with agronomists that independently assess and collect crop data can often be prone to errors. This is due to the inconsistency of human observation, assessment and opinion from the team in the field

Research Insights

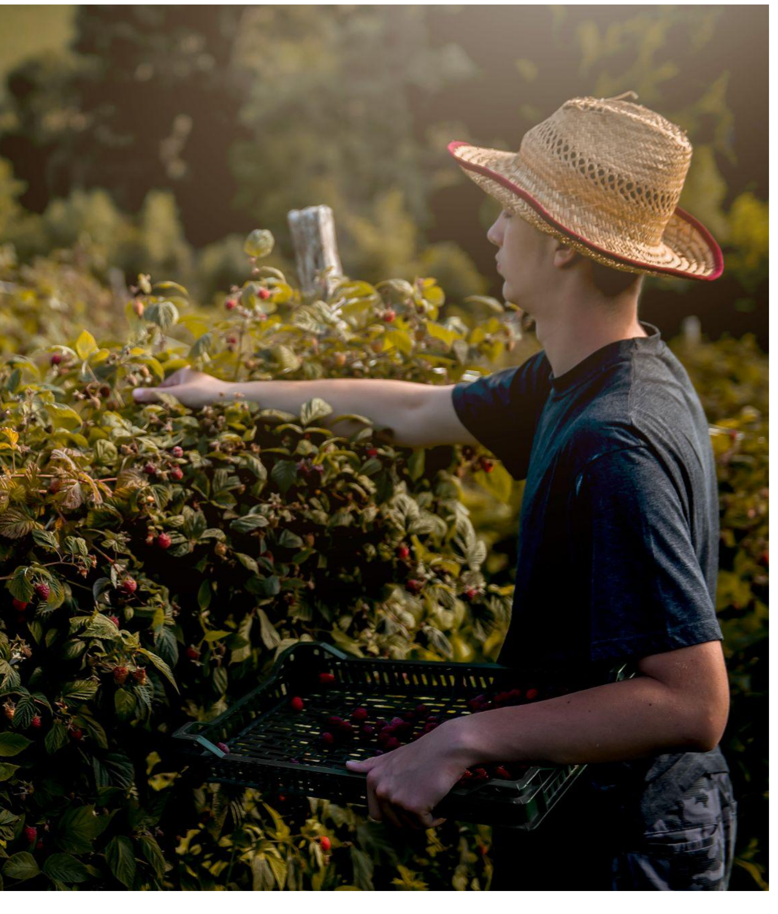
2.4 | Advantages and disadvantages for forecasting over or under yields.

Being aware of and understanding the movements and demands of the rubus market gives growers the ability to know whether they would benefit more from over or underestimating their yield in forecasting, however, growers typically only have historical data and experience to inform their assumptions.

3.0 Harvest efficiencies

3.1 | Accessibility to cooling facilities

For many smaller-scale growers on-site cooling facilities are either unviable or require capital investment beyond their means. As a result, these growers rely on other solutions such as refrigerated trucks or moving fruit quickly from site to a local distribution centre to help maintain product shelf life. This adds an extra dimension to the complexity of managing harvests.



3.2 | Managing Incentives

To get the most out of their workers, growers need to respond to the dynamics of their crops and create the right incentives. Piece rate contracts for workers are effective for both the grower and pickers under normal conditions. Many pickers on piece rate will earn well above the award rate. However, under certain circumstances piece rate is ineffective.

This may include situations where pickers need to work slower and with a higher QA control, or at the tail of a production curve where the productivity of the crop will not afford the picker the award rate.

3.3 | No one way to harvest

Approaches to harvest are varied between growers. No one approach is viewed as being irrefutably more effective than another. Supply chain pressures ensure all growers maintain fairly high QA standards. The approach adopted by growers reflects their own unique growing context and what has worked in the past. The new minimum award rate though may test this for some growers.

3.4 | Picking efficiency achieved before harvest

A significant variable in the efficiency of picking crews is how well a crop is presented. Crops that have not been cared for as effectively will result in poorer distribution of fruit and lower yields due to fruit-bearing laterals not receiving adequate sunlight. This places significant importance on crews responsible for crop presentation.

3.5 | Punnet design as a constraint

The majority of growers that are supplying fresh-to-market fruit, will be responsible for the placement of the fruit in its final packaging as provided by their supply partners. This is a dimensional constraint that significantly impacts harvest processes and tools such as trolleys and packing tray design. Changes in the design of punnets and or tools must ensure interoperability.

Research Insights

Focus Area 4.0 Non-harvest labour

4.1 | High utility trellising is a hurdle for small growers
Improved utility of modern steel trellises afford growers improved presentation capabilities. This reportedly allows them to reduce labour associated with tucking plant laterals to improve fruit visibility and accessibility, as well as exposure to sunlight. Although, the trellises are a hefty investment for growers and are more accessible to advanced and industrious growers. A range of trellising options is adopted by growers ranging from the highly engineered to the more traditional approach of wooden poles and string.

4.2 | Inhouse grower innovation and experimentation
Innovative growers are trialling and tweaking growing processes. Growers that are encouraged to experiment feel empowered to improve their practices and take more risks. However, many growers do not have the capability or capacity to effectively test new ways of working or varieties to accurately determine their feasibility or viability.

Focus Area 5.0 Crop production & waste

5.1 | Contrasting opinions on long cane production
Long cane production of both raspberries and blackberries can support consistency in production by staggering crop planting that results in an overlap of production curves. However, sophisticated growers are claiming they are achieving similar results through new careful crop management, new varieties and a standard "double cropping" approach.

5.2 | Increased risks of pests and disease
Innovations in tunnel and greenhouse design are improving crop yield and enabling the development of new varieties and effective yields in areas previously unviable. Tunnels further support crop growth by encouraging beneficial insects which biologically control pests as well as bee pollination. However, these favourable conditions also create an environment more prone to pests and disease placing greater importance on monitoring and responding to pests in a measured and timely fashion.

5.3 | Crop variables affecting picking efficiency
Growers that choose to supply through one of the major marketing supply partner are expected to grow the varieties supplied to them. These varieties have been engineered to align with consumer preferences and support effective yields for the grower. Between varieties differences such as fruit size, firmness and density will impact how efficient a picker will be.

Appendix B

Grower Segments & Archetypes

Introduction to Segments & Archetypes

Rubus Segments and Archetypes

Four semi-quantitative segments and Six qualitative archetypes

Why do we use segments and archetypes?

The main goal of this study is to find best practises, processes, or technological solutions that, if used, could have a beneficial effect on how well Australian rubus growers utilise their labour. The industry is diverse, thus it is important to keep in mind that a solution that works for one grower might not be the best option for another. These differences between growers can be attributed to a variety of factors, including geographic location, climate, crop type, farming practises and systems, cold chain infrastructure, supply chains, and many others. Australian growers can be infinitely different from one another. In order to assess and select technology and practise or process improvements that are specific to the needs of growers, we employ methods like segmentation and construct archetypes based on behavioural observations to help us understand complexity and highlight these differences. This also improves the chances that solutions that are mapped to identified grower needs also have a strong chance of being adopted.

01 | Grower Segments

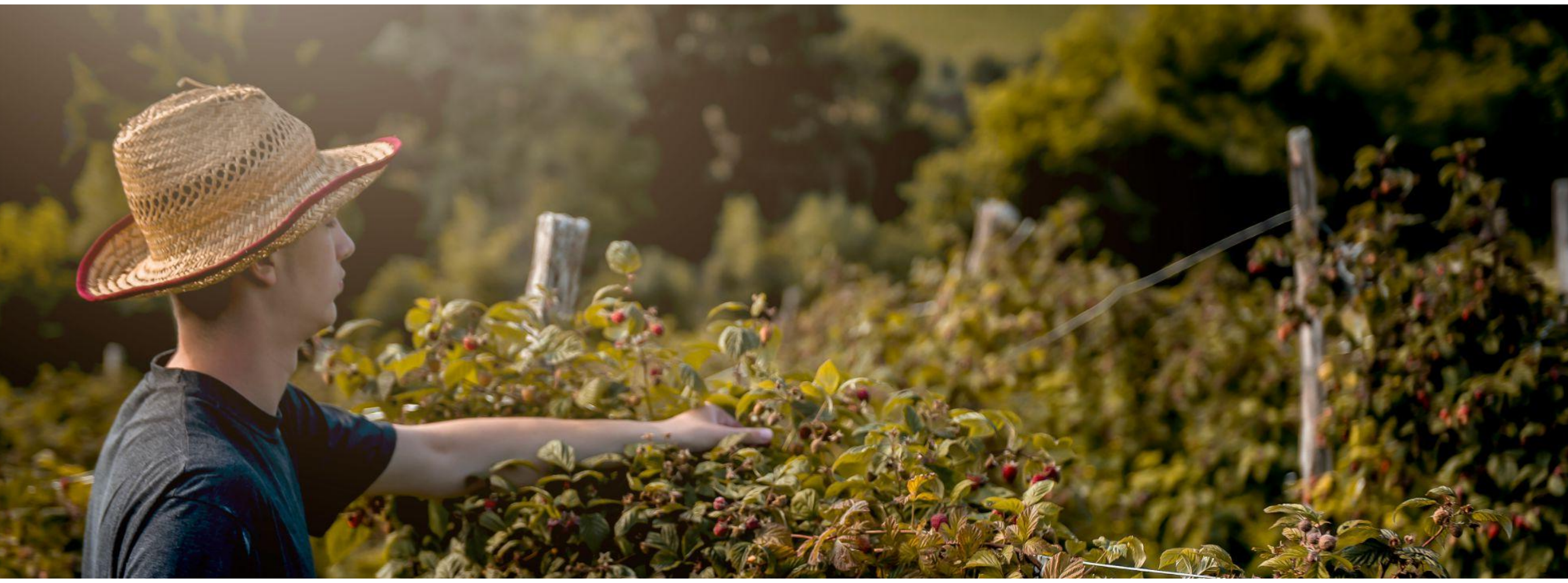
Grower Segments capture tangible characteristics of their grower businesses and can help distinguish one grower from another. For the purpose of this work, 4 grower segments are identified and described by comparing the following; farm scale, business ownership model, the extent of current technology use, and crop diversity.

Segmentation is the first step for grouping grower-types but it doesn't fully explain grower behaviours and motivations or provide insights into decision making.

02 | Archetypes

Archetypes are used to help understand grower motivations, challenges, pain points, and opportunities for improvement. We have identified 6 primary archetypes within the Australian rubus industry.

Growers may identify with one or multiple archetypes. These highlight specific challenges and opportunities that growers with these characteristics, and behaviours may face in adopting and implementing any identified solutions.



Grower Segments

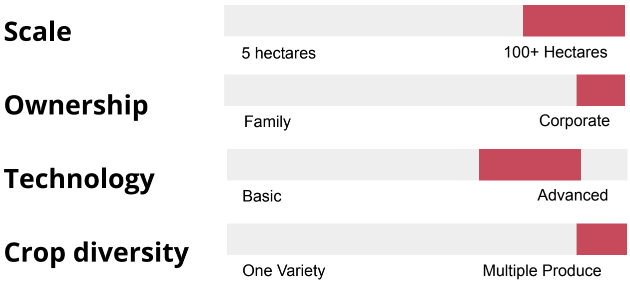
Large Corporate

The Large Corporate is a widely known and trusted brand often with a consumer-facing presence. Collectively they represent the majority of raspberries and blackberries produced throughout Australia. Between them, they directly compete for market share amongst the large retailers with their own unique supply chains and partners.

The diversity of their product portfolio extends far beyond rubus into other berry categories as well as other produce. As such, they have grown their businesses over time to include a multitude of farms across the country and overseas as well as a network of third-party growers that supply to them.

Key Challenges

Whilst the scale of The Large Corporate has enabled their market dominance, it conversely makes them less nimble to responding to changing consumer preferences, and adapting to policy changes that affect the industry. Their scale also makes it challenging to manage the systems and structures associated with a large workforce, especially regarding new minimum award rates.



Exemplars

Costa, Pinata, Perfection

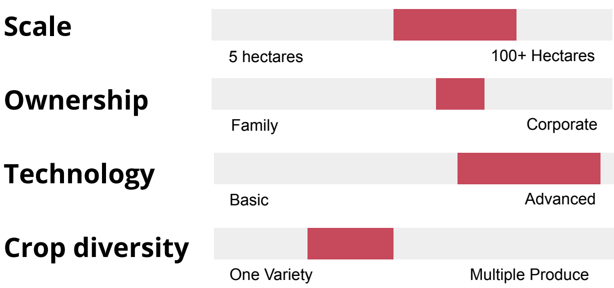
Established commercial

Established commercial producers encompass medium to large-scale operations. Many have been growing rubus for over a decade and have solidified their position in the market. They grow crops across the berry category and supply through major retailers. For some this may be through their supply and genetic partners, and for others that are more vertically integrated, this can be direct.

Their operations centre on a single location though they may have multiple farms close by. These producers have been identified across all major growing areas but have a strong presence throughout Tasmania.

Key Challenges

Established Commercial growers work with narrower harvest windows and have greater pressure to plan their harvest labour profile adequately. Growers located throughout Tasmania in this segment compete with other crop types for the same pool of workers and endeavour to attract experienced workers back in the face of a long off-season.



Exemplars

Burlington Berries, Hillwood Berries, Queensland Berries

Grower Segments

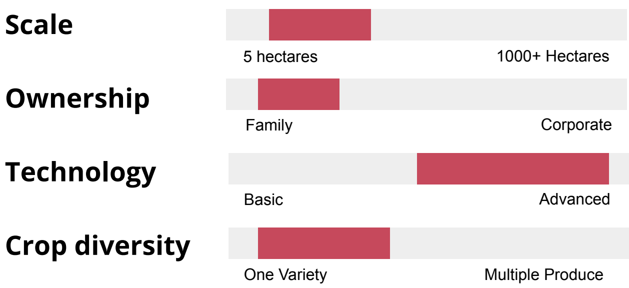
Independents

Independents consist of small to medium size operations producing commercial quantities for supply through to major retailers. They rely on partnerships with either Large Corporate growers or genetic and marketing entities to enable market access. This segment encompasses growers that have formed or joined co-op groups to support best practices through knowledge sharing as well as further enabling the processing and distribution of their produce.

Producers within this segment are focused on one or two crops across the berry category, with some also expanding into other categories to help support greater consistency in revenue throughout the year. Their farm is an extension of their home with their residence either directly adjacent or within close proximity to any operational facilities.

Key Challenges

Being smaller operations the Independent's greatest challenge is in growing to an optimal size that can support the capital outlay required for suitable site infrastructure and equipment. Co-op groups are achieving this collectively, though some infrastructure and equipment, such as cooling facilities are not suitable for sharing.



Exemplars

OzGroup Coop growers, The Big Berry,

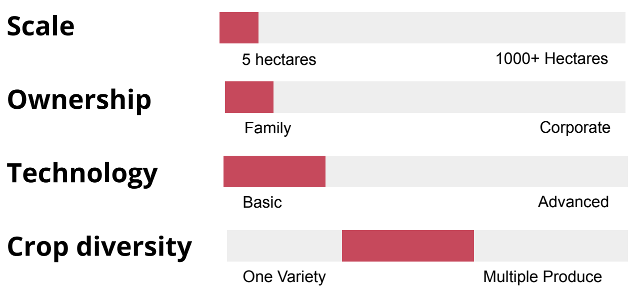
Cottage Farmer

The Cottage Farmer is representative of the small to micro-producers. Unlike the rest of our grower segments, this group's revenue streams focus on a direct-to-consumer model. This may include supply via farm-gate sales, through local farmers' markets or pick-your-own. Growers within this segment are generally lifestyle focused and with other revenue streams outside of rubus to support them. The smaller scale and reduced sophistication of their operations reduce the pressure to closely manage labour efficiencies.

This segment has a dominant presence throughout Victoria but can be found throughout all growing regions. Whilst their presence as part of the footprint of rubus growers is noted, the scope of this project is unlikely to provide a significant impact on the continued viability of these grower's operations

Key Challenges

The Cottage Farmer is faced with less pressure to ensure optimal labour efficiency amongst their pickers and maintenance crews, as they work on higher margins with a more direct to consumer revenue model. For this segment, there's a greater focus on managing multiple revenue streams and a presence in their local community.



Exemplars

Kinglake Raspberries, Warrandyte Berry Farm

Archetype Overview

Below is a high-level summary of the four farmer archetype for rubus growers. Arising from the research activities of this project, in particular the interviews, they indicate the general characteristics and circumstances of real-life growers.

These archetypes were sorted by **3 themes**, human and social, technology, and business and network.

Human & Social

Describing the social, community and human focus for growers. These archetypes are focused on moral, people

The Community Builder

CB

We pride ourselves on making our farm(s) a good place to work and abiding by an ethos of respect, communication and fairness.

The Cooperative Networker

CN

I aim to offer support to other farmers and ask for help or advice from my coop group or close, professional network of farmers.

Technology

Describing the innovative growers that rely on or are drawn towards new technologies and advancements.

The Early Agritech Adopter

AA

Advancement and using new technologies is how I aim to stay ahead of competition and make my life easier.

The Analytical Horticulturist

AH

The numbers don't lie! I considers data analytics the best way to make improvements. It's important to test, measure and review results before implementing.

Business & Network

Describing the types of motivations and drives that are inline with a business structure or or way of doing business.

The Family Enterprise

FE

With experience and ties to the industry, we aim to grow the farm and expand operations but stick true to our family values.

The Evidence Seeker

EB

To invest money and time on something I'll wait for the evidence, until then I'll continue with the practices I know make me a return on my investment.

The Eco-Minded

EM

We keep inline with the consumers values and uphold a responsibility we have as a business to do the best for the planet.

Diffusion of Innovation

Segmentation and the development of archetypes are useful to profile and understand grower motivations in the Australian rubus industry. Another important aspect to consider when advocating for positive change in the industry is to understand how change occurs, where it starts and how it may nucleate and grow into widespread adoption or stagnate.

We use the Diffusion of Innovation (DOI) theory, first proposed by E.M. Rogers (1962) to guide our understanding of the change process. The DOI theory distinguishes between five types of adoptors who display the behaviours shown below. Note that the DOI theory was originally used to describe individual behaviours in purchasing and change decisions, and our context considers business entities. Businesses decisions are driven by a varied collection of individual decision makers, which can be complicated by governance structures and corporate history. For simplicity, we will use the DOI theory in this context and to the extent necessary to plan and provide insights on adoption of the potential solutions presented.

Innovators: Represent ~2.5% of a community and are Individuals that are eager to be the first to test out new ideas. Often they have a low threshold of evidence required to make the change decision.

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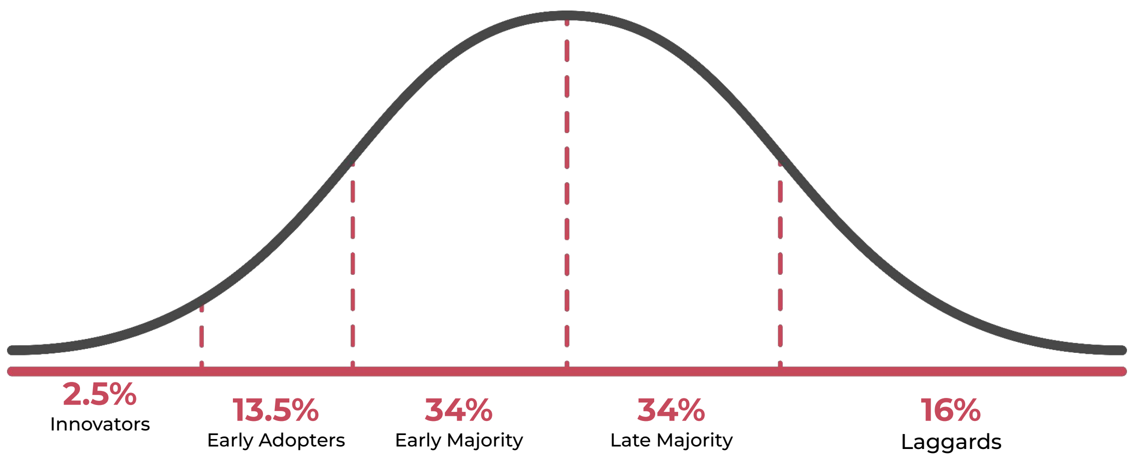
Early Adopters: Represent ~13.5% of a community and are Individuals who are thought leaders. They are aware of the need for change and feel quite at ease implementing novel concepts with reliable commercial and feasibility data.

Early Majority: Represent 34% of a community. Although they hardly ever act as leaders, this group does absorb novel concepts earlier than the norm.

Late Majority: Represent 34% of a community. They are individuals who are resistant to change and won't adopt a new idea until the majority has proven adoption.

Laggards: Represent the final 16% of a community. These individuals are considerably constrained by tradition, and are frequently sceptical and conservative of any form of change.

For our purpose, we define adoption as meaning that an individual or business does something differently than what they had previously (e.g., purchasing a new machine and or changing picking practice). The key to adoption is that the business (or people within it) must perceive the idea, behaviour, or product as new or innovative, and also believe that the benefits of making the change outweigh those of the status quo. Adoption within the rubus and most other industries is unlikely to occur simultaneously amongst all growers. Different strategies can be employed to appeal to the different adopter categories.



Source: Everett Rogers, 1962 - *Diffusion of Innovations*

Archetype Theme Human & Social

The Community Builder

We're honest with people and treat them with respect. We welcome our workers to a community that offers them the incentives that they need to stay.

Characteristics

Staff retention | In-house hiring | High communication | Receptive to feedback

We look for people with talent, drive, and a strong work ethic. In exchange, we aim to make sure that they're looked after, feel valued and treated fairly.

We focus heavily on building and sticking to an ethos that makes its way through the business and being held accountable to that ethos.

We train people to become highly proficient, and look after workers who put in the effort. Fair pay for fair work.

We offer incentives and opportunities to workers who typically work seasonally and get pickers coming back year after year. This helps us avoid the costs and loss in productivity of training new, inexperienced, and at times, unmotivated workers.

Barriers and Challenges

Time constraints | Ability to pivot

There's still lots to learn when it comes to different technology, and new information coming in from overseas. At times it's a lot to keep up with.

It's difficult to manage worker productivity and remain a strong community with the new award rate. We have to make changes to our practices, and consider other options after putting so much effort into expanding our current practices and processes.

To give our workers a stabler source of income, some of the options we're considering are diversifying our crops to include winter ones, changing the varieties and growing methods we use (which adds risk), and partnering with other farms that don't always share our values.

Capability

Opportunity

Motivation

What might this mean for adoption?

This archetype embodies a progressive relationship with staff, recognising the value that a skilled labour force provides and the symbiotic relationship between business and labour, likely to look for best practice opportunities and ways to integrate into standard practice.

For majority of technical solutions they're likely to align with either the early or late majority of adopters depending on their other traits.

Archetype Theme Human & Social

The Cooperative Networker

There's no need to go at it alone, half my mates are farmers and we're not keeping any secrets.

Characteristics

Medium to small scale | Flexible & agile | Supported | Represented

I'm represented as a part of a bigger group of farmers, there's nothing to lose and so much to gain from being a part of a bigger group of independent farmers.

Half the things I know now, I wouldn't have if I weren't visiting other farms, keeping in touch with the other growers, attending trainings and joining in on cooperative learning opportunities.

Not only have I learned lots, I'm exposed to more opportunities that, at my scale I wouldn't have access to otherwise.

Barriers and Challenges

In-house capability | Lack of capital for investment |

Certain things that come my way I'm not able to get involved in because I don't have the scale or the investment capital to capture the opportunity.

Scaling and improving my practices takes time. Some things I can't afford to invest in without the confidence that the return will definitely be worth the investment. Some examples are longcane production, or replacing old tunnels with improved tunnel designs.

Some smaller growers within networks haven't been able to invest in cooling facilities, which drastically reduces the shelf time of their products, especially during the summer. This affects their pathways to market and limits their options.

Capability

Opportunity

Motivation

What might this mean for adoption?

Within this segment, adoption through co-op boards will be vital. If those offering solutions provide reasonable evidence, they could utilise these co-op structures to gain access to a group of eager farmers that are willing to trial their proposed solutions. Leading genetics suppliers have already utilised this dynamic to test different berry varieties against a range of climates, growing conditions, and farming practices.

This means Cooperative Networkers would make very good early adopters for a range of solutions.

Archetype Theme Technology

The Agritech Adopter

It's not that I love gadgets, I see an opportunity to get ahead of the competition and be at the front of a changing practice.

Characteristics

Investment | Advanced | Premium berry

Advancement and using new technologies is how I aim to stay ahead of the competition and make my life easier.

I have become highly proficient at making incremental gains to efficiency and production, and I am looking to find innovative improvements to the way me and my employees work.

While I don't consider all technologies to be viable, given the dynamic and changing nature of my work, I'm on top of the latest trends and advancements, ready to adopt new technologies and trial different approaches.

I have access to capital that I'm willing to invest if the right opportunity comes around.

Barriers and Challenges

Contrasting experiences | Higher risk

I'm not always able to speak to others about their experiences with different technologies. As an early adopter of certain technologies, there's a lot of figuring out I have to do before I really get the most value out of something, and get comfortable scaling it to other parts of my business.

I have to be careful of big changes and consider possible flow-on effects.

I have to prioritise the primary sector of my farm and business that makes money, and not lose sight or be distracted from the everyday problems that occur when running a business.

Capability

Opportunity

Motivation

What might this mean for adoption?

This segment is likely to be an early adopter of innovative and novel solutions that don't have established roots or a foothold. They are smart and progressive farmers who are used to problem solving. They are constantly making improvements and learning to accommodate solutions, paving the way for other adopters over a longer period of time.

Archetype Theme Technology

I'm competing against $5/kg imports, Aus grown only goes so far.

The

Analytical Horticulturist

Characteristics
Experienced | Management skillset

In my experience, as long as my data is accurate, the numbers don't lie. I run tests and trials frequently, whether they are large scale or smaller farmer-style tests, I always make sure I can measure, and if possible, control the variables.

Manual data capture is very tedious; technologies that can be used to automate the data capture process are very useful, leaving me and my agronomists to do what we do best.

The only reason I'm able to act on the data I make available is because of extensive experience in the industry.

I'm highly motivated and competitive. This is where my drive to lower prices and expenses comes from.

Barriers and Challenges
Manual data | Data handling | Privacy

I have to be very patient while conducting research. Even if I make small alterations and tweaks, it can take a long time to see the results.

Any manual data capture can be very time consuming, and if I want to capture data or conduct a trial on a large scale, it magnifies the required resources even more.

As these autonomous technologies emerge, there are a range of growing pains that early adopters have to persist through.

Capturing data through farm management systems requires workers to input data accurately and be consistent in scanning-on, and following procedure. At times this is easier said than done.

Capability


Opportunity


Motivation


What might this mean for adoption?

Solutions that lend themselves to data capture and analysis will have a foothold within this user group. Understanding the needs of analytical horticulturalists will also offer valuable insights into which of their needs are critical and which already have existing solutions. This being said, evidence on effectiveness and provision of control over the data and capture mechanism is important to fulfill a desire to change, test and measure a variety of things against differing factors.

This group is highly motivated by being provided information that tells them how much time, money or effort could be saved, so providing proposed solutions on top of data capture such as automated forecasting, are likely to see strong adoption.

Archetype Theme Business & Network

The Family Enterprise

We're more than you small family farm, we're expanding with pace and have outgrown the title.

Characteristics

Strong social networks | Family legacy |

With a wealth of experience and matured roots in the industry, we aim to grow the family farm and expand operations, while sticking to family values.

These growers are multigenerational farmers and agriculturalists, typically a privately owned enterprise and are on the same farm their parents owned. They have a strong, existing social network in the industry for advice and support.

The scale of these businesses range form a mature enterprise, interested in expanding to a family farm at the beginning of scaling their business.

Barriers and Challenges

Staff perceptions | Family and business values |

Roles and responsibilities can sometimes get tied up in family matters. We need to be careful not to affect relationships through what happens at work.

We want long term employees to feel just as welcome as family members in the business. At times the perceptions of staff don't align with how we want to be viewed.

They may face leadership transition challenges with different expertise coming into the business that isn't a part of the family structure, sometimes resulting in bold plans and disruption.

Sometimes the challenges presented by running a family business result in them being takeover targets and being sold off.

Capability

Opportunity

Motivation

What might this mean for adoption?

These growers are hungry to upscale and are already on their way to doing so. If they are in their growth phase, they make for great partners for pilots, case studies, tests and trials as long as they're offered something of value, whether it's learnings or early access.

This segment will identify with many of the needs and characteristics of archetypes, though, more than other archetypes, they must consider the implications of their internal business dynamic on decisions.

Archetype Theme Business & Network

Sometimes I'm limited in the decisions I can make because we're a shareholder farm.

The
Evidence Seeker

Characteristics
Traditional | Pragmatic | Accountable to others | Secure investments

In order to invest in something new, I need strong evidence that I'm going to see a worthwhile return on my investment.

This archetype has a low risk appetite. At times this is because they are older and want to maintain their wealth/business for retirement or to sell.

Not always a solitary decision maker, these organisations may be made up of a board of executives or be held accountable by stakeholders that make up the ownership of the farm and don't wish to see risky decisions be made with their collective investment.

When I decide to invest I'm much more likely to profit from that investment.

Barriers and Challenges
Money | External stakeholders

Whether money is tight or economic security is their priority, this segment may see stagnation in growth over long periods of time due to inaction. Their share of the market may even shrink due to this.

They suffer from being late to the game for certain innovations and opportunities. This results in resource scarcity or having to compete with the demand of other growers. For rubus genetics, this is particularly prevalent.

One overhead that may increase is the amount of spending on industry insights, advisory, or financial services.

Capability

Opportunity

Motivation

What might this mean for adoption?

A strong set of evaluations and trials will need to be conducted to capture this segment of growers. The benefit to understanding this archetype is that if solutions are able to cater to this group's need, they have a much better chance of accessing more of the market as these stakeholders make for reputable adopters.

This stakeholder group further serves as a litmus test for many ideas, technologies and practices in the solution space, as they are much more likely to adopt secure and successful solutions that have been well thought out and tested to a high standard.

Archetype Theme Business & Network

The Eco-Minded

We keep inline with the consumers values and uphold a responsibility we have as a business to do the best for the planet.

Characteristics

Environmentally Minded | Process Control

As a business, we have an important responsibility to practice in the most sustainable way possible, with respects to all the other aspects of running a healthy business.

We provide a product that makes adds value to our berries and is in-line with the customers values.

We consider all parts to the business in how we can make a more sustainable product.

Some of this group develop our own packaging because it's the first thing the customer sees when they buy.

We use organic crop treatments and natural predators as much as possible to treat crops.

Barriers and Challenges

Moral Dilemma | Availability of Crop Treatment | Competition

As environmental impact is included in their decision making process, they may face tough decisions, when the bottom line or other important factors are at risk.

During particularly bad infestations or outbreaks, we can't always rely on the organic treatments we prefer and sometimes need to consider harsher chemicals. These chemicals can help us get through an outbreak, but are also likely to kill the native predators we use and rely on in the field. It can be a huge challenge trying to get those populations up again.

Growing rubus is a highly competitive industry. At times we need to sacrifice some productivity competitors might be able to achieve/pay a higher price to remain sustainable.

Capability

Opportunity

Motivation

What might this mean for adoption?

When it comes to decision making, long and short term impact on the environment will always make up a part of their considerations among this user group.

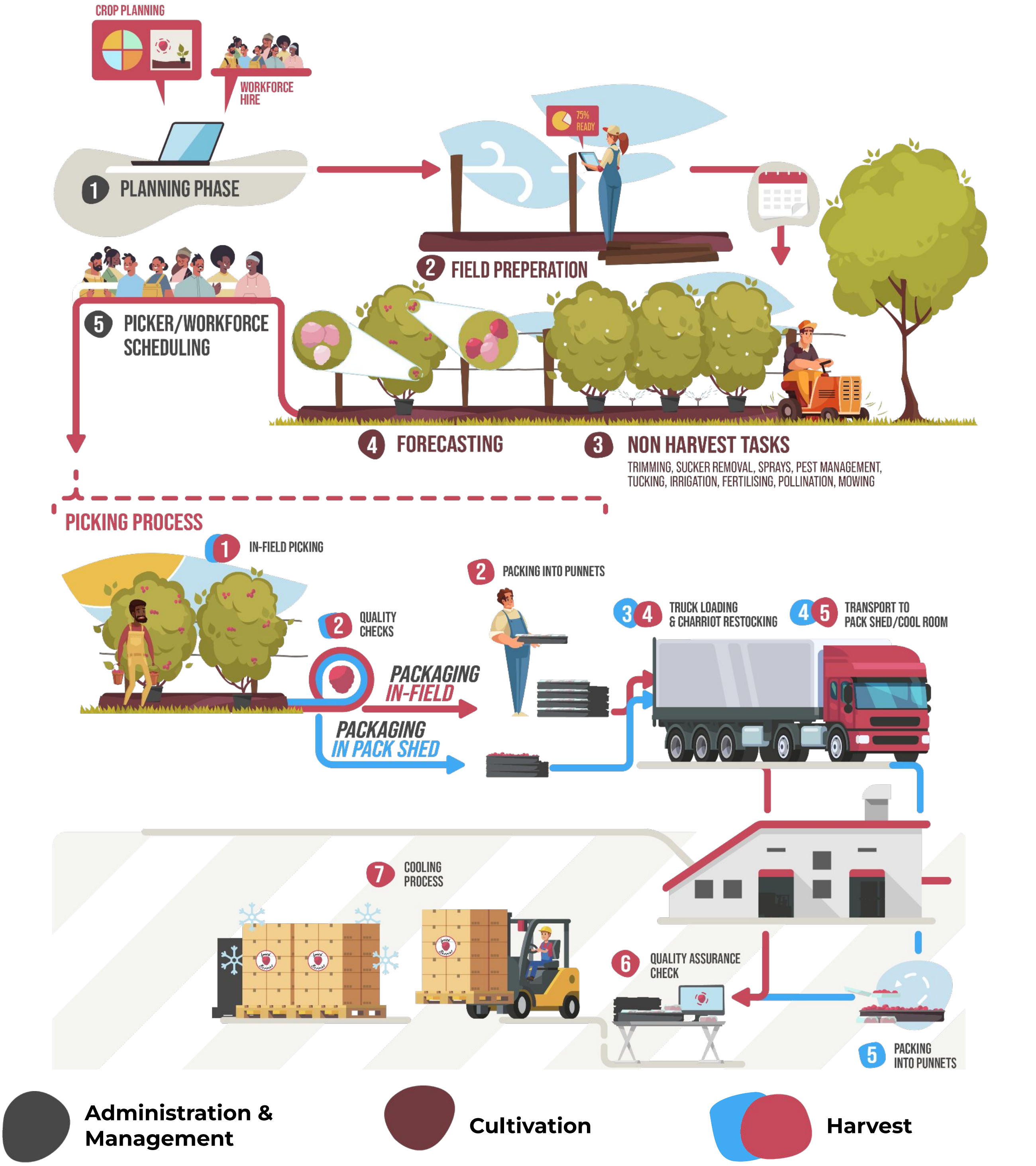
It's difficult to say where they would be positioned according to the diffusion of innovation, it's likely that this group ranges from the early majority, to laggards, as they are likely to wait to see the effects many solutions are likely to have on the environment. Though in contexts in which an effective sustainable solution is presented to them, they may make up the innovators and early adopters.

Appendix C
Process Mapping

Harvest & Picking Process Map

Producing rubus involves numerous processes that a grower must navigate to ensure a viable crop. The specifics of these processes vary between growers, depending on a range of factors including: the local climate, the scale of the operation and available workforce composition. At a high level, we have outlined these processes that a grower experiences in the below process map.

The process map aims not to define or describe the optimum process, but to capture some general steps that workers and growers take in a commercial scale practice. From this map, we drill down into specific processes to explore the embedded labour use and expand upon specific areas, to provide a more detailed picture of where these practices may vary. This has been done with the intent of understanding the key activities, and analysing where the opportunities and barriers are within them.



Harvest & Picking Process Variations

Harvest processes
Across rubus producers there are three main divisions in the harvest process;

- Direct to punnet
- Bucket to punnet
- Pack house processing

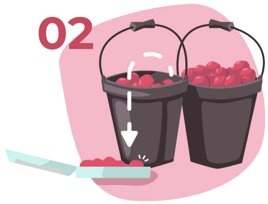
The harvest process maps on the following page illustrate this and serve as a point of reference for the positioning of interventions and the exploration of activity arrangements to form new approaches. It is acknowledged that within each of the three broad categories the exact process steps may vary slightly from grower to grower or even at the picker level.

The harvest process adopted by growers will be determined by several factors that include

- Scale of operation & volume
- Strategic choices regarding QA
- Availability of infrastructure
- Number of personnel required
- Cost & risk to change

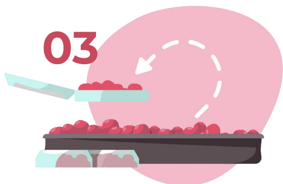
01 In Field
Direct to punnet

Pickers use trays or a trolley to hold punnets and pick directly into them. This process is preferred by some growers as it minimises fruit handling. Any secondary handling is to resolve QA issues. This process is common amongst smaller growers



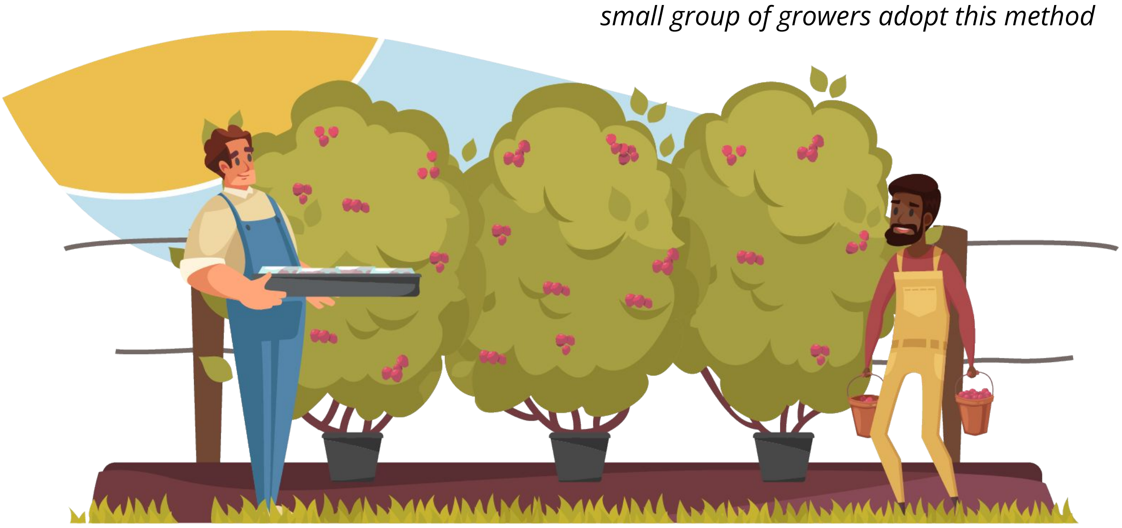
02 In Field
Bucket to punnet

Pickers place into buckets then take buckets full of berries to a trolly/table to pack into punnets. This process is adopted by some growers as it supports picking speed. However, it is also considered prone to increased QA issues through extra handling and the stacking of berries in buckets.



03 In Pack Shed
Pack house processing

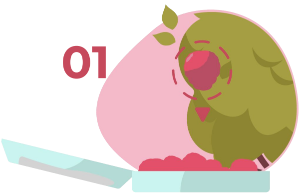
Workers pick into trays, which are transported to a pack-house/cold room and packed into punnets. This method is considered by those that adopt it to provide improved quality assurance. Presently only a small group of growers adopt this method



Harvest & Picking Process Variations

In Field
Direct to punnet

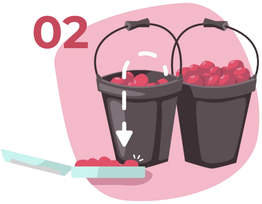
01



Set-up → **Trolly / Tray** → **Picking** → **Drop-off** → **QA Check** → **Restock** → **Palletisation**

- **Set-up**: Trolley is set up & moved to allocated row
- **Trolly / Tray**: Punnets are either set up on the trolley or in a tray strapped onto the picker
- **Picking**: Picker proceeds to pick fruit filling up each punnet as they go
- **Drop-off**: Picker takes full trays to the drop-off point *ie. chariot*
- **QA Check**: Supervisors check quality and weight of punnets
- **Restock**: Picker restocks with supplies for trolley
- **Palletisation**: Trays of punnets are collected for on-site or off-site palletisation

02

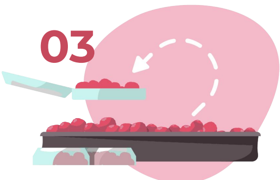


In Field
Bucket to punnet

Set-up → **Fill Buckets** → **Place Bucket** → **Return to trolly** → **QA Check** → **Drop-off** → **QA Check** → **Restock** → **Palletisation**

- **Set-up**: Trolley is set up & moved to allocated row
- **Fill Buckets**: Picker proceeds to pick fruit filling buckets attached to their waist
- **Place Bucket**: Picker places full buckets on the ground as they move through the row
- **Return to trolly**: Picker returns to trolley collecting full buckets
- **QA Check**: Picker fills punnets on trolley, checking punnet weight with scales
- **Drop-off**: Picker takes their full trays to their drop-off point *ie. chariot*
- **QA Check**: Supervisors check quality and weight of punnets
- **Restock**: Picker collects any supplies required for their trolley and returns to picking
- **Palletisation**: Trays of punnets are collected for on-site or off-site palletisation

03



In Pack Shed
Tray to punnet

Set-up → **Fill Punnets** → **Placing Trays** → **Collection** → **Transport** → **Loading** → **QA Check** → **Heat Sealing** → **Palletisation**

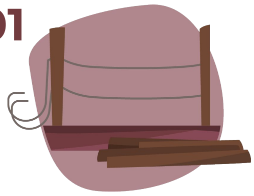
- **Set-up**: Pickers strap a tray to their waist and load with empty punnets
- **Fill Punnets**: Picker proceeds to pick fruit directly to punnet
- **Placing Trays**: Filled punnets are placed in empty packing trays pre-placed on the ground
- **Collection**: Packed trays are placed at end of row for collection
- **Transport**: Trays at row ends are collected and taken to pack-house
- **Loading**: At the pack-house punnets are loaded onto conveyor belts
- **QA Check**: Punnets are pulled off belt for QA and weight adjustments
- **Heat Sealing**: Completed punnets have a lid placed on them and are sent back to conveyor belt
- **Palletisation**: Completed punnets are stacked in trays before being stacked on pallets

Cultivation and Non-Harvest

Once the productivity of a crop has been depleted the site crew will set about removing and disposing of the crop and then installing new plants to the trellis and irrigation system. The frequency of these activities will depend on the variety being grown and whether the grower is adopting a double cropping approach or using long-canes. Generally, long-cane production will see the grower replace the plants each harvest cycle (ie each year). Whereas double cropping can achieve multiple harvests, particularly with some of the blackberry varieties.

Non-harvest activities encompass all activities undertaken by site crews in the upkeep of a crop. This includes trimming, tucking, sprays, sucker removal, pest management, irrigating & fertilising, pollination and mowing. These activities are typically completed by a permanent year-round crew supported by a team of casuals. These staff members, unlike picking crews, are paid on an hourly wage and with performance management through KPIs. As such, there is a direct cost benefit in the optimisation of their tasks.
The work undertaken by crews in crop maintenance has a direct impact on the overall yield of the crop and the scope of efficiency by pickers. Tucking of plants for crop presentation ensures the fruit receives adequate sunlight whilst also making picking easier.

01



Field Preparation

Preparing the fields, irrigation, trellises and other infrastructure and preliminary work required before putting plants in.

02

Non-Harvest Tasks

An assortment of tasks required during the cultivation phase and throughout the harvest that are not harvest but may be complimentary.

Trimming | Pollination | Mowing
Sucker Removal | Pest Management | Spraying
Tucking | Irrigation | Fertilising

Forecasting

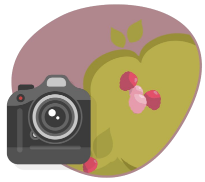
Growers are required to forecast their supply to the market, providing both medium and short-term projections to their supply partners. Approaches to forecasting between growers vary, largely as a function of size. Smaller growers may base this off experience and support from agronomists provided through their supply partners. Larger growers may employ Agtech solutions to scan and assess or rely on a team of agronomists to make their own assessments on an allocated crop.

Forecasting whilst requiring specialist skill sets and several years of experience does not represent significant labour cost. The accuracy of the forecasts produced, however, directly impacts a grower's ability to plan their harvest labour effectively.

Some of the key variations that have been highlighted through this research are outlined as follows:

- Autonomous video scanning and surveillance and agronomist forecasting
- Teams of agronomist surveying blocks or individuals observing manually
- Utilising expert agronomists, either independent or a part of a larger genetics provider partnership

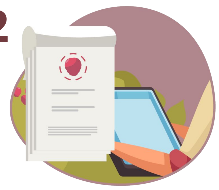
01



Autonomous
Video scanning

A camera will survey the crops and the software will identify and tag how many berries and at which stage they are for an agronomist to review.

02



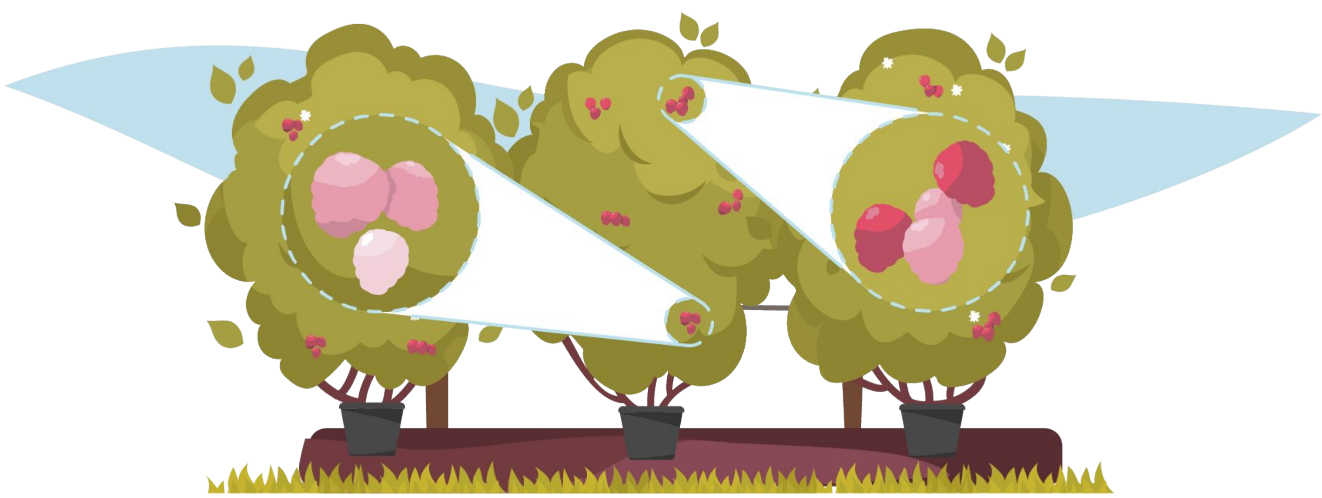
Manual
Reporting back

Agronomist(s) will make their way out to the field to manually check on crops and come back with the report(s) for the head agronomist to aggregate.

03

Manual
Expert agronomist

An expert agronomist, usually from a genetics provider will come out to the site regularly to observe the berries and develop forecasting, among other things.



Planning and Scheduling

Growing rubus crops begins with careful planning by the management team in consultation with agronomists and supply chain partners. Growers must navigate the unique characteristics of the rubus varieties provided to them by their supply chain partners as well the allocation of their crops to ensure optimal harvest windows. This may also involve the viability assessment of expanding operations in the setup of new tunnels, trellises and irrigation.

Decisions made in planning both affect labour the labour profile for the operation but also are in response to the labour availability and efficiencies of present practices.

Leading into and during harvest, the picking teams requires consistent oversight. This involves defining the piece rates, allocation of picking teams to reflect the crop production, monitoring the performance of pickers to ensure they're picking above award rate and hiring to reflect forecasting. As the scale of an operation increases so does the complexity of this task. Decisions here directly affect the efficiency of the picking teams. Having too many people will create a greater risk for pickers to pick below the award rate, too few and the grower will be left with ripe fruit that remains unpicked and spoils.

01

Planning Phase

This key phase encompasses a lot of different activities and is something that, in reality is revisited and broken down throughout the year for most growers.

02

Workforce Scheduling

Workforce scheduling involves coordinating teams and adapting to the day-to-day challenges.

Appendix D
Time & Motion Study

Time & Motion Study Background

Background

Site selection for our T&M studies was a large grower located near Coffs Harbour. The land area is approximately 611 hectares, of which ~100 hectares are dedicated to rubus production. The farm is able to produce rubus continuously for the entire year due to crop rotations that make use of double cropping and long-cane production. Given the operation's size, this prolonged production window is both possible and profitable. At the time, the majority of the other farms in the region were not harvesting.

We were assigned a crew to observe that was made up of roughly 21 pickers, a supervisor, and one additional support person. On-site teams can have up to 41 pickers, 1 supervisor, and 3 other support employees. Blackberry harvest was our team's primary focus, with raspberries secondary. However, since blackberries were not in full production at the time we were on location for the study, the team was mainly seen collecting raspberries.

We chose three participants for our T&M data collection who agreed to take part in the study and represented a fast, average, and slow picker. These volunteers, like the rest of the crew, were largely immigrants who lived nearby and had previous work experience on the job. English presented certain difficulties for many people, making it difficult at times for our team to comprehend their own particular experiences and motivations.

While on site, we witnessed the Canopy staff in addition to the picking crew. This smaller team of about 7 individuals was in charge of a variety of tasks linked to crops, such as planting, trellis upkeep, and crop display. During the brief time we spent observing this crew, we were able to capture crop presentation work being done on a blackberry field that was about to begin producing. This work was identified as being important to capture as it directly affects a pickers opportunity to improve pack speed.

Approach

Over the course of several hours, T&M data was gathered on-site with a focus on the procedures used by picking teams when collecting rubus. To ensure data consistency, capture techniques were devised on the day prior to monitoring the pickers and other team members' work habits. We were able to gather a number of data sets from the study participants by using GoPros to record video and the time tracking tool Toggl.

After leaving the site, Adobe Premiere Pro was used to analyse the video material by placing marks that served as timestamps and exporting the results as.csv files. Additionally, toggle data was transferred to a.csv file and combined with video footage data. This data collection was subsequently processed to separate a number of process patterns and classify activities for efficient analysis. After that, the information was analysed.

Dataset

We obtained our final information after cleaning the data by reviewing several cycles, beginning at the picking of a new row and continuing through to packaging, delivering punnets, and ending at the workers starting to pick again. The dataset included activities performed by the Canopy crew while they were being observed conducting crop presentation tasks between trellis posts. Cycles of pallets being unloaded from the truck and dropped off in the cold room were recorded by Packhouse data.

Picker Data

# punnets packed	178
# participants studied	3
# personnel observed	21
Observation time	181 minutes
Cycles per participant	2/2/3

Set up

Canopy Crew Data

# trellis sections processed	4
# pots processed	28
Observation time	50 minutes
# participants studies	2
# personnel observed	7

Pack shed data

# pallets processed	4
# personnel observed	4
Observation time	20 minutes

Intent, Limits & Limitations

A T&M study is included to provide the process maps with a quantitative overlay. Along with the process maps, these project artefacts are intended for review and discussion with industry representatives and the project reference group members to deliver insights and important processes at critical control points. Additionally, this work can be used in the high-level evaluation of the viability and feasibility of candidate future solutions.

The study did not adhere to a formal scientific process because its goal was to promote the discovery of generalised insights. As a result, care should be taken while using the collected data as inputs, or to specify technical requirements for solution development. The variables that must be taken into account when interpreting results are listed below in a non-exhaustive list.

1. **Farm practice variability**: The study was limited to a single larger farm. This does not capture the variability of practices adopted by farms as documented in our process maps.
2. **Crop productivity:** Crop production can vary depending on where that crop is in its production cycle and the specific genetics being grown. Data captured was over the course of a single day and two fields growing the same genetics and were planted at the same time.
3. **Grower observation effect**: Performance effects on participants who knew they were being filmed, were not controlled for.
4. **Team size**: The team that we were allocated for the day was a smaller team of 21. Teams can reach as large as 40. The effect of team size on productivity was not captured.
5. **Time of day**: Over the duration of around 3.5 hours, from 07:30 to 10:30 am, the study subjects were observed. This study does not adequately account for how the picker's performance can change during the day or the magnitude of its impact.

Equipment

Trolley: *[image 1]*
Lightweight aluminium trolley. Two designs were observed. One with four wheels and another with two. Trolleys are used to house scales, empty punnets and empty trays. Pickers use the trolleys for QA and packing their punnets each picking cycle.

Chariot: *[image 2]*
The chariot acts as a central hub for pickers. Continually staffed by at least one person, the chariot is where pickers drop off filled punnets to be entered into the HMS system and collect supplies such as empty trays and punnets

Waist buckets: *[image 3]*
Pickers fasten buckets for picking berries onto onto their waist. This is sometimes done through specialist straps or occy straps

Scales:
Each of the pickers is provided with a set of basic digital scales that they place on their trolley for QA of punnets as they're filled

Sorting Tray: *[image 4]*
Sorting trays are white acrylic trays with a handle and pouring spout. They're designed to support pickers to QA the fruit when there are quality concerns

HMS unit:
At the chariot a specialist wireless unit is set up to enter in data to harvest management system (HMS) on punnets being filled as pickers drop them off.

2-tonne truck: *[image 5]*
A 2-tonne truck setup with a single pallet at the rear is used on site to deliver packed punnets waiting at the chariot through to the packing shed.


[Image 1] - One of two types of picker trolley observed on site


[Image 2] - Picker Chariot


[Image 3] - Picker with buckets setup on waist


[Image 4] - Berry Pouring tray


[Image 5] - Field to pack shed truck

Roles

Roles
Below details the typical roles and responsibilities of various people on site. As our team for observation was somewhat smaller than typical teams on site, our supervisor assumed the role of runner as well.

Picker:
Responsible for picking fruit and packing it into punnets then trays. They're expected to maintain a high QA

Supervisor:
Coordinates pickers, equipment and supplies on the day. They ensure everything is setup on each site to ensure minimal downtime for pickers. They also take a lead role in ensuring QA is adhered to addressing problems as they arise

HMS data entry:
Responsible for entering what each picker has picked into their HMS system.

Runner:
Quality checks the rows that the pickers have gone through to ensure the row has been adequately picked and no ripe fruit has been missed

Driver:
Sole role is driving to collect berries from chariots and drop off supplies such as punnets and trays. They service one or multiple teams/chariots depending on the team size and how productive the they are. They ensure fruit makes it to the packing shed within one hour of picking

Forklift driver:
In the pack shed the forklift driver supports the movement fruit pallets from the truck into the cool room. This is done through manual handling of some items, driving the forklift and use of the pallet jack

Pack shed QA:
As pallets of fruit arrive in the packshed the Pack Shed QA will take a sample from the pallet to assess the fruit providing the pallet an overall score which will determine the supply chain for the fruit

Canopy Crew:
The canopy crew are responsible for a range of tasks, including the planting of new fields, sucker management and crop presentation. They're a smaller team and on casual contracts at an hourly rate

Canopy Crew Supervisor:
Manages the canopy crew team ensuring they have everything they need to complete their work. As well as coordinating their movement across various fields on site.

A Day-In-The-Life

This day-in-the-life outlines a typical day for berry pickers at our subject grower. Whilst this experience will undoubtedly vary between farms we would expect some crossover particularly with other larger farms.

- Day starts with meeting supervisor on site who then guides the team to their first plot for the day.
- At their first location trolleys, a chariot and supplies including punnets and scales are ready to go. These are setup the day before.
- Pickers set-up their trolleys and move them to the first row they have been given, where they load them with trays, scales, picking buckets, waist belts, and punnets. To ensure that no picker receives preferential treatment, rows are chosen at random. Pickers generally prefer to stay away from the tunnel valleys. Due to weather exposure and uneven lighting, the quality and quantity of fruit in these places is frequently lower. To increase light distribution, the plastic used in tunnels serves as a light diffuser.
- Pickers begin picking their assigned row, pushing deeper into the aisle as they pick fruit. Picked fruit is filled into buckets that they keep on their waist for easy access. As these buckets are filled they are unstaked and placed on ground for collection once they've filled all their buckets. (observed as approximately 5 buckets)
- Back at their trolley, filled buckets are transferred one at a time from there into a number of punnets. These berries are used to fill punnets to the required weight, and the weight is checked on scales to make sure it is within the target zone. Here is where further quality control procedures to filter out subprime fruit take place.
- Punnets (12 punnets per tray) are loaded into cardboard trays, and once all buckets have been filled, they are transferred to the chariot for quality assurance (QA) and entry into the HMS system.
- Picker then returns to where they left off and continues moving along the row until it is finished.
- The picker will have the chance to address quality issues upon returning to the chariot if any QA issues are noted by the HMS representative or supervisor. Any subprime punnets are then excluded from calculation in their piece rate payment.
- The team will start moving over to a new plot for the day whenever they are close to finishing the current one. Usually, this is close by, preventing teams from wasting too much time travelling. It can just require crossing to a nearby plot or getting in the car (typically with a teammate) and moving on to the next location.
- When they arrive at a new plot, another chariot will already be setup and waiting for them, along with trolleys and supplies, if not in the adjacent plot.
- Two structures breaks are available to pickers throughout the day. The first time is for a 15-minute mid-morning break (smoko), and the second time is for a 30-minute lunch. Porta toilets that have been located throughout the venue are frequently used at this period. The pickers typically avoid using facilities during their shift because lost productivity reduces their take-home pay.
- Picker brings in final fruit, once booked into the HMS picker signs off. A tally is printed for the picker with total units and price on, this is given to the picker to keep for their own records.
- Pickers return home, often in their own cars or with teammates

Picker Data Analysis

After cleaning the picker data from our video and toggle recordings we identified 7 picking cycles across our three participants; representing 'Slow', 'Average' and 'Fast' pickers. Table 1.0 describes the resulting datasets at a glance. This dataset was then explored and analysed using Tableau.

Note: Source data and more detailed copies of each visualisation provided throughout the time & motion section can be found in the appendix

1. Activity time distribution (all participants)
2. Picker pace observed vs HMS data
3. Picker pace per picking cycle
4. Picker pace per key activity
5. Individual picking cycle activity time distribution
6. Qualitative insights from picker observation

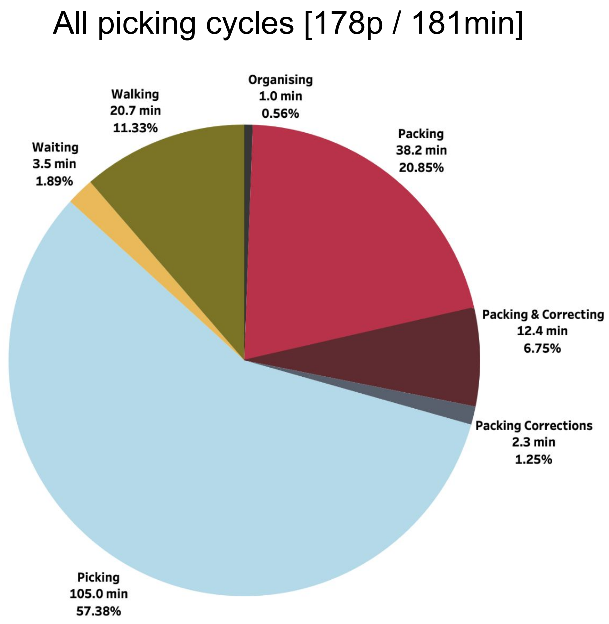
Study	Participant	# Punnets	Total time
SL1	Slow	21	0:27:19
SL2	Slow	33	0:33:36
AV1	Average	32	0:27:37
AV2	Average	14	0:12:13
FA1	Fast	43	0:32:03
FA2	Fast	32	0:21:54
FA3	Fast	35	0:28:19

[Table 1.0] - Picker study legend and overview

Note - Pickers breaks, consisting of a 15-minute break mid-morning, a 30-minute lunch break, and one transit between field locations that took approximately 10 minutes, were not captured in this data set.

1. Activity time distribution (all participants)

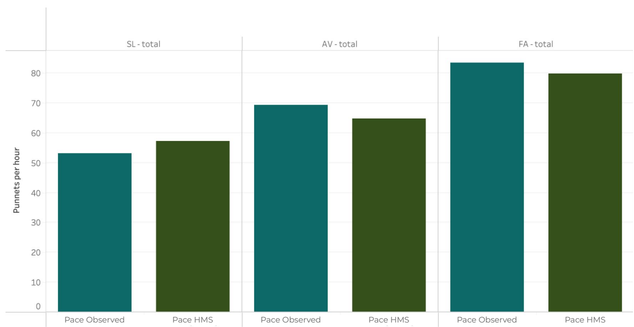
Our first analysis explores the distribution of time spent per activity type across all three picker types. Its purpose is to provide a baseline on the significance of each activity to overall picking performance. This allows for a shared understanding of the scope for impact by addressing labour efficiencies in each of the activities.



Unsurprisingly, picking represented the activity comprising the majority (57.38%) of the total time observed with our three picker types. This was then followed by packing (20.85%) and walking (11.33%). Although it is not obvious from this dataset, it is believed that QA assessment and interventions will have a reasonable impact on time performance as a whole. Further research may also be necessary, particularly when it comes to larger picking crews, to investigate why waiting times that were often caused by delays at the chariot for HMS entry.

2. Picker pace observed vs HMS data

To validate our datasets we have reviewed the picker pace observed against the data captured by the HMS system for each pickers performance that day. The comparison suggests strong correlation between results and validates our dataset.

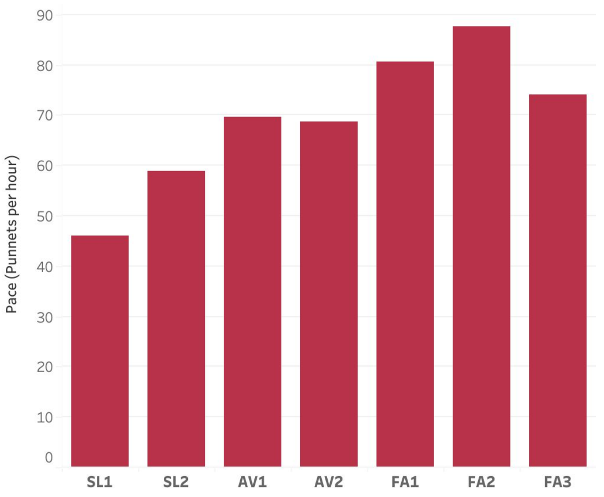


[Visualisation 2.0] - Pickers pace observed compared to total recorded by HMS system over the day provided by the grower

Picker Data Analysis Continued.

3. Picker pace per picking cycle

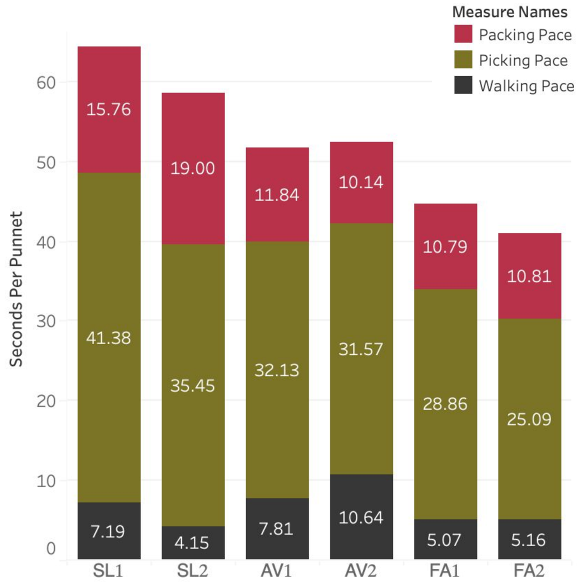
To support the detailed analysis of each picking cycle we have reviewed the overall pace in punnets delivered per hour across each cycle.



[Visualisation 3.0] - Pace observed across each picking cycle study

The pace across each picking cycle reflects the overall performance of each picker. Our average picker maintained a similar pace across each picking cycle, whilst our slow and fast picker had notable drops in pace as per study SL1 and FA3.

A key observations from this visualisation is that the gains achieved by the Fast picker were achieved through picking, rather than packing, when compared to our Average picker. The fast picker also consistently walked at a faster pace which reflected our observed experience during data capture. This visualisation also suggests that reasonable gains may be made in supporting the slow picker in packing activities who across both cycles packed at a significantly slower pace.



[Visualisation 4.0] - Pickers pace by key activities across each picking cycle observed. FA3 has been omitted as on this picking cycle punnets were packed at the same time as making corrections

4. Picker pace per key activity

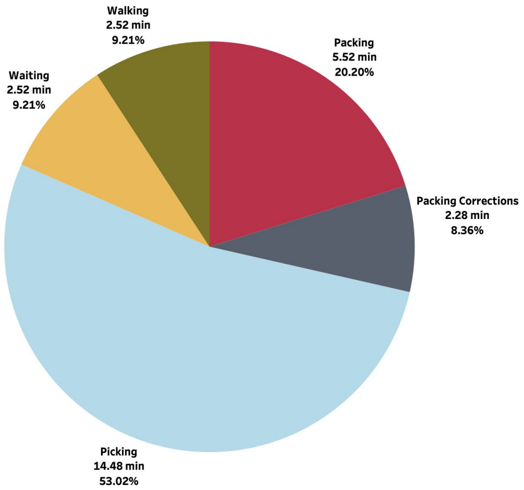
To further explore difference in performance between the three pickers across each picking cycle we analysed the pace of each picker across activities comprising the most significant use of time; picking, packing and walking. The visualisation that follows shows the average amount of time in seconds spent per activity. For this analysis we omitted study FA3 as during this cycle packing was done in conjunction with QA corrections that made it unsuitable for direct comparison. It acknowledged that walking pace per punnet would would be highly dependent on the pickers row allocation.

Picker Data Analysis Continued.

5. Individual picking cycle activity time distribution

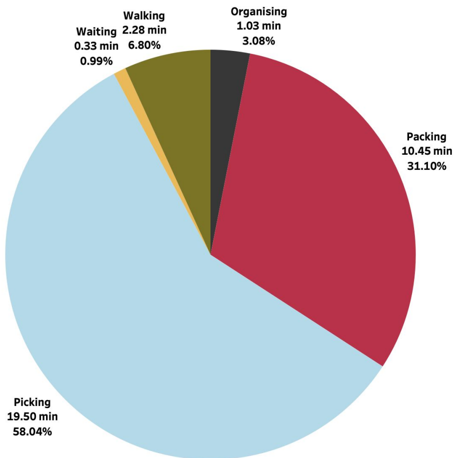
The visualisations that follow capture the breakdown of activities by each picker across each of the picking cycles. The purpose of these analyses is to capture how time spent across the activities observed affected the pickers overall pace for that picking cycle. Observations from analyses are provided on a per picker basis

SL1 [21p / 27:19sec]



[Visualisation 5.0] - Distribution of time spent during study SL1

SL2 [33p / 33:36sec]

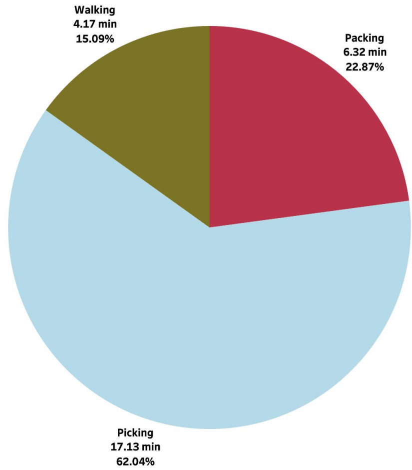


[Visualisation 6.0] - Distribution of time spent during study SL2

The two cycles following our Slow picker illustrate the impact of QA corrections and other interruptions on overall performance. It also suggests that the pickers packing pace reduced considerably on the their second cycle.

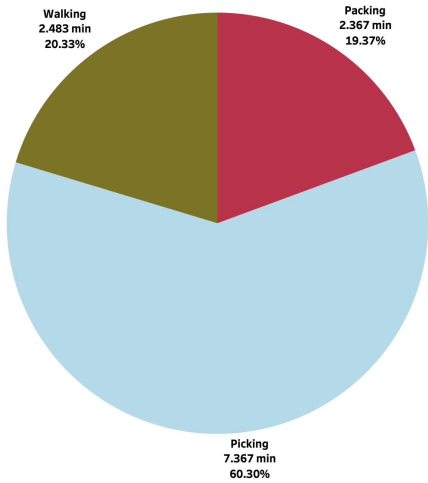
Aside from the packing correction that hindered pace over SL1 picking cycle, the picker was also further affected by a wait time whilst at the chariot, to have their punnets entered into the HMS system. This was the most significant wait time observed over the 7 picking cycles.

AV1 [32p / 27:37sec]



[Visualisation 7.0] - Distribution of time spent during study AV1

AV2 [14p / 12:13sec]

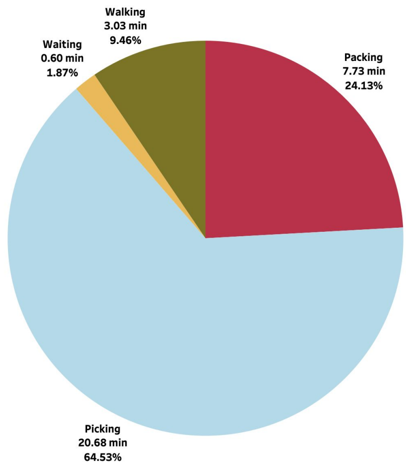


[Visualisation 8.0] - Distribution of time spent during study AV2

Our Average picker's workflow was not disrupted, according to data collected. This picker kept a steady rate throughout both cycles, and the difference in the quantity picked between the two time periods was merely the result of the different lengths of picking time. Additionally, we observe that picking takes up about 60% of their time during both cycles, which is a consistent ratio compared to other activities.

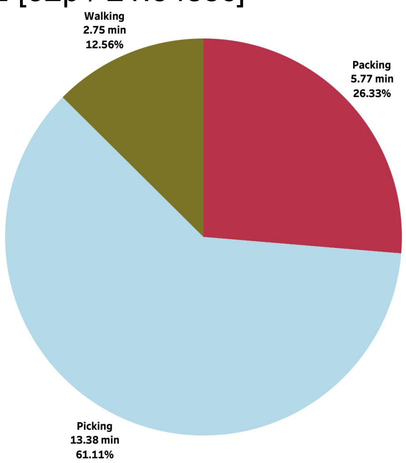
Picker Data Analysis Cont.

FA1 [43p / 32:03sec]



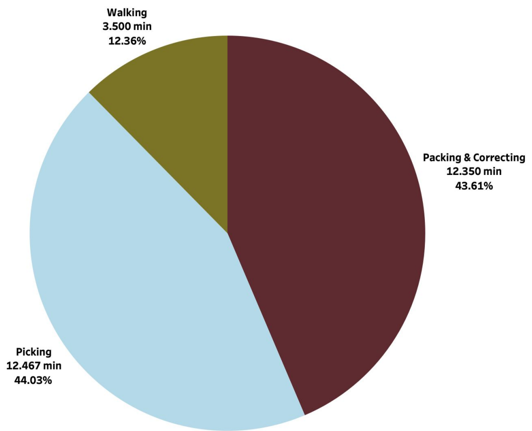
[Visualisation 9.0] - Distribution of time spent during study FA1

FA2 [32p / 21:54sec]



[Visualisation 10.0] - Distribution of time spent during study FA2

FA3 [38p / 28:19sec]



[Visualisation 11.0] - Distribution of time spent during study FA3

Our Fast picker over the three picking cycles delivered punnets at a pace that exceeded the Slow and Average pickers. This was despite corrections to 32 punnets they had to make in FA3 due to QA issues from previous picking cycle. For FA3, if we allocate 10.79 seconds per punnet to the 32 punnets delivered in this cycle, we can attribute ~6:49 sec to packing punnets and ~5:31sec to corrections. This would place the pickers pace at approximately 92p/hr on this cycle without QA corrections. Given this pickers overall pace for the day was 79.81p/hr, it suggests that QA corrections may have presented multiple times throughout the day.

6. Qualitative insights from picker observation

Supporting our quantitative time & motion analysis we have provided a series of qualitative insights from observations on site and upon review of video footage.

Picking

Given the complexity of movements involving the coordination of hands and line of site during the act of picking, makes analysing the video footage complex to determine the differences between a fast, average and slow picker quantitatively. Review of the video footage, suggested that the Average and Fast pickers had similar picking styles. They moved through the rows with fairly light touch to the plants, picking with both hands and relying on their periphery vision to guide their hands to the next fruit. The fast pickers on return to their trolley's would quickly pick any fruit they missed as they walked. In comparison our Slow picker handled the plants much more to uncover fruit, they also scanned backwards to previous plants to identify fruit they had missed. This meant the Slow picker would shift backwards several times whilst picking a row.

The Fast picker was observed filling their picking buckets up considerably more than our average and slow picker. This was despite requests from the supervisor calling out for pickers to not fill their buckets more than 6 punnets worth.

Picker Data Analysis Cont.

In discussions with the picking team supervisor, they expressed their frustrations with the Fast picker as they had to be much more diligent with QA on their punnets as they would often find damaged or under ripe fruit. This may suggest that some of the fast pickers efficiencies are at the expense of supervisors and HMS operators time.

Packing

During packing across observed picking cycles the Average and Fast pickers would pour the fruit direct from their picking buckets in the punnets spayed out on their trolley. The Average picker appeared to do this with a bit more care than the Fast picker, filling one punnet at a time from the bucket before checking each for target weight. The Fast picker poured the fruit out across the punnets with less of a pause at each punnet. The Slow picker comparatively used the Pouring Tray to fill their punnets. First pouring their bucket of picked fruit into the tray, inspecting fruit to remove debris and occasionally under ripe or damaged fruit before pouring into punnets.

Other

- No pickers were observed taking a bathroom break whilst picking. Use of the provided portable toilet on site were kept to their break times.
- Pickers expressed they don't like working through the valleys of the tunnels as the fruit and plant quality in these sections is typically poorer and they have obstruction to navigate as they move down the row.
- With the picking location set up and ready for pickers, very little time was lost that day.
- The least amount of picking crew transportation between crops was achieved. The supervisor contacts in advance when the picking team is wrapping up on one crop to make sure their next area is ready to go and minimise downtime. Our picking crew only changed locations once.
- The chariots at times appeared to be a hive of activity and somewhat chaotic but would also quieten quickly.

Transit, Packshed & Crop Presentation Analysis

Only high-level data has been used in the assessments of Transit, Pack Shed, and Canopy crews that follow. There was less room for in-depth research because these activities were simpler and required much fewer staff. With the exception of the Canopy crew, they also made up a significantly smaller proportion of the site's labour force.

Transit time

While working with the pickers on site, we saw the truck pick up boxed fruit twice from the chariot and deliver it to the packshed. Each time, the driver worked by themselves to pack the lone pallet at the back of the vehicle. In the first instance, it took 4:44 seconds for the driver to open the back doors before closing them; in the second, it took 5:20 seconds. Quantities gathered were not recorded. Even though we were unable to follow the truck back to the pack shed to measure transit time, we were still able to calculate that it took about 4 minutes.

Pack Shed

Our Time & Motion analysis focussed on field processes, and access to operations within the pack shed were limited. Generally, pack shed operations consisted of removal of the pallet from the rear of the truck with a forklift, placement in holding areas, where a QC sample is taken before moving it into the cool store via the pallet jack. Supporting these activities were three staff; one person for QC, the forklift driver, and the truck driver. We observed the movement of three pallets of rubus in the pack shed.

Pallet #	Time to cool room
Pallet 1	03:41
Pallet 2	05:29
Pallet 3	04:30

Pallet processing times in pack shed

Crop Presentation

At the time of our visit we were able to observe and collect data on the Canopy Crew working through a field of Victorian blackberries that were approaching their fruiting window. We captured approximately 50 minutes of footage of two of the team working along a row. This involved a highly repetitive process of arranging the laterals coming off the plant to be evenly distributed and supported across the trellis. For our analysis we used the trellis posts as our intervals. On this crop the spacing was set 6 meters post to post, with 7 pots containing four verticals.

Crew Member	Duration	Pace (plants/hr)
Employee A - Trellis 1	10:02sec	83p/hr
Employee A - Trellis 2	09:37sec	87p/hr
Employee B - Trellis 1	11:02sec	76p/hr
Employee B - Trellis 2	10:04sec	83p/hr

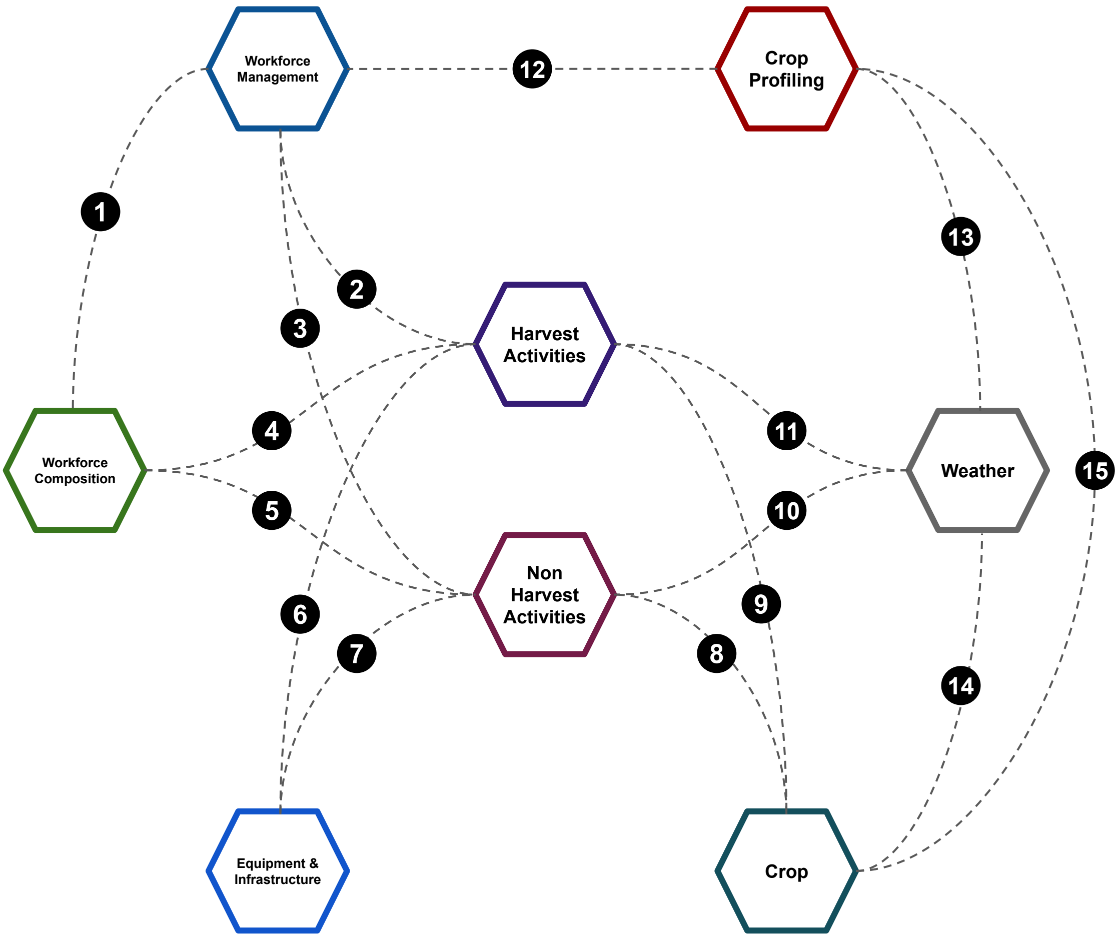
Canopy crew crop presentation timing mature Vic blackberry

Over the crops lifecycle we were advised that this crew would perform crop presentation 2 to 3 times before it goes into fruiting. This crew who works on an hourly rate has a key performance indicator (KPI) of 80 plants per hour which was reflected their observed performance. This performance, however, is expected to vary between crop genetics as well as the growth stage of the plant. It is important to keep in mind that although though on the surface this would seem to be a substantial expense given the time it takes every trellis section, the number of times a given row is harvested over the crop harvest window should be taken into account.

Appendix E
Critical control points

Systems Map - Orienting on the problem

The diagram below maps the problem space to show how the varying areas of focus interrelate to affect labour use on-farm in either Harvest or Non-Harvest activities. Each of the numbered connections corresponds to a short description in the table on right. The purpose of this map is to support an understanding of the flow on effects of solutions, as well as other changes that must be made to support solution implementation ie. a change in picking equipment may necessitate a change in harvest process that may also impact the design of KPIs or employee contracts.



Description	
1: The composition of the available workforce will influence the design of the management mechanisms, such as the amount of training, and how closely they need to monitor worker performance.	10,11:The weather directly impacts both harvest and non-harvest activities. Most of these activities occur within the growing tunnels, however significant wet weather can slow movement due to muddy conditions. Wet weather can also create a challenge during harvest as fruit must be kept dry to ensure mould does not develop. Conversely, hot weather necessitates picking process adaptations to maintain a high QA as the fruit softens due to the warmth.
2,3: Workforce management mechanisms directly impact worker productivity. For picking activities this is typically managed through employment contracts and piece rates. For non harvest activities, this is done through KPIs and hourly rates.	12: The effectiveness of a grower to profile their crop directly impacts their ability to plan their harvest workforce. Knowing the peaks and troughs of the production curve ensure no fruit is left on the plant to spoil unpicked or conversely that pickers/harvest crew have sufficient work.
4,5: The composition of the available workforce will directly affect labour efficiency in both picking and non-harvest activities. Returning and experienced workers will not take as long to perform optimally, whereas inexperienced workers will have a lead in time. Different employee segments have varying levels of motivation that directly impact the scope for efficiencies that can be achieved	13: The ability to profile a crop to determine the production curve over the short and long term is limited by the accuracy of weather predictions. If this input is incorrect predictions whether they be through a digital platform or by agronomic experience will be off.
6,7: The equipment both informs and is informed by the processes/activities involved in harvest and non-harvest activities. eg buckets for picking suit the picking process but also inform the actions taken by the picker	14: Weather patterns will directly affect the yield of a crop. Growers may account for local normal climatic conditions, however, weather variability is beyond a grower's control and can negatively impact the yield of a crop.
8: The intensity of non-harvest activities is informed by various intrinsic crop attributes such as genetics, as well as the effectiveness of the grower and agronomists in managing the crop. Failing to stay on top of pests and plant growth can increase the labour use in pest management, sucker removal, or tucking of laterals Conversely, non-harvest activities impact crop yield and presentation. Activities such as tucking of laterals ensure optimal light exposure for fruit whilst also setting it up for ease of picking during harvest (see #7).	15: The various attributes of a crop become key inputs for effective profiling. The criticality of crop profiling will also depend on the grower's capability and capacity to extend harvest windows and overlay crop production curves.
9: How well a crop is managed and its intrinsic attributes directly impacts the scope for efficiency by picking crews during harvest. The genetics that gives higher fruit density per plant improve picking efficiency. Crop presentation further improves the scope for picking efficiency by ensuring fruit receives adequate sunlight to ripen whilst also exposing the fruit for ease of picking	

Critical Control Variables

Across the following two pages, a list of critical control variables has been provided that represent variables within a growers' control that can be manipulated to support labour efficiency. Each of the control variables listed corresponds to an area of focus mapped on the system map on the previous page. The purpose of this list is to establish where interventions may be best placed to create a positive impact on labour efficiency.

Workforce Composition

- Labour Contractors
- Accomodation
- Worker Programs

Workforce Management

- Training
- KPIs
- Employee Contracts
- Incentives

Non Harvest Activities

- Planting
- Irrigating & Fertilising
- Cane Removal / Mow Down
- Pest Management
- Trellis Maintenance
- Crop Presentation
- Sucker Removal

Equipment & Infrastructure

- Cold Storage
- Tractors
- Tunnels
- Trellis System
- Scales
- Trolley
- Packing Trays
- Punnets
- Picking Buckets/Trays
- Trucks / Quad-bikes
- Chariot / Cart

Critical Control Variables

Harvest Activities

- Row QA
- Supervising
- Picking
- Punnet Packing & QA
- Transporting / Carrying
- QA
- Walking
- Data Entry
- Palletising

Crop Profiling

- Genetics/Varieties
- Farm Scale
- Agronomic Consultation
- Digital Solutions
- Grower Knowledge & Experience

Crop

- Grower Knowledge & Experience
- Crop Management System
- Agronomic Consultation
- Growing Method
- Genetics/Varieties
- Farm Scale
- Location / Local Climate

Process automation assessment

The following section provides an assessment of various harvest and non-harvest processes for automation. The purpose of this assessment is to identify processes that may be best placed for an automated solution as well as uncover common complexities across activities. This assessment utilises a Fibonacci sequence for scoring and has been validated with several growers. A common complexity that emerged from this assessment is the need for visual assessment, responding to variability in terrain and variable movement patterns, that were common across several processes.

Harvest Processes

Picking

Description: Hand-picking of fruit from cane and placing it into a vessel. Depending on practices adopted this may be a bucket or tray setup with open punnets

Complexity			Intensity		
This task involves movements that are highly varied as the fruit position varies both vertically and laterally (in & out from the trellis centre), as well as longitudinally as pickers work along the row. Blackberries and particularly raspberries require high dexterity to be picked without bruising or damage. Pickers must also make a quick and considered assessment of fruit ripeness based on colour and other visual attributes	1. Visual assessment 2. High amount of dexterity required 3. Highly varied movements	**21**	Picking represents the most significant use of labour on farm. It can be highly intensive due to the accelerated production curve of raspberries and blackberries.	1. Large crews 2. Fast paced 3. Largest proportion of time	**21**

Packing Punnets

Description: Involves the placement of fruit into their punnet. Experienced pickers can visually fill the punnet to the correct weight with reasonable accuracy. In experienced pickers may need to make more corrections. **Note: This activity is only applicable where pickers pick to an intermediary vessel before placement in punnet**

Complexity			Intensity		
Movement of the fruit from the intermediary vessel into the punnet must be done with care to avoid bruising and damage. Punnet design creates a dimensional constraint that affects the arrangement of punnets & movements involved in packing. Typical clamshell punnet design has a lid that must be closed and considered in punnet arrangement.	1. Visual assessment 2. High amount of dexterity required	**13**	Packing to the punnet represents approximately 20% of a pickers time where the picking process involves picking to an intermediary vessel. This still represents the second largest use of labour on-farm.	1. Large crew 2. Fast paced 3. Medium proportion of time	**8**

Transporting / Carrying

Description: This encompasses the movement of fruit from the rows to the designated drop-off location then onto a cool-room/packing-shed. This may also include movement of vessels to trolley for punnet packing. Smaller operations may go direct from the drop-off location into a refrigerated truck.

Complexity			Intensity		
Pickers/Personnel moving fruit from between locations may have to navigate varied terrain. The location of drop-off point varies as do field proportions. Packed fruit must be kept level and stable to avoid damage. Fruit must be moved into a cool room as quickly as possible to avoid the reduction in shelf life. Supply chain partners may stipulate/provide trays for punnets to be packed into providing a dimensional constraint.	1. Varied Terrain 2. Inconsistent patterns	**5**	Movement of fruit to drop-off location is typically done by pickers. This is a proportionately small use of pickers time, however, given representation of picking labour still constitutes a considerable use of overall on-farm labour	1. Large crews 2. Small proportion of time	**3**

Data entry

Description: Data entry involves capturing the amount a picker has produced and recording it so that a) the picker on a piece rate is paid accordingly, b) operations knows how much is being produced on any given day and c) picker performance can be managed. This may be digitally to a harvest management system or to a paper spreadsheet.

Complexity			Intensity		
Count of packed trays and recording. The personnel responsible must ensure the right quantities are attributed to the right picker. Complexity will vary depending on the system adopted	1. Picker identification 2. High accuracy requirement	**3**	Data entry is typically conducted by one person as part of a picking crew.	1. Single Person responsibility	**2**

Harvest Process Automation Assessment

Supervising

Description: Supervising of picking crews involves a range of responsibilities that vary with farm size. This can include ensuring picking crews have adequate supplies ie trays & punnets, making judgement calls on the amount buckets are to be filled, coordinating pickers by assigning them rows, providing positive reinforcement and motivation, and coordination of crew across locations on site

Complexity			Intensity		
Picker management is a complex task that, for the most part requires human oversight	1. Highly varied set of responsibilities 2. Oversight of dynamic environment	**21**	Picker management is typically conducted by one person per picking crew	1. Single Person responsibility	**2**

Walking

Description: Walking involves the movement of harvest staff in between activities and not moving fruit. This may include moving to a new site or row. Walking is differentiated from Transporting/Carrying in that it does involve carrying of fruit

Complexity			Intensity		
Personnel must navigate varied terrain. Low repetition of walking patterns.	1. Varied Terrain 2. Inconsistent patterns		Walking without movement of fruit is estimated to be similar in labour use as walking in carrying/transporting of fruit. Pickers after drop-off will return either to a new row or position on the row they last finished up at.	1. Large crews 2. Small proportion of time	**3**

Quality Assurance

Description: The quality assessment of fruit and weight to ensure they meet standards. This activity may be conducted at various points along the production process, however for the purpose of this assessment does not include the assessments made by the picker of fruit on the plant.

Complexity			Intensity		
Fruit ripeness assessed visually on colour depth and vibrancy as well as consistency of colour across the fruit. Punnet weight must fall between designated weight brackets as defined by the grower or supply partner. Corrections to weight may be made during QA involving the removal or addition of fruit to the punnet. As with punnet packing this involves careful fruit handling to avoid bruising or damage.	1. Visual assessment 2. High amount of dexterity required	**8**	Quality assessment is usually conducted by multiple people, including the picker, the supervisor and dedicated QA personnel.	1. Small crew 1-3 people 2. May be a secondary responsibility on smaller farms	**5**

Row QA

Description: As pickers move through rows, either the supervisor or a dedicated 'runner' will go through picked rows to ensure no ripe is left on the plant to spoil and that the picker has not caused any damage to the plants

Complexity			Intensity		
Row QA involves a visual assessment of a row as they move quickly through the row. This may require the worker to move laterals as they walk through to make sure nothing was left at the back of the plant.	1. visual assessment 2. varied terrain	**8**	Row QA labour requirements is proportionate to picking crew size. Crews with under 10 pickers may have rows QA'd by the supervisor. Crews as large as 21 may have 2 dedicated 'runners'	1. Small crew 1-3 people 2. May be a secondary responsibility on smaller farms	**5**

Palletising

Description: Palletising consists of activities associated with packing and preparing a pallet of fruit for distribution. This may be fragmented in cases such as where trays of punnets are packed directly to a pallet in-field then further prepared in a packing-shed

Complexity			Intensity		
Punnets and Trays are designed with dimensional constraints of a standard pallet size (1165 x 1165mm). This creates some consistency in the arrangement on the pallet. Pallet wrapping has consistent movements and with known automation solutions	1.		Row QA labour requirements is proportionate to picking crew size. Crews with under 10 pickers may have rows QA'd by the supervisor. Crews as large as 21 may have 2 dedicated 'runners'	1. Small crew 1-3 people 2. May be a secondary responsibility on smaller farms	**2**

Non-Harvest Processes

Crop Presentation

Description: Involves the redistribution of laterals coming off the main cane to ensure they are adequately supported by the trellis , receiving adequate sunlight and fruit is well presented. This is often referred to as 'tucking'.

Complexity			Intensity		
Movements involved in tucking careful assessment of laterals as the personnel move along the row. When moving laterals care needs to be taken to avoid any damage to the plant. The longer interval between tucking a row may make the process more arduous as personnel have longer laterals to move. To the untrained eye it is not immediately obvious how crop presentation personnel identify laterals that need tucking and how best to place them. Different trellising systems may afford greater ease than others in tucking	1. Visual assessment 2. Highly varied movements	**21**	Crop presentation is typically conducted by a small crew on site that are also responsible for many other non-harvest activities	1. Smaller team of full-time plus casuals 2. Slow process 3. Conducted 2-3 times per crop	**8**

Sucker Removal / Spawn Selection

Description: Removal of suckers that are new growths emerging from coir that will take nutrients away from the main plant and will not fruit on same cycle

Complexity			Intensity		
Suckers must be identified as early as possible to avoid the diversion of nutrients away from the fruiting plant. Removal of suckers involves the separation of the sucker from the main plant and removal from coir by hand.	1. Visual assessment 2. Inconsistent movement patterns	**8**	Sucker removal is one of several activities typically undertaken by a small team of full-time employees, or repurposing of pickers amongst smaller farms	1. Smaller team of full-time personnel 2. Secondary responsibility	**3**

Pest Management

Description: Monitoring and addressing pests & disease as they emerge on field. Timely action is required to avoid spread that may exacerbate labour use in remedying the problem, or result in reduced yield. Spraying for treatment of pests & disease may involve manual spraying or automated through devices such as an atomizer on the back of a quad bike.

Complexity			Intensity		
Pests & disease are identified through visual inspection. Application of remedy needs to ensure high efficacy. This may be through an integrated pest management approach, or the application pesticides, biopesticides or other treatments. Spraying needs to ensure a high level coverage to affected area to be effective.	1. Visual assessment 2. Solution identification	**5**	Pest & disease identification is usually a result of other non-harvest activities. Labour involved in remedying the solution will often involve the spraying of plants either by hand or through spray unit attached to the back of a quad bike.	1. Smaller team of full-time personnel 2. Secondary responsibility	**2**

Field Presentation

Description: Field presentation encompasses activities that support access on field and around the site. This consists mostly of mowing of rows and surrounds and other general maintenance such as resolving ruts or other OH&S concerns.

Complexity			Intensity		
Mowing activity requires navigation of varied terrain and ensuring no inadvertent damage to plants or other infrastructure	1. Varied terrain	**3**	Field presentation fits amongst several activities typically conducted by a smaller group, or as little as one, full-time personnel	1. Small Crew 2. Infrequent 3. Often a secondary activity	**2**

Irrigating & Fertilising

Description: Irrigating and fertilising encompass ongoing activities to support optimal plant growth. For most growers, this is an automated process requiring the human oversight of an agronomist or an experienced grower. Oversight consists of monitoring plant health by visual assessment of plants as well as taking readings from a range of in-field sensors.

Complexity			Intensity		
Irrigating and fertilising is already a highly automated process. The remaining processes that encompass the use of labour require human oversight to some degree.	1. Human oversight	**13**	Labour gains in irrigating and fertilising are minimal as the human oversight component only requires periodic assessment by an agronomist or the grower.	1. Single person responsibility	**1**

Planting

Description: Planting involves the establishment of new plants in coir, along a trellis row and connecting them to the irrigation and fertilization system. Depending on the cropping method employed this may involve the planting of pre-established long-canes or in a double cropping approach the planting of seedlings/smaller unestablished plants

Complexity			Intensity		
Complexity will vary depending on the cropping method. Long-canes are slightly more difficult to handle due to the size of the plant. The process is otherwise highly repetitive. Plants need to be inspected prior to installation for defects, disease and pests	1. Navigating varied terrain 2. Visual inspection	**8**	Planting is a slow process conducted by full-time staff with the support of casuals. In long-cane production, this activity is repeated every season, in double cropping or standard cropping method a grower will not have to repeat planting for multiple seasons	1. Conducted by small crew 2. Secondary responsibility 3. Low frequency	**5**

Trellis Maintenance

Description: Trellis maintenance involves the assessment and repair of trellis system

Complexity			Intensity		
Varied work depending on the trellis system adopted on farm. Maintenance activities mostly consist of minor repairs to uprights or string.	1. Highly varied movement patterns	**13**	Trellis maintenance is typically an ad hoc activity conducted by full-time staff as required	1. Ad-hoc activity 2. Secondary responsibility	**3**

Removing Canes / Mow Down

Description: Mow down or cane removal involves removing and disposing of plants that will no longer produce an optimal yield. For long-cane production this involves removal of the entire plant. In double cropping this involves selective removal of spent floricanes. Standard cropping involves mow down where plants are cut back to ground level for new primocanes. Removal of canes involves cutting with secateurs and pulling foliage out into row for collection. For long-canes this involves disconnecting plant from irrigation system and disposal

Complexity			Intensity		
Varied work depending on the trellis system adopted on the farm. Maintenance activities mostly consist of minor repairs to uprights or strings.	1. Visual inspection 2. Varied movement patterns	**8**	Low-frequency activity conducted at most once a season.	1. Conducted by small crew 2. Secondary responsibility 3. Low frequency	**5**

Appendix F
Grower Technology Workshop

Detailed Workshop Agenda

Setup

Participants to arrive from 8:30am for a 9am start. Room will be setup with four tables oriented around the projector screen. Each of the three tables will have assigned seats and will form the breakout groups for the day. A webcam and room mic will be setup to support video conferencing calls with solution providers on the day.

09:00 - 09:30: Introductions & overview

Purpose: Set the scene for the day. Bring everyone up to speed with the work done to date. Answer questions why we are here, run through the format for each of the days activities, explain what we will produce and how this will be used in the future.
Capture participants perspectives on the most promising solutions, so we can see how it changes through the activities of the day.

Format: Presentation w/ Digital Poll, Q&A and individual introductions

Materials: Slide presentation w/ Digital poll

09:30 - 09:40: Icebreaker

Purpose: Get everyone in the room talking and energised

Format: Two truths and a lie activity

Materials: None needed

Workshop 1 Overview

Over the course of workshop 1 we will further develop 8 priority solutions over 2 rounds. Each round will begin with an in plenary presentation on the three solutions for the round, each table will then be assigned one of the three solutions to develop up in accordance to template printout materials. Upon completion groups will present the solution back to the rest of the group for their input.

09:40 - 09:50: Workshop 1 Overview of solutions for Round 1

Purpose: Ensure there is an understanding of the technology and intent of solutions breakout groups will be developing in round 1.

Format: Recap on what everyone needs to do in their breakout groups. Slide presentation with relevant materials to explain technology include videos where appropriate

Materials: Slide presentation,

09:50 - 10:30: Workshop 1, Round 1

Purpose: Workshop priority solution 1

Format: 40min working in breakout groups

Materials: Solution canvas printouts, sticky notes, markers

10:30 - 10:45: Morning Tea

10:45 - 11:15: Workshop 1, Round 1 Report Back

Purpose: Each group reports back key findings, insights from Round 1 with feedback and questions from the rest of the group. Each participant fills out a solution assessment form during report back.

Format: 5min presentation from each group and 5min of comments/feedback

Materials: Slide presentation,

Detailed Workshop Agenda

11:15 - 12:00: Q&A with Burro representative

Purpose: Provide opportunity for the group to ask questions pertaining to barriers identified in prior session

Format: 30min video conferencing call allowing participants to effectively grill the solution representative on key items raised on D-F-V of the solution as identified through Round 1 development.

Materials: None - ensure appropriate mic and camera for call

12:00 - 12:45: Q&A with Think Digital

Purpose: Provide opportunity for the group to ask questions pertaining to barriers identified in prior session

Format: 30min video conferencing call allowing participants to effectively grill the solution representative on key items raised on D-F-V of the solution as identified through Round 1 development. Followed by 15min discussion.

Materials: None - ensure appropriate mic and camera for call

12:45 - 13:15: Lunch

13:15 - 13:35: Workshop 1 Overview of solutions for Round 2 w/ pres by Chris

Purpose: Ensure there is an understanding of the technology and intent of solutions breakout groups will be developing in round 2. Recap on what everyone needs to do in their breakout groups.

Format:

Materials: Slide presentation,

13:35 - 14:15: Workshop 1, Round 2

Purpose: Workshop priority solution 2

Format: 40min working in breakout groups

Materials: Slide presentation, Solution canvas printouts, sticky notes, markers

14:15 - 14:45: Workshop 1, Round 2 Report Back

Purpose: Each group reports back key findings, insights from Round 2 with feedback and questions from the rest of the group. Each participant fills out a solution assessment form during report back.

Format: 5min presentation from each group and 5min of comments/feedback

Materials: Slide presentation, Solution assessment form

14:45 - 15:00: Afternoon Tea

15:00 - 15:30: Q&A with Bitwise

Purpose: Provide opportunity for the group to ask questions pertaining to barriers identified in prior session

Format: 30min video conferencing call allowing participants to effectively grill the solution representative on key items raised on D-F-V of the solution as identified through Round 1 development. Followed by 15min discussion.

Materials: None - ensure appropriate mic and camera for call

Detailed Workshop Agenda

Workshop 2 Overview

Workshop 2 intent is to address with a lighter touch the other 5 solutions not developed in the first half of the day (Workshop 1). It also intends to get participants thinking creatively to come up with further solutions that we have yet to explore in the project.

15:30 - 15:40: Workshop 2 intro

Purpose: Run through the non-priority solutions to support shared understanding and explain workshop 2 activities

Format: Presentation

Materials: Presentation

15:40 - 16:20: Workshop 2: Solution Ideation

Purpose: To source capture new ideas for solutions. This may be 1. tech being trialled or considered currently in their businesses, 2. tech they've seen in global rubus or berry businesses, 3. a new idea based on earlier concepts

Format: Lead facilitator engage discussion to have the group come up with new ideas that may address one or more of the problem statements.

Materials: Solution template printouts

16:20 - 17:00: Wrap up

Purpose: Identify stewards for progressing solutions. Capture participants perspectives on the most promising solutions, so we can see how it changes through the activities of the day. Opportunity for reflections on the day and any

Format: Brief presentation w/ digital poll, ask the group for growers to become solution stewards, open conversation.

Materials: Slide presentation, Digital Poll

Technology Canvas Capture 1

Autonomous Collaborative Robots |

To be useful to growers, minimum value solution would need to not bruise the fruit, have pre-established routes and infrastructure/ locations established prior to trials and comply with the biosecurity requirements for growers.

Barriers identified by growers include:

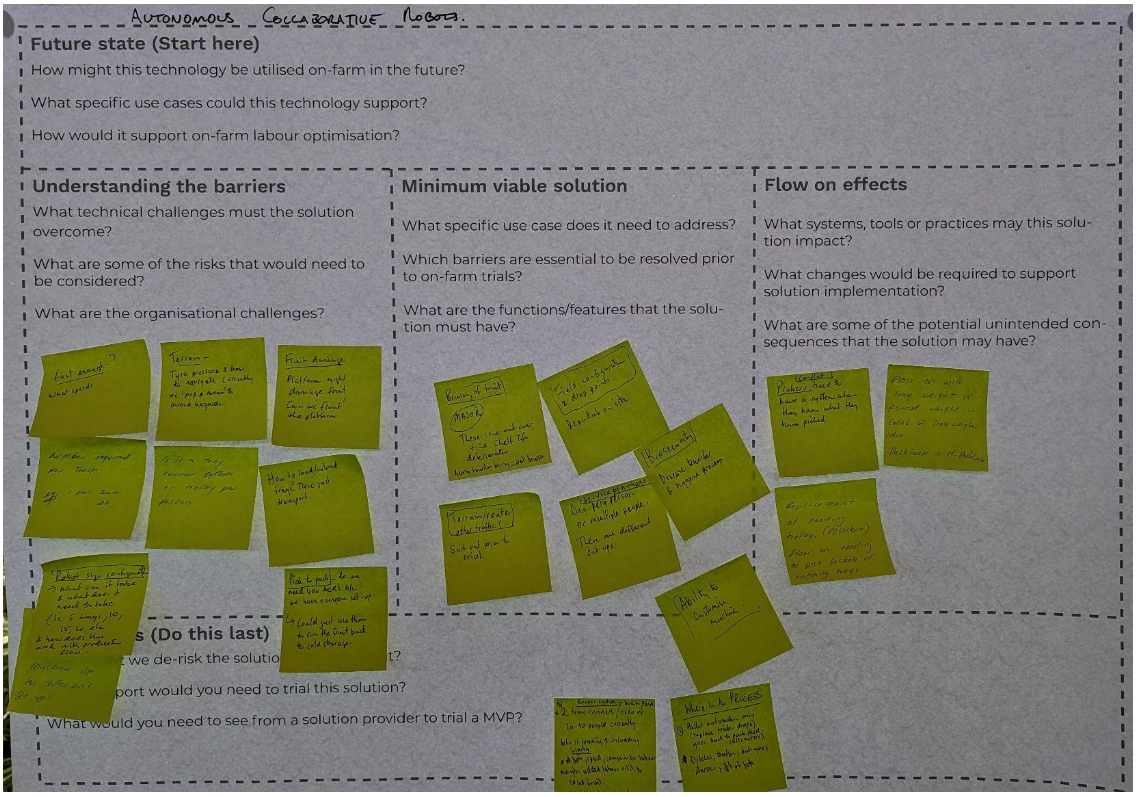
- Terrain and navigation difficulties and inconsistencies
- Shock absorption and potential damage to fruit
- Understanding of where in the process this technology should play a role and how people should interact with it
- Technology provider and accessibility
- Commitment to a subscription mode

Potential flow-on effects:

- Systems for pickers to know what they've picked [conflict]
- Tray weight VS punnet weight, collaborating with the "Packing equipment" idea
- Replacing the need for trollies flowing to needing to carry buckets and trays

Next Steps:

- x2 Tray runners *per* crew of 20/30 people currently
- Who is loading/unload and what are the limits to this?
- Compare the robots capabilities (speed, efficiency, cost, etc.) to the cost of labour
- Focusing on pallet automation first
- Clearing of ditches and prepare terrain



Technology Canvas Capture 2

Advanced Recruitment Assessment|

Future state

1. Clear understanding a great picker
2. Supporting growers in placing people in the right roles, including non-picking tasks
3. Hand in hand with phycological assessments
4. Standardising the tool and information
5. Targeting specific crop profiles

To be useful to growers, minimum value solution would prioritise motivation while also assessing dexterity and coordination while measuring physical attributes.

Barriers identified by growers include:

- Avoiding discrimination
- Understanding what the criteria should be
- Consider cultural sensitivities
- The time required to test
- Proof of effectiveness and evidence
- Correlation between assessment and performance

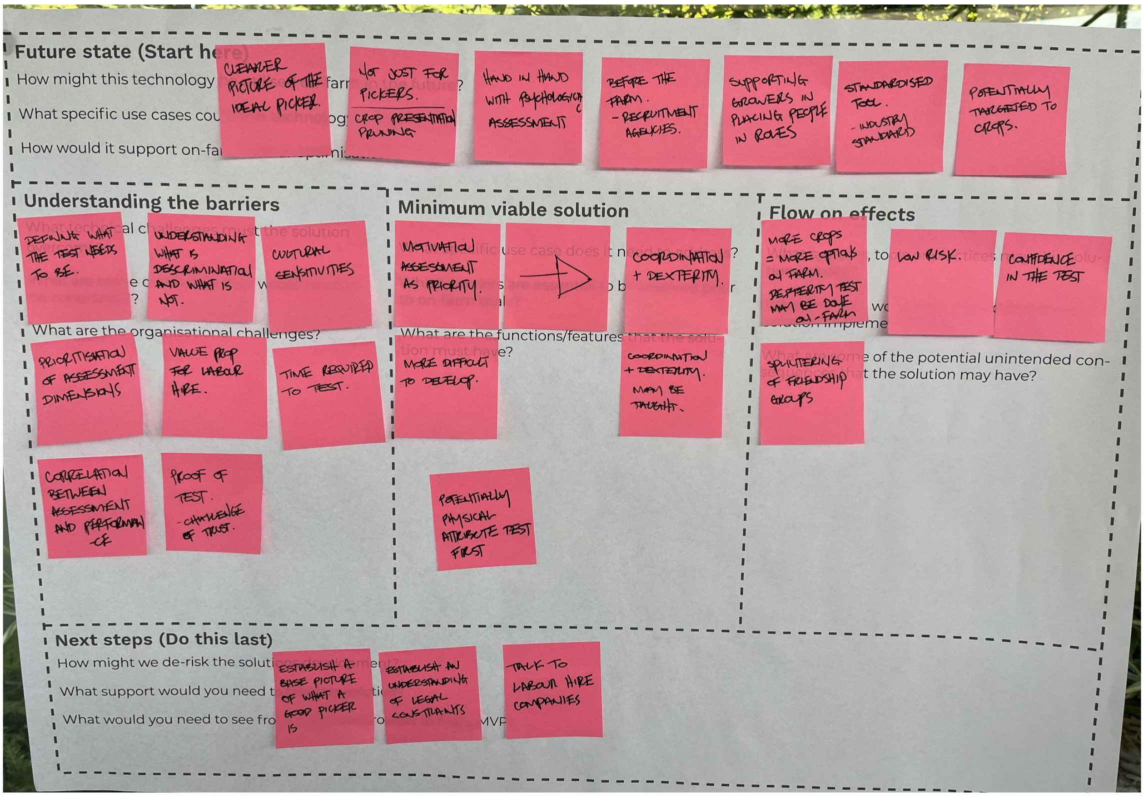
Potential flow-on effects:

Growers expressed that they felt there is a low risk for negative flow-on effects from this practice

- Expanding the practice to more crops
- Splintering friendship groups
- Evidence can provide confidence in testing

Next Steps:

- Establish a base picture of what a good picker is
- Establish and understanding of the legal requirements and constraints
- Talk to recruitment organisations.



Technology Canvas Capture 3

VR Training and Assessment |

Future state

1. Used as a recruitment assessment tool
2. Has passive data collection mechanisms eg. reaction speed, height, size, reach.
3. Bridges language barriers
4. Portable, to take overseas.

To be useful to growers, minimum value solution may contain an initial module that focuses on safety and hygiene. It must reduce the cost of infrastructure and labour, suit the unique needs of each farm, be usable offline and the processes from farmers must disperse responsibility among a wider group to ensure knowledge is distributed.

Barriers identified by growers include:

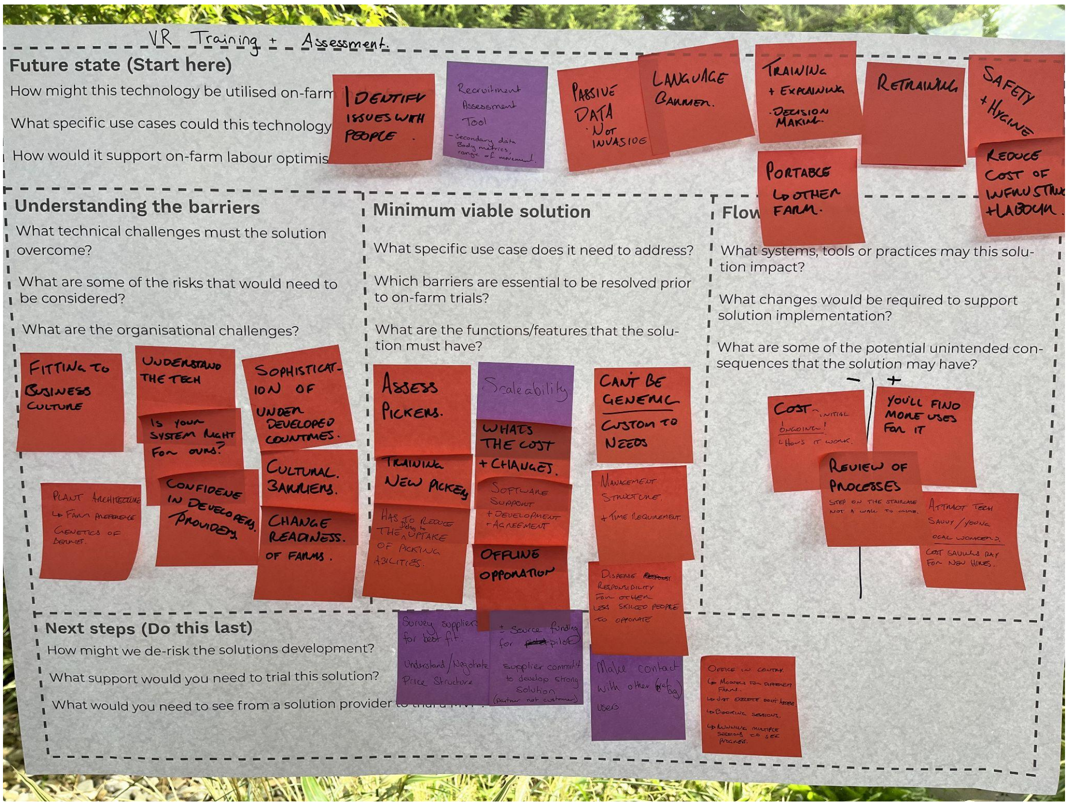
- Underdeveloped countries
- Confidence in the developers/providers
- Cultural barriers and the readiness of farms to change
- A business culture match and internal understanding of the technology

Potential flow-on effects:

Positive flow-on effects could include more uses/modules are likely to be discovered as it gets used, and with the right use, this technology could attract fresh innovative talent to the industry. Contrasting this, negative potential could include, the ongoing and unexpected costs in resources, dependency to a provider, etc.

Next Steps:

- Review of the process.
- Survey potential suppliers for 'best fit'
- Understand and negotiate a price structure
- Source co-funding for a pilot
- Contract with additional partner/users



Technology Canvas Capture 4

Packing equipment |

Future state

1. Simple to set weight ranges and add in additional custom requirements
2. Evidence shows that it improves the efficiency of checks per picker
3. Reduces the need to re-pack punnets

To be useful to growers, minimum value solution would need to be simple, perform consistently, and be simple to clean. Moving further, it can be improved to ensure quality through metal detection, cooling, QA checking and digitiase feedback for use in farm management systems.

Barriers identified by growers include:

- Portable, transportation & storage
- Maintain hygiene
- If it doesn't work property, pickers are may not fix it and look for work-arounds
- Warranties, provision and logistics
- Complexity
- Charging and maintaining use

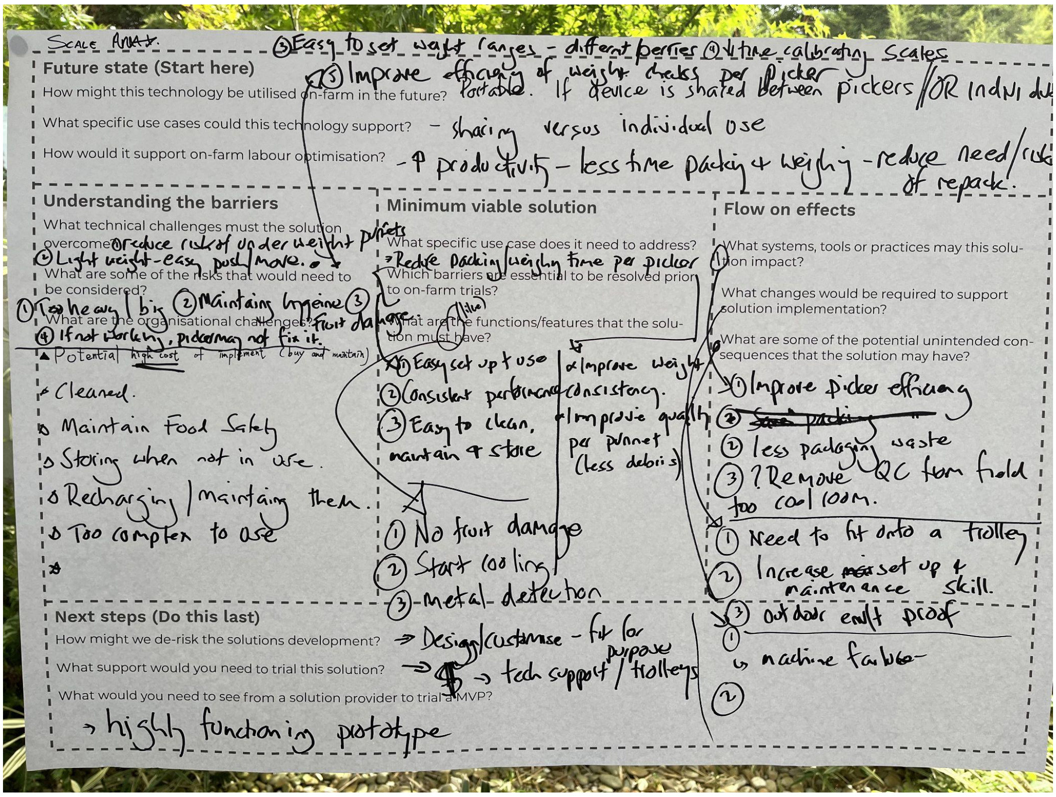
Potential flow-on effects:

Brief sentence

- Improve picking efficiency
- Less packaging waste
- Remove QC from field to cool rooms
- Needs to push a trolly
- Increase set up an maintenance skills
- Higher maintenance costs & machine failures

Next Steps:

- Design the product and customise it to ensure it's fit-for-purpose
- Cost of tech support / trolleys
- High function prototypes



Technology Canvas Capture 5

Exoskeletons for workers|

Future state

1. Use in off-season strenuous tasks
2. Cost-efficient model for use in harvest
3. Validated for tray handling
4. Improve comfort and satisfaction

To be useful to growers, minimum value solution would need to meet hygiene requirements, consistent for workers and be simple to put on and set up quickly.

Barriers identified by growers include:

- Storage
- Cleaning
- Maintenance and repair process for wear and tear
- Components snapping could present safety hazards

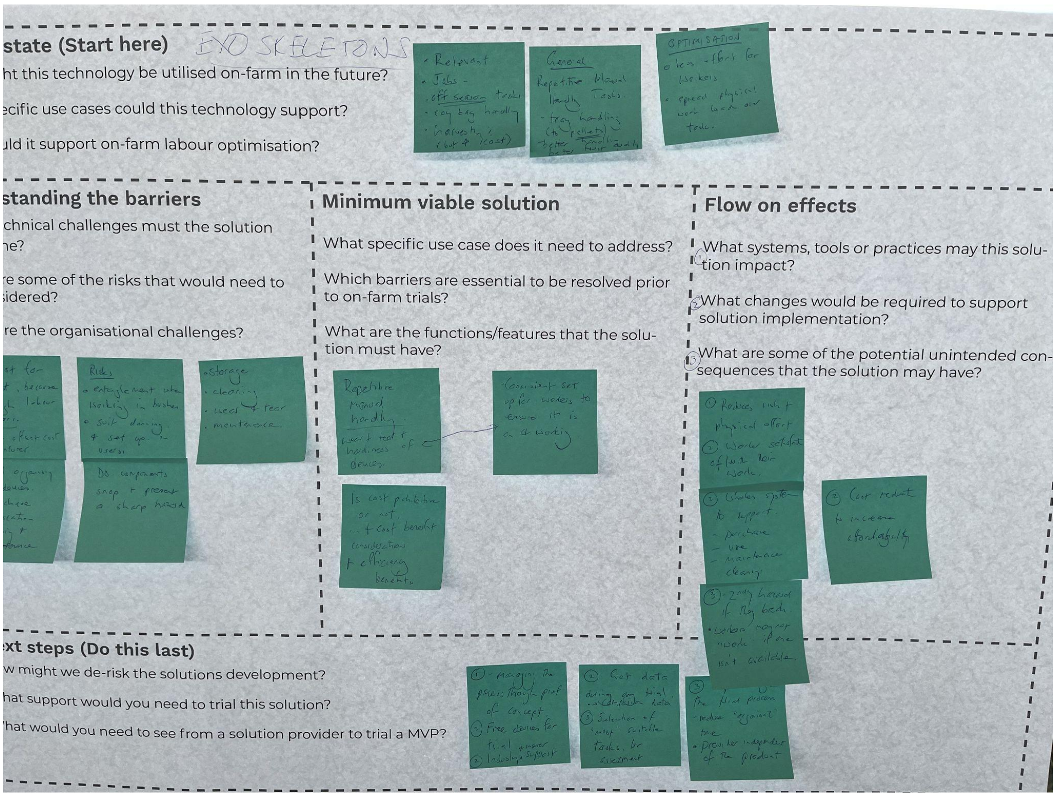
Potential flow-on effects:

Brief sentence

- Reduces the right physical effort
- Worker satisfaction increases
- Support systems needs (purchase, use, maintenance, cleaning)
- Hazards on breaking
- Workers may not work if they're unavailable

Next Steps:

- Managing the process through a proof of concept
- Free devices for trials
- Source industry support
- Acquire data to support a business case
- Assess the 'most suitable' tasks
- A provider that is independent of the product



Technology Canvas Capture 6

Ergonomic picking equipment|

Future state

1. Works effectively across a range of heavy and light loads
2. Short horizon technology
3. Affordable price point to compete with current solutions
4. Farm level tests
5. Reduce exposure of fruits to the elements

To be useful to growers, minimum value solution must ensure they do not reduce range of movement to impact picking and work across heavy and light loads. The product must be lightweight, meet highine requirements, be durable and reduce picking times. Any trials must capture data to provide evidence of the effectiveness.

Barriers identified by growers include:

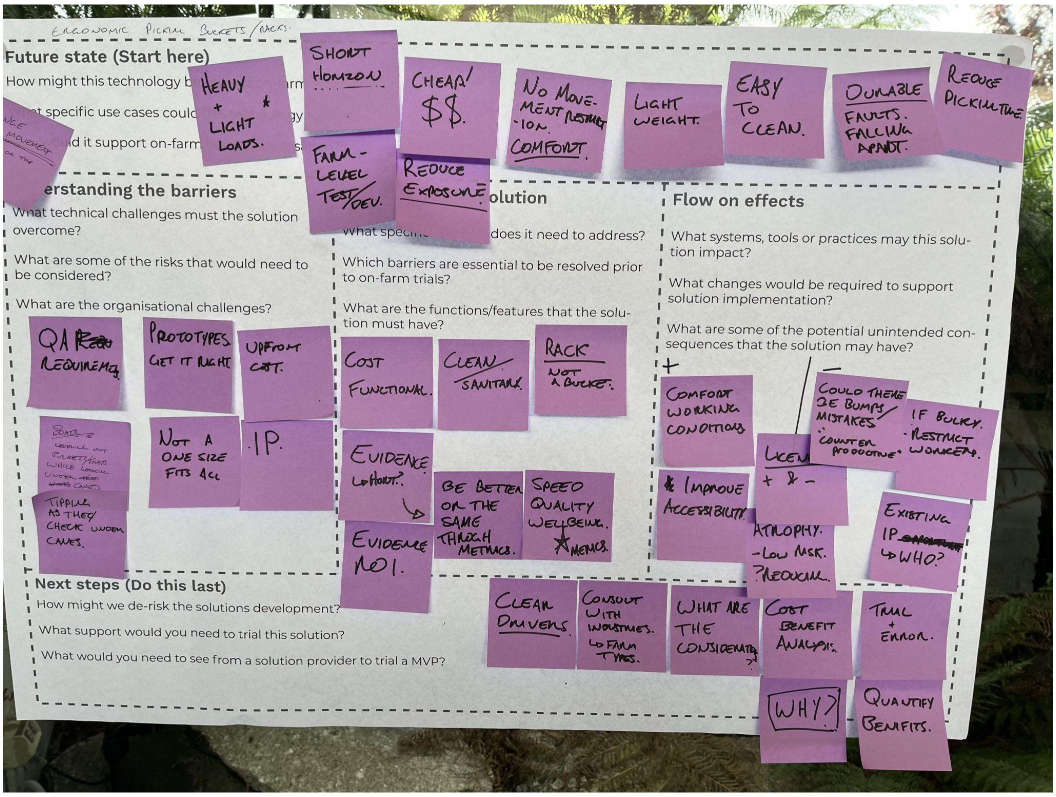
- QA and Hygiene requirements
- IP landscape
- Not a one size fits all solution
- Tipping under canes
- Upfront costs

Potential flow-on effects:

- Pickers will need a system that lets them know how much they have picked
- Connection point for *"Packing equipment"*
- Replace the need for a trolly
- Comfort and improved working conditions
- Conflicts with existing IP

Next Steps:

- Likely a design that holds buckets/trays rather than something that you place into
- Understand the design requirements
- Cost benefit analysis needed
- Quantify the benefits



Technology Canvas Capture 7

Data Empowered Resource Planning and Deployment|

Future state

1. Optimal timing for crops
2. Planning crop pest and disease treatment and detection
3. A system that removes flies from blocks

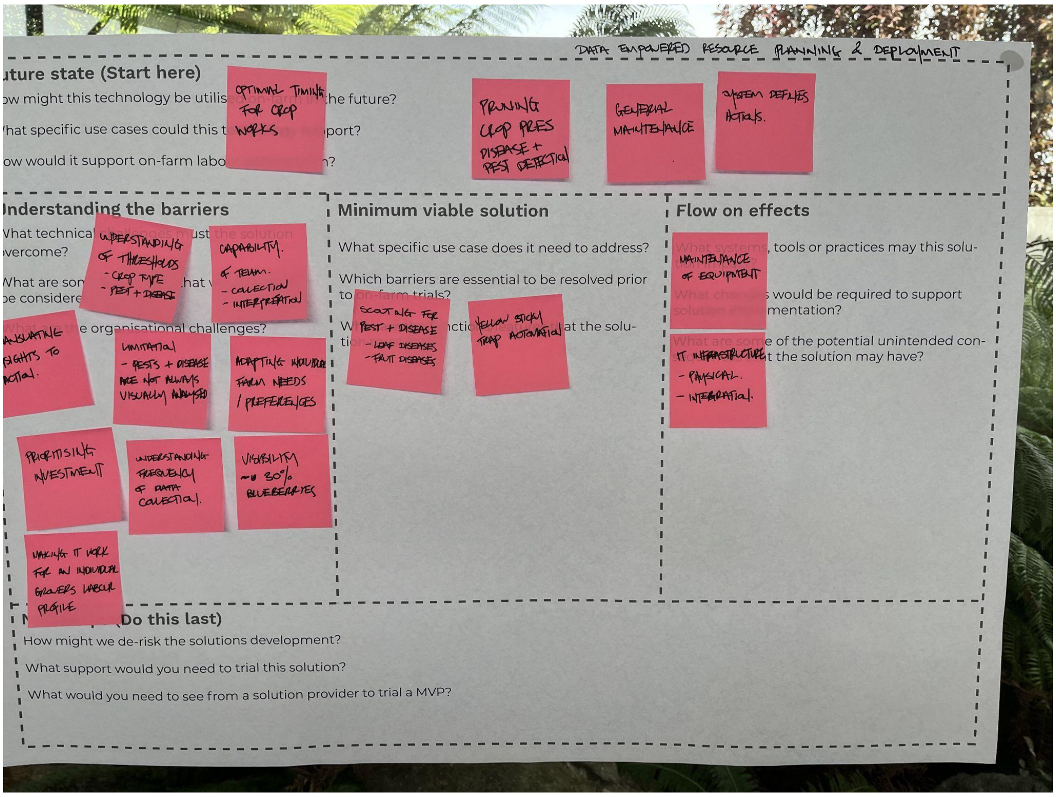
An MVP for growers would need to scout for pests & disease on leaves and fruit, potentially automating the process of laying deterrent/extermination like 'yellow sticky tape'.

Barriers identified by growers include:

- Adapting to individual farm needs
- Contextual understanding of crop times and pest/disease
- Team capabilities for collections and interpretation of data
- Directing investment
- Working for various individual grower's labour profiles

Potential flow-on effects:

- Maintenance and equipment
- IT infrastructure requirements, physical and integration



Technology Canvas Capture 6

Computer Vision for Quality Assessment

Future state

1. In depth QC before packing to keep QC honest and collect data
2. Capture of waste data - Impact operational decisions - granular data used year to year

To be useful to growers, minimum value solution would need to have a clear way to adjust QC systems based on feedback through the season, need to feed back into the software to improve over time and would need to produce evidence of known defects in both lab conditions and in-field.

Barriers identified by growers include:

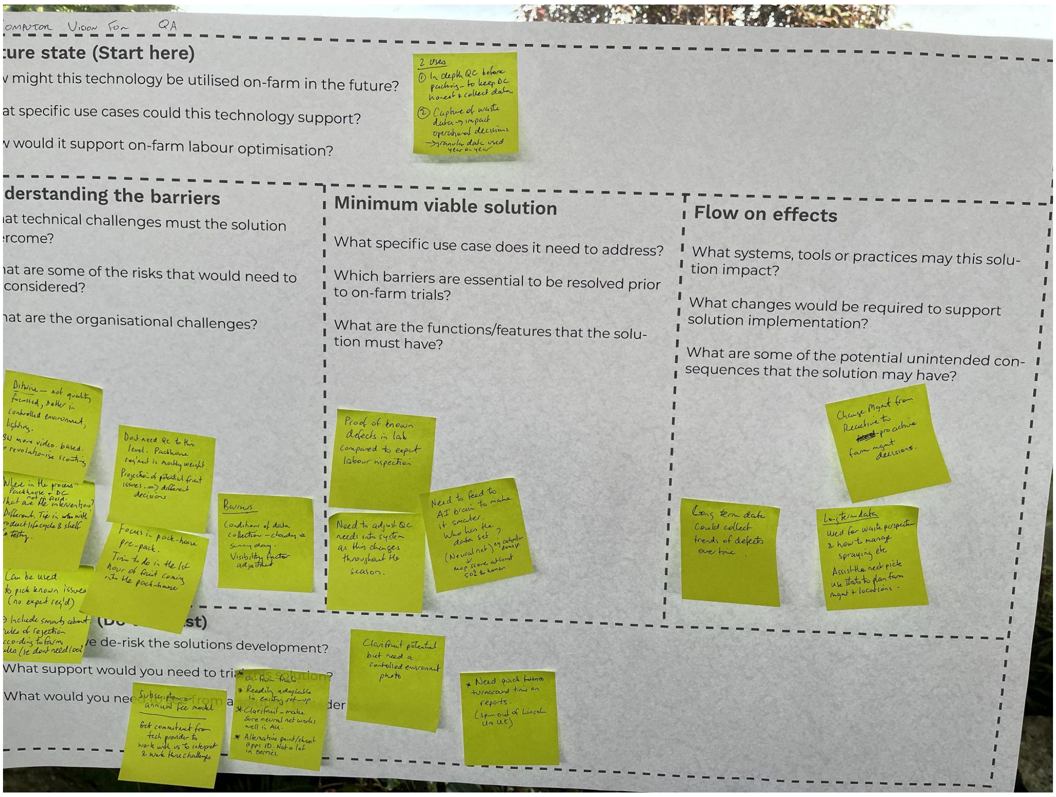
- How do weather and climate conditions affect the collection
- Being provided too much detail, growers only need information that is relevant to the kinds of decisions they're prepared to make

Potential flow-on effects:

- Change on-farm practices to being more proactive than reactive
- Long term data could collect defect trends overtime, exposing systematic flaws
- Long term data could be expanded to waste and managing how spraying is done

Next Steps:

- Subscription and or annual fee model and having a commitment from a provider to collaborate and improve the technology
- Run on farm trials
- Explore use of clarifruit and alternative point and shoot apps
- Exploring ways to get a quicker turnaround on information being reported



Appendix G

Solution Assessments

Solution assessment rubric

[Solution name]

The lenses of commercial opportunity

The Growth Drivers (TGD) have developed an approach for initial solution screening of solutions that extends upon the original work by IDEO [1], [2]. Our solution assessment rubric is used by the project team to investigate how well a particular solution addresses desirability, feasibility, viability, and scalability criteria. The solution assessment rubric is intended to be utilised by individual growers, as well as advisory groups. Completed forms help the project team eliminate and prioritise solutions, identify potential barriers to adoption, and plan the next stages of solution concept development.

Mark the most relevant box from each prompt below.

Desirability

How relevant is it to growers?

The solution **is not of interest** to any grower segment.	
The solution **has confirmed interest** from a grower segment	
The solution **has confirmed interest from several** grower segments	

Is the solution linked to problem statement(s)?

The solution is **not linked** to a problem statement	
The solution is **weakly linked** to a problem statement	
The solution is **strongly linked** to a problem statement	

How much does the solution address?

The solution addresses **minor** issue(s)	
The solution addresses **major** issue(s)	
The solution has the **potential to significantly change or revolutionize** the practice or operations of growers	

Feasibility

What's the resolution of the solution?

The solution is a **concept only**	
The solution **can be demonstrated**	
The solution **can be demonstrated and is as good or better than current practice**.	

Are there technical barriers to overcome?

The solution **requires solving minor technical barriers**	
The solution **requires solving major technical barriers**	

Viability

What are the potential business gains?

The solution **does not make business sense** to growers	
The solution offers the potential of **marginal** financial and non-financial gains to growers	
The solution offers the potential of **moderate** financial and non-financial gains to growers	
The solution offers the potential of **significant** financial and non-financial gains to growers	

What is the required investment?

The solution requires **zero or minimal** investment	
The solution requires **moderate** investment	
The solution requires **significant** investment	

How quickly will businesses see a ROI?

The solution could provide benefit **immediately**	
The solution could provide benefit **within 1 year**	
The solution could provide benefit **within 1-3 years**	
The solution could provide benefits in **over 5 years**	

Scalability

Can difficult is it for businesses adopt it as is?

It would be **easy** to adopt the solution into existing operations	
It would be **hard** to adopt the solution into existing operations	

How well does it scale?

The solution could **not easily scale within the rubus business**	
The solution could **easily scale within the rubus business**	
The solution could **easily scale beyond rubus to other crops**	

1 Design Thinking Defined. IDEO
2 IDEO's Design Thinking Framework. Falvo, L., Hagahmed, M., & Chan, T. M. Education Theory Made Practical, Volume 5.

Comments and Recommendations

[Solution name]

General comments or recommendations

Are there any specific comments to note or recommendations for this solution?

[Please write your comments in here]

Category specific comments

Anything specific to desirability, feasibility, viability or scalability of the solution?

Desirability

What is desirable from a human perspective?

[Please write your comments in here]

Viability

What is viable from a technical perspective?

[Please write your comments in here]

Feasibility

What is feasible from an economic perspective?

[Please write your comments in here]

Scalability

What is scalable through to other or more aspects of the business?

[Please write your comments in here]

Autonomous Collaborative Robots

Participation:
9/9

Grower Sentiment Score
5.72/8

	Question / Names	Participant 1 (Large)	Participant 2 (Medium	Participant 3 (Large)	Participant 4 (Medium)	Participant 5 (Large)	Participant 6 (Very Large)	Participant 7 (Medium)	Participant 8 (Other)	Participant 9 (Medium)
Desirable	How relevant is it to growers?	2: The solution is of interest to me	2: The solution is of interest to me	2: The solution is of interest to me	3: The solution is of significant interest to me	3: The solution is of significant interest to me	3: The solution is of significant interest to me	3: The solution is of significant interest to me	2: The solution is of interest to me	2: The solution is of interest to me
	Is the solution linked to problem statement(s)?	3: The solution is strongly linked to a problem statement	3: The solution is strongly linked to a problem statement	2: The solution is weakly linked to a problem statement	2: The solution is weakly linked to a problem statement	3: The solution is strongly linked to a problem statement	3: The solution is strongly linked to a problem statement	2: The solution is weakly linked to a problem statement	3: The solution is strongly linked to a problem statement	2: The solution is weakly linked to a problem statement
	How much does the solution address?	3: The solution has the potential to significantly change or revolutionize the practice or operations of growers	1: The solution addresses minor issue(s)	1: The solution addresses minor issue(s)	2: The solution addresses major issue(s)	1: The solution addresses minor issue(s)	2: The solution addresses major issue(s)	2: The solution addresses major issue(s)	2: The solution addresses major issue(s)	3: The solution has the potential to significantly change or revolutionize the practice or operations of growers
Viable	What's the resolution of the solution?	2: The solution can be demonstrated	2: The solution can be demonstrated	2: The solution can be demonstrated	2: The solution can be demonstrated	3: The solution can be demonstrated and is as good or better than current practice.	2: The solution can be demonstrated	3: The solution can be demonstrated and is as good or better than current practice.	2: The solution can be demonstrated	2: The solution can be demonstrated
	Are there technical barriers to overcome?	2: The solution requires solving major technical barriers	1: The solution requires solving minor technical barriers	2: The solution requires solving major technical barriers	2: The solution requires solving major technical barriers	2: The solution requires solving major technical barriers	2: The solution requires solving major technical barriers	1: The solution requires solving minor technical barriers	1: The solution requires solving minor technical barriers	2: The solution requires solving major technical barriers
Feasible	What are the potential business gains?	3: The solution offers the potential of moderate financial and non-financial gains to me	3: The solution offers the potential of moderate financial and non-financial gains to me	3: The solution offers the potential of moderate financial and non-financial gains to me	4: The solution offers the potential of significant financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me		4: The solution offers the potential of significant financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me
	What is the required investment?	3: The solution requires significant investment	3: The solution requires significant investment	3: The solution requires significant investment	3: The solution requires significant investment	3: The solution requires significant investment		2: The solution requires moderate investment	3: The solution requires significant investment	2: The solution requires moderate investment
	How quickly will businesses see a ROI?	2: The solution could provide benefit within 1 year	3: The solution could provide benefit within 1-3 years	3: The solution could provide benefit within 1-3 years	1: The solution could provide benefit immediately	2: The solution could provide benefit within 1 year		2: The solution could provide benefit within 1 year	3: The solution could provide benefit within 1-3 years	2: The solution could provide benefit within 1 year
Scaleable	How difficult is it for businesses adopt it as is?	2: It would be hard to adopt the solution into existing operations	2: It would be hard to adopt the solution into existing operations	2: It would be hard to adopt the solution into existing operations	2: It would be hard to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations		1: It would be easy to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations
	How well does it scale?	1: The solution could not easily scale within our rubus business	1: The solution could not easily scale within our rubus business	1: The solution could not easily scale within our rubus business	3: The solution could easily scale beyond rubus to other crops I grow	3: The solution could easily scale beyond rubus to other crops I grow		3: The solution could easily scale beyond rubus to other crops I grow	2: The solution could easily scale within our rubus business	2: The solution could easily scale within our rubus business

Virtual Reality Training and Assessment

Participation:
7/9

Grower Sentiment Score
4.92/8

	Question / Names	Participant 1 (Large)	Participant 2 (Medium	Participant 3 (Large)	Participant 4 (Medium)	Participant 5 (Large)	Participant 6 (Very Large)	Participant 7 (Medium)	Participant 8 (Other)	Participant 9 (Medium)
Desirable	How relevant is it to growers?	3: The solution is of significant interest to me		2: The solution is of interest to me	2: The solution is of interest to me	1: The solution is not of interest to me	2: The solution is of interest to me	2: The solution is of interest to me	2: The solution is of interest to me	
Desirable	Is the solution linked to problem statement(s)?	3: The solution is strongly linked to a problem statement		2: The solution is weakly linked to a problem statement	2: The solution is weakly linked to a problem statement	2: The solution is weakly linked to a problem statement	2: The solution is weakly linked to a problem statement	3: The solution is strongly linked to a problem statement	3: The solution is strongly linked to a problem statement	
Desirable	How much does the solution address?	3: The solution has the potential to significantly change or revolutionize the practice or operations of growers		1: The solution addresses minor issue(s)	1: The solution addresses minor issue(s)	1: The solution addresses minor issue(s)		1: The solution addresses minor issue(s)	2: The solution addresses major issue(s)	
Viable	What's the resolution of the solution?	2: The solution can be demonstrated		2: The solution can be demonstrated	2: The solution can be demonstrated	2: The solution can be demonstrated	1: The solution is a concept only	2: The solution can be demonstrated	2: The solution can be demonstrated	
Viable	Are there technical barriers to overcome?	2: The solution requires solving major technical barriers		2: The solution requires solving major technical barriers	1: The solution requires solving minor technical barriers	1: The solution requires solving minor technical barriers		1: The solution requires solving minor technical barriers	1: The solution requires solving minor technical barriers	
Feasible	What are the potential business gains?	3: The solution offers the potential of moderate financial and non-financial gains to me		4: The solution offers the potential of significant financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me	3: The solution offers the potential of moderate financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me	3: The solution offers the potential of moderate financial and non-financial gains to me	
Feasible	What is the required investment?	3: The solution requires significant investment		3: The solution requires significant investment	1: The solution requires zero or minimal investment	2: The solution requires moderate investment	3: The solution requires significant investment	2: The solution requires moderate investment	2: The solution requires moderate investment	
Feasible	How quickly will businesses see a ROI?	3: The solution could provide benefit within 1-3 years		2: The solution could provide benefit within 1 year	1: The solution could provide benefit immediately	3: The solution could provide benefit within 1-3 years	2: The solution could provide benefit within 1 year	2: The solution could provide benefit within 1 year	2: The solution could provide benefit within 1 year	
Scaleable	How difficult is it for businesses adopt it as is?	1: It would be easy to adopt the solution into existing operations		1: It would be easy to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations	2: It would be hard to adopt the solution into existing operations	2: It would be hard to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations	
Scaleable	How well does it scale?	2: The solution could easily scale within our rubus business		2: The solution could easily scale within our rubus business	2: The solution could easily scale within our rubus business	1: The solution could not easily scale within our rubus business	2: The solution could easily scale within our rubus business	3: The solution could easily scale beyond rubus to other crops I grow	2: The solution could easily scale within our rubus business	

Advanced Recruitment Assessment

Participation:
5/9

Grower Sentiment Score
6.73/8

	Question / Names	Participant 1 (Large)	Participent 2 (Medium	Participant 3 (Large)	Participant 4 (Medium)	Participant 5 (Large)	Participant 6 (Very Large)	Participant 7 (Medium)	Participant 8 (Other)	Participant 9 (Medium)
Desirable	How relevant is it to growers?	3: The solution is of significant interest to me		1: The solution is not of interest to me		3: The solution is of significant interest to me	3: The solution is of significant interest to me		2: The solution is of interest to me	
	Is the solution linked to problem statement(s)?	3: The solution is strongly linked to a problem statement		2: The solution is weakly linked to a problem statement		3: The solution is strongly linked to a problem statement	3: The solution is strongly linked to a problem statement		3: The solution is strongly linked to a problem statement	
	How much does the solution address?	2: The solution addresses major issue(s)		1: The solution addresses minor issue(s)		2: The solution addresses major issue(s)	2: The solution addresses major issue(s)		2: The solution addresses major issue(s)	
Viable	What's the resolution of the solution?	2: The solution can be demonstrated		2: The solution can be demonstrated		3: The solution can be demonstrated and is as good or better than current practice.	3: The solution can be demonstrated and is as good or better than current practice.		2: The solution can be demonstrated	
	Are there technical barriers to overcome?	1: The solution requires solving minor technical barriers		1: The solution requires solving minor technical barriers		2: The solution requires solving major technical barriers	1: The solution requires solving minor technical barriers		1: The solution requires solving minor technical barriers	
Feasible	What are the potential business gains?	3: The solution offers the potential of moderate financial and non-financial gains to me		2: The solution offers the potential of marginal financial and non-financial gains to me		4: The solution offers the potential of significant financial and non-financial gains to me	3: The solution offers the potential of moderate financial and non-financial gains to me		3: The solution offers the potential of moderate financial and non-financial gains to me	
	What is the required investment?	2: The solution requires moderate investment		2: The solution requires moderate investment		2: The solution requires moderate investment	1: The solution requires zero or minimal investment		2: The solution requires moderate investment	
	How quickly will businesses see a ROI?	2: The solution could provide benefit within 1 year		2: The solution could provide benefit within 1 year		2: The solution could provide benefit within 1 year	1: The solution could provide benefit immediately		2: The solution could provide benefit within 1 year	
Scaleable	How difficult is it for businesses adopt it as is?	1: It would be easy to adopt the solution into existing operations		1: It would be easy to adopt the solution into existing operations		1: It would be easy to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations		1: It would be easy to adopt the solution into existing operations	
	How well does it scale?	2: The solution could easily scale within our rubus business		1: The solution could not easily scale within our rubus business		3: The solution could easily scale beyond rubus to other crops I grow	3: The solution could easily scale beyond rubus to other crops I grow		2: The solution could easily scale within our rubus business	

Packing Equipment

Participation:
5/9

Grower Sentiment Score
3.73/8

	Question / Names	Participant 1 (Large)	Participant 2 (Medium	Participant 3 (Large)	Participant 4 (Medium)	Participant 5 (Large)	Participant 6 (Very Large)	Participant 7 (Medium)	Participant 8 (Other)	Participant 9 (Medium)
Desirable	How relevant is it to growers?			2: The solution is of interest to me		2: The solution is of interest to me	2: The solution is of interest to me		2: The solution is of interest to me	1: The solution is not of interest to me
	Is the solution linked to problem statement(s)?			2: The solution is weakly linked to a problem statement		2: The solution is weakly linked to a problem statement	2: The solution is weakly linked to a problem statement		2: The solution is weakly linked to a problem statement	2: The solution is weakly linked to a problem statement
	How much does the solution address?			1: The solution addresses minor issue(s)		1: The solution addresses minor issue(s)			1: The solution addresses minor issue(s)	2: The solution addresses major issue(s)
Viable	What's the resolution of the solution?			1: The solution is a concept only		2: The solution can be demonstrated	2: The solution can be demonstrated		2: The solution can be demonstrated	2: The solution can be demonstrated
	Are there technical barriers to overcome?			1: The solution requires solving minor technical barriers		1: The solution requires solving minor technical barriers	1: The solution requires solving minor technical barriers		1: The solution requires solving minor technical barriers	1: The solution requires solving minor technical barriers
Feasible	What are the potential business gains?			1: The solution does not make business sense to me		2: The solution offers the potential of marginal financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me		2: The solution offers the potential of marginal financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me
	What is the required investment?			2: The solution requires moderate investment		2: The solution requires moderate investment	2: The solution requires moderate investment		1: The solution requires zero or minimal investment	2: The solution requires moderate investment
	How quickly will businesses see a ROI?			1: The solution could provide benefit immediately		2: The solution could provide benefit within 1 year	1: The solution could provide benefit immediately		2: The solution could provide benefit within 1 year	2: The solution could provide benefit within 1 year
Scaleable	How difficult is it for businesses adopt it as is?			1: It would be easy to adopt the solution into existing operations		1: It would be easy to adopt the solution into existing operations				
	How well does it scale?			2: The solution could easily scale within our rubus business		2: The solution could easily scale within our rubus business	2: The solution could easily scale within our rubus business			

Computer Vision Quality Assessment

Participation:
5/9

Grower Sentiment Score
5.83/8

	Question / Names	Participant 1 (Large)	Participant 2 (Medium	Participant 3 (Large)	Participant 4 (Medium)	Participant 5 (Large)	Participant 6 (Very Large)	Participant 7 (Medium)	Participant 8 (Other)	Participant 9 (Medium)
Desirable	How relevant is it to growers?			3: The solution is of significant interest to me	2: The solution is of interest to me		2: The solution is of interest to me	3: The solution is of significant interest to me	2: The solution is of interest to me	
Desirable	Is the solution linked to problem statement(s)?			3: The solution is strongly linked to a problem statement	2: The solution is weakly linked to a problem statement		2: The solution is weakly linked to a problem statement	3: The solution is strongly linked to a problem statement	3: The solution is strongly linked to a problem statement	
Desirable	How much does the solution address?			2: The solution addresses major issue(s)	1: The solution addresses minor issue(s)		2: The solution addresses major issue(s)	2: The solution addresses major issue(s)	2: The solution addresses major issue(s)	
Viable	What's the resolution of the solution?			3: The solution can be demonstrated and is as good or better than current practice.	2: The solution can be demonstrated		1: The solution is a concept only	2: The solution can be demonstrated	2: The solution can be demonstrated	
Viable	Are there technical barriers to overcome?			2: The solution requires solving major technical barriers	1: The solution requires solving minor technical barriers		2: The solution requires solving major technical barriers	1: The solution requires solving minor technical barriers	1: The solution requires solving minor technical barriers	
Feasible	What are the potential business gains?			4: The solution offers the potential of significant financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me		3: The solution offers the potential of moderate financial and non-financial gains to me	3: The solution offers the potential of moderate financial and non-financial gains to me	3: The solution offers the potential of moderate financial and non-financial gains to me	
Feasible	What is the required investment?			3: The solution requires significant investment	2: The solution requires moderate investment		2: The solution requires moderate investment	2: The solution requires moderate investment	2: The solution requires moderate investment	
Feasible	How quickly will businesses see a ROI?			3: The solution could provide benefit within 1-3 years	1: The solution could provide benefit immediately		2: The solution could provide benefit within 1 year	2: The solution could provide benefit within 1 year	3: The solution could provide benefit within 1-3 years	
Scaleable	How difficult is it for businesses adopt it as is?			2: It would be hard to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations		2: It would be hard to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations	
Scaleable	How well does it scale?			1: The solution could not easily scale within our rubus business	2: The solution could easily scale within our rubus business		3: The solution could easily scale beyond rubus to other crops I grow	3: The solution could easily scale beyond rubus to other crops I grow	2: The solution could easily scale within our rubus business	

Exoskeletons for Workers

Participation:
4/9

Grower Sentiment Score
4/8

	Question / Names	Participant 1 (Large)	Participant 2 (Medium	Participant 3 (Large)	Participant 4 (Medium)	Participant 5 (Large)	Participant 6 (Very Large)	Participant 7 (Medium)	Participant 8 (Other)	Participant 9 (Medium)
Desirable	How relevant is it to growers?		2: The solution is of interest to me	2: The solution is of interest to me			2: The solution is of interest to me		2: The solution is of interest to me	
Desirable	Is the solution linked to problem statement(s)?		3: The solution is strongly linked to a problem statement	2: The solution is weakly linked to a problem statement			2: The solution is weakly linked to a problem statement		3: The solution is strongly linked to a problem statement	
Desirable	How much does the solution address?		1: The solution addresses minor issue(s)	1: The solution addresses minor issue(s)			2: The solution addresses major issue(s)		2: The solution addresses major issue(s)	
Viable	What's the resolution of the solution?		2: The solution can be demonstrated	2: The solution can be demonstrated			1: The solution is a concept only		2: The solution can be demonstrated	
Viable	Are there technical barriers to overcome?		1: The solution requires solving minor technical barriers	1: The solution requires solving minor technical barriers			2: The solution requires solving major technical barriers		2: The solution requires solving major technical barriers	
Feasible	What are the potential business gains?		2: The solution offers the potential of marginal financial and non-financial gains to me	3: The solution offers the potential of moderate financial and non-financial gains to me			2: The solution offers the potential of marginal financial and non-financial gains to me		3: The solution offers the potential of moderate financial and non-financial gains to me	
Feasible	What is the required investment?		3: The solution requires significant investment	2: The solution requires moderate investment			3: The solution requires significant investment		3: The solution requires significant investment	
Feasible	How quickly will businesses see a ROI?		3: The solution could provide benefit within 1-3 years	2: The solution could provide benefit within 1 year			1: The solution could provide benefit immediately		2: The solution could provide benefit within 1 year	
Scaleable	How difficult is it for businesses adopt it as is?		2: It would be hard to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations			2: It would be hard to adopt the solution into existing operations		1: It would be easy to adopt the solution into existing operations	
Scaleable	How well does it scale?		1: The solution could not easily scale within our rubus business	1: The solution could not easily scale within our rubus business			1: The solution could not easily scale within our rubus business		3: The solution could easily scale beyond rubus to other crops I grow	

Ergonomic Picking Equipment

Participation:
5/9

Grower Sentiment Score
4.67/8

	Question / Names	Participant 1 (Large)	Participant 2 (Medium	Participant 3 (Large)	Participant 4 (Medium)	Participant 5 (Large)	Participant 6 (Very Large)	Participant 7 (Medium)	Participant 8 (Other)	Participant 9 (Medium)
Desirable	How relevant is it to growers?		2: The solution is of interest to me	2: The solution is of interest to me	2: The solution is of interest to me		2: The solution is of interest to me		2: The solution is of interest to me	
Desirable	Is the solution linked to problem statement(s)?		2: The solution is weakly linked to a problem statement	2: The solution is weakly linked to a problem statement	2: The solution is weakly linked to a problem statement		2: The solution is weakly linked to a problem statement		3: The solution is strongly linked to a problem statement	
Desirable	How much does the solution address?		1: The solution addresses minor issue(s)	1: The solution addresses minor issue(s)	1: The solution addresses minor issue(s)		1: The solution addresses minor issue(s)			
Viable	What's the resolution of the solution?		2: The solution can be demonstrated	1: The solution is a concept only	2: The solution can be demonstrated		2: The solution can be demonstrated		2: The solution can be demonstrated	
Viable	Are there technical barriers to overcome?		1: The solution requires solving minor technical barriers	1: The solution requires solving minor technical barriers	1: The solution requires solving minor technical barriers		1: The solution requires solving minor technical barriers		1: The solution requires solving minor technical barriers	
Feasible	What are the potential business gains?		2: The solution offers the potential of marginal financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me	2: The solution offers the potential of marginal financial and non-financial gains to me		2: The solution offers the potential of marginal financial and non-financial gains to me		3: The solution offers the potential of moderate financial and non-financial gains to me	
Feasible	What is the required investment?		2: The solution requires moderate investment	2: The solution requires moderate investment	1: The solution requires zero or minimal investment		1: The solution requires zero or minimal investment		2: The solution requires moderate investment	
Feasible	How quickly will businesses see a ROI?		2: The solution could provide benefit within 1 year	1: The solution could provide benefit immediately	1: The solution could provide benefit immediately		1: The solution could provide benefit immediately		2: The solution could provide benefit within 1 year	
Scaleable	How difficult is it for businesses adopt it as is?		1: It would be easy to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations		1: It would be easy to adopt the solution into existing operations		1: It would be easy to adopt the solution into existing operations	
Scaleable	How well does it scale?		2: The solution could easily scale within our rubus business	1: The solution could not easily scale within our rubus business	2: The solution could easily scale within our rubus business		3: The solution could easily scale beyond rubus to other crops I grow		2: The solution could easily scale within our rubus business	

Data Empowered Resource Planning & Deployment

Participation:
4/9

Grower Sentiment Score
6.94/8

	Question / Names	Participant 1 (Large)	Participant 2 (Medium	Participant 3 (Large)	Participant 4 (Medium)	Participant 5 (Large)	Participant 6 (Very Large)	Participant 7 (Medium)	Participant 8 (Other)	Participant 9 (Medium)
Desirable	How relevant is it to growers?			3: The solution is of significant interest to me			2: The solution is of interest to me	3: The solution is of significant interest to me	2: The solution is of interest to me	
	Is the solution linked to problem statement(s)?			3: The solution is strongly linked to a problem statement			2: The solution is weakly linked to a problem statement	3: The solution is strongly linked to a problem statement	2: The solution is weakly linked to a problem statement	
	How much does the solution address?			3: The solution has the potential to significantly change or revolutionize the practice or operations of growers				3: The solution has the potential to significantly change or revolutionize the practice or operations of growers	2: The solution addresses major issue(s)	
Viable	What's the resolution of the solution?			3: The solution can be demonstrated and is as good or better than current practice.			2: The solution can be demonstrated	3: The solution can be demonstrated and is as good or better than current practice.	2: The solution can be demonstrated	
	Are there technical barriers to overcome?			2: The solution requires solving major technical barriers			2: The solution requires solving major technical barriers	1: The solution requires solving minor technical barriers	2: The solution requires solving major technical barriers	
Feasible	What are the potential business gains?			4: The solution offers the potential of significant financial and non-financial gains to me			3: The solution offers the potential of moderate financial and non-financial gains to me	4: The solution offers the potential of significant financial and non-financial gains to me	3: The solution offers the potential of moderate financial and non-financial gains to me	
	What is the required investment?			3: The solution requires significant investment			2: The solution requires moderate investment	2: The solution requires moderate investment	2: The solution requires moderate investment	
	How quickly will businesses see a ROI?			3: The solution could provide benefit within 1-3 years			3: The solution could provide benefit within 1-3 years	1: The solution could provide benefit immediately	2: The solution could provide benefit within 1 year	
Scaleable	How difficult is it for businesses adopt it as is?			2: It would be hard to adopt the solution into existing operations			2: It would be hard to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations	1: It would be easy to adopt the solution into existing operations	
	How well does it scale?			1: The solution could not easily scale within our rubus business			3: The solution could easily scale beyond rubus to other crops I grow	3: The solution could easily scale beyond rubus to other crops I grow	2: The solution could easily scale within our rubus business	

Appendix H
Case Studies

Field Work Robotics

Background Information

Fieldwork Robotics Limited (FRL) was launched in 2016 to develop and commercialise the work of Robotics expert, Dr Martin F. Stoelen, from the University of Plymouth, UK. The spinout company is now based at The Paddocks Business Centre in Cambridge, UK. The first two robots developed are being used to harvest berries in polytunnels on a farm operated by the Summer Berry Company near Odemira, in south-west Portugal. The Summer Berry Company is headquartered near Chichester in West Sussex, and is a leading supplier to British supermarkets including Marks & Spencer, Ocado, Tesco, Sainsbury's and Waitrose. The first iteration of the robot in 2019 had one harvesting arm that carefully approached the fruit and took a full minute to pick and deposit a berry into a punnet. Since then,sensor technology and grippers have been completely redesigned to reduce slippage and harvesting time. The robots stand 1.8m tall and and are now fitted with four 3D-printed plastic arms that simultaneously pick raspberries.

Core Team

Dr Martin Stoelen is the academic Founder and Chief Scientific Officer (CSO). Martin has extensive experience in RD&I from the US, Spain, UK and Norway and has also led projects to develop a cauliflower and tomato harvesting robot systems.

Rui Andres is the Chief Executive Officer (CEO) and has a background in electrotechnical engineering, specialised in energy and robotics. Rui has experience in asset management, finance and management.

Andrea Perticati, is the Chief Technology Officer (CTO) and has an electrical and mechanical engineering academic background. Andrea brings a wide range of experience from the automotive industry as well as senior program management. Andrea understands how to bring products from prototype to high volume mass manufacture.

Awards

| London's 12 Most Impressive & Successful CEOs in the AgTech Space
| Top 14 Super Promising #AI Companies in the UK using AI for a Positive Impact 🚀
| New to the Market award, British Embassy in Portugal

Partnerships & Funding

The company has developed partnerships with some of the world's leading fruit and vegetable producers, including Bonduelle and the Hall Hunter Partnership, while also working to optimise its technology in conjunction with engineers at Bosch. A field trial is currently underway with the Summer Berry Company at their farms in Portugal. .

FRL is supported by the EIT Food Impact Fund, which funds up to 500,000 Euros per venture in grant funding for promising start-up companies.

Field Work Robotics

Current State & Future Trajectory

Technology

The FRL robots use a combination of technologies to to maximise the harvesting capabilities of their robots. Currently the robots are able to adjust their picking height for a variety of picking circumstances by adjusting the vertical position of the arm. The robots utilise an autonomous mobile platform, developed to navigate in various farming environments and able to be deployed through rows of crops for picking without human supervision. Advanced artificial intelligence developed in-house allows the robot to detect the ripeness of soft fruits and vegetables, while the modular soft robotic arms can operate adapting to any crop configuration.

> "Raspberries are very sensitive so we have had to develop technology that can apply enough pressure to release the fruit from the stem without damaging it. At the same time, our sensors are now so advanced that they can tell if the fruit is ready to be harvested or not, meaning what can be sold is all that is picked."

FRL are currently developing additional data services to support forecasts and yield improvements. Proof of concept trials for spraying and harvesting of other crops are ongoing, with a view to having these services being part of scaled up trials in early 2023.

Cost

Currently, FRL operate "harvesting as a service" and **charge the same as human labour**. FRL are working with growers to determine the most desirable non-picking task capabilities and robot features to optimise both parties business case. Furthermore, future business models are being considered that may also involve leasing of the robots.

Pick Rate

Currently the core variety is picked at around 1 kg/hour. FRL are on track to increase pick rates to 2 kg/hour in 2023, with an ultimate goal of 4 kg/hour or 25,000 raspberries a day, compared with 15,000 for a human working an eight-hour shift.

The labour Shortage

Even though the FRL robots are still being developed, there is a potential opportunity to fill a skilled labour shortage gap in the EU.

Risks & Limitations

1. FRL are a startup company that currently has some reliance on grant funding to sustain its operations and progress its development program. Raising sufficient funds to provide a sufficient runway will be important in the near term.
2. The FRL team must develop a business case that makes financial and operational sense to growers that validates the reliable performance of both harvest picking and non-picking activities when compared to the current business practice which relies on labour.
3. The current field trials must also consider other grower circumstances to make the developed solutions translatable to other growers to ensure they can scale.

So what

The Australian Rubus and berry industry should actively monitor the development of integrated robotic and AI platform solutions since these have the potential to address current and future industry pains that can't be solved by efficient labour use alone. The industry are encouraged to work with entrepreneurs, such as those from FRL, to design the exact requirements of the technology to ensure that needs are met.

Amazon Logistics Robotics

Background Information

Amazon acquired robotics company Kiva in 2012 for $775 million USD, investing to improve productivity in the supply chain. The subsidiary of Amazon is now called Amazon Robotics and is based in Massachusetts. It specialises in development of manufactures mobile robotic fulfillment systems, previously supplying to US retail companies such as The Gap, Staples and Walgreens, they have since, concluded contracts and now, their assets exclusively work for Amazon Warehouses. In the last decade, the company has developed an effective collaborative suite of robotics and practices to streamline, handling of orders through their ecommerce site.

In 2019, Amazon warehouses had more than 200,000 robots working within them, and in 2022, the company announced its first autonomous mobile robot (AMR) Proteus.

Leadership Team 2022

Due to high media exposure, Amazon Robotics does not make clear/transparent who holds leadership positions within the organisation.

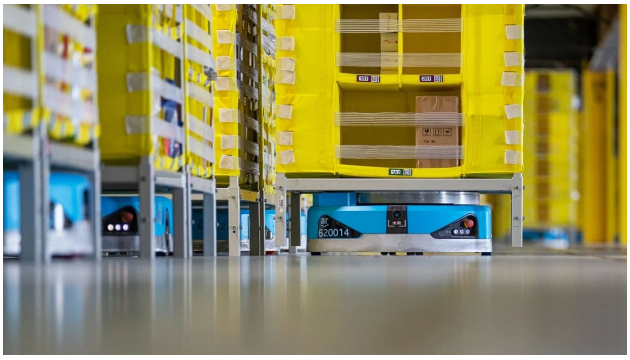
Tye Brady is the Chief Technologist at Amazon Robotics as of the 2022 AMR announcement.

Kiva Systems Founders 2003

Mick Mountz

Raffaello D'Andrea

Pete Wurman



"Proteus" Fully autonomous mobile, collaborative robot

"Cardinal" Robotic workcell for packing boxes into GoCarts

Awards

While Amazon has a comprehensive robotic suite, it appears the organisation does not participate in many external contests, however, they do run contests within the robotics industry.

Amazon Science runs and operates the Amazon Research Awards (ARA)

Previously Amazon Robotics has run a global challenge called the Amazon Robotics Challenge, now transformed into a STEM program, called Amazon Cyber Robotics Challenge, run by Amazon Future Engineer

Partnerships & Funding

Amazon Robotics is a subsidiary of Amazon.com, with between 3,500 & 4,000 employees.

amazon robotics

Amazon Logistics Robotics

Current State & Future Trajectory

Technology

Amazon Robotics is best known for their high-density grid network, which works to opportate their order fulfillment system separate from people. The progress that Amazon Robotics has taken to evolve their system includes development of their first collaborative Autonomous Mobile Robot, Proteus. This robot works within close proximity to humans in critical areas of the fulfilment network. Because of this close proximity, it is critical that this autonomous robot has an effective communication interface, high degree of safety, the ability to react to new and unexpected situations and additional systematic features that other robots need not consider.

Amazon Robotic Fleet

Kiva*: a goods to person robot near with a 450 kilograms (1000 lbs) lifting capacity and a speed of 5 km/h*

Hercules*: Similar to Kiva but with 1360 kg (3000 lbs) lifting capacity*

Pegasus*: replaces the original Kiva but 19cm thinner with a 560 kg (1230 lbs) lifting capacity*

Xanthus*: a hybrid robot that succeeded Pegasus in 2019, this drive unit also carries pods and has a variety of attachments*

Bert*: A warehouse navigation robot, programmed to transport packages within a facility by a worker*

Ernie*: Moves around the stack using a robotic arm. It lifts totes from the stack to place them in front of workers*

Cardinal*: an autonomous workcell able to pick boxes and put them into GoCarts*

Sparrow*: identify, select, and handle millions of individual warehouse inventory items*

Proteus*: the first AMR fully developed by AMAZON able to navigate safely and collaborate with humans*

Scooter*: automated tractor that tows empty totes around*

Kermit*: an automated guided cart with magnetic navigation, carrying large loads of containers*

Enabling Technologies

Key technologies enable the development and creation of AMRs for a wide range of organisations and applications. Intel and Nvidia are two organisations that build tools that enable many organisations such as Amazon, BMW Group, Alphabet inc (Google), etc. to build AMRs for warehouse manufacturing and fulfillment. Products such as Intel® RealSense™ (depth sensing cameras), NVIDIA Omniverse (development of digital twins), Intel® DevCloud for the Edge (cloud-based evaluation and prototyping) and others are used by R&D departments and robotics organisations to develop AMRs. These companies and other offer toolkits specifically built to streamline the development of AMRs, that provide artificial intelligence, navigation and simulation software (NVIDIA Isaac™ robotics platform) and for the development and refinement of the AI (Intel® Distribution of OpenVINO™ Toolkit).

Availability

Amazon Robotics assets are currently exclusive to Amazon's fulfillment warehouses, though similar solutions are for available within the logistics robotics industry. Locus Robotics is an organisation that offers a range of warehouse robotics solutions, selling access via a robots-as-a-service model, This model has a streamlined implementation period, guaranteeing "Up And Running In 4-6 Weeks" and offering "immediate productivity improvements and ROI in just months".

So what

This case study shows the effectiveness of robotics when used as small parts of a larger process, rather than assets that are applied across a range of tasks, they can be used effectively to refine and automate specific parts. The Australian rubus and berry industry can utilise products that are refined and optimised for warehouse logistics in distribution in the immediate and short term future seeing ROI much quicker than longer term and less mature partnerships with emerging businesses and technologies.

Hort Innovation
Strategic levy investment

RASPBERRY AND BLACKBERRY FUND

TGD™