FOREST VALUE CHAIN
CONSORTIUM

PRIMARY GROWTH PARTNERSHIP BUSINESS CASE

Te Mahi Ngahere i te Ao Hurihuri – Forestry Work in the Modern Age

Business Case prepared for the Ministry for Primary Industries

30 September 2018

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1. Executive Summary

This new Primary Growth Partnership (PGP) programme "Te Mahi Ngahere i te Ao Hurihuri – Forestry Work in the Modern Age" has three major aims: to create value, improve profitability and enhance sustainability across the forestry value chain through automation. It aims to do this by developing a new integrated forestry value chain from harvest to market, incorporating new technologies that will promote both industry and Government interests.

Vision

The vision is "No boots on the ground, no hands on the log". It reflects the focus on new automation and robotics technology in the ever-changing world. But the concept isn't solely about change, it encapsulates the idea of people as the constant core that act as an anchor to the change occurring across the industry. The programme is led by the Forest Value Chain Consortium, a partnership of forestry companies, harvesting and logistics contractors, and machinery manufacturing firms. It builds on the successful development of forestry mechanisation, remote control and teleoperation developed in the earlier PGP Steepland Harvesting programme.

To achieve this vision the Consortium proposes development of new log sort yards as a wood logistics solution which redesigns the harvesting, log manufacturing and logistics process. The goal is that by 2030, over 20% of all harvesting operations will be fully automated, using products developed in this programme.

Our plan brings together a number of interdependent parts into one system based around five relocatable centralised robotic log sort yards, which are key to the entire new system. These initial five sort yards will handle over 2.8 million cubic metres (m^3) per year supplied from different harvesting sites ("log landings") by up to 40 different harvesting crews**.** Each sort yard will deliver sorted grades of logs to diverse customer destinations.

The Value Proposition

Total investment over the seven years of this PGP programme, from co-investor cash and in-kind contributions, and from Ministry for Primary Industries (MPI) is $29.36 million, excluding GST. The amount of MPI funding sought is $11.74 million (excl. GST). The cumulative net economic benefits from the programme out to 2030 will total $395 million, from forestry value chain efficiencies and sales of new machinery and equipment. Annual benefits in 2030 will be $100 million p.a. If the new logistics solution was rolled out to the whole industry (excluding existing centralised log processing facilities) a total of 55 log sort yards could be created, adding over $225 million of additional value to the industry per year.

This radical new wood logistics solution will address multiple goals:

1. Labour shortages will be alleviated
2. Forestry value chain costs will be reduced
3. Economic viability of harvesting small forests will be improved
4. Long term sector sustainability will be enhanced
5. New product opportunities will be created for domestic sale and export.

For the Consortium forestry companies that adopt this new supply chain the benefits will include:

- Increased labour productivity through smaller harvesting crews
- The ability for increased forest harvest to be handled by the same size workforce, alleviating current labour shortages
- Lower forestry value chain costs from stump to customer, generating cumulative gross operational cost savings of $338 million by 2030
- Smaller log landings, reducing the annual volume of excavated soil during landing construction
- Less chemical fumigation, due to in-forest debarking.

For the Consortium manufacturing partners the new forestry value chain will result in the development of eight new commercial products, with sales of over 1240 units of new equipment and machinery, generating cumulative gross sales margin of $86 million by 2030.

Benefits for New Zealand will include improved economic viability of harvesting small forests, enabling the potential annual forest harvest to expand to over 35 million m^3 per year, improved profitability of forestry to incentivise new forest planting, and improved public safety through increased use of High Productivity Motor Vehicles (HPMV), which have larger gross vehicle mass and will reduce the number of logging trucks on public highways.

Programme Summary

This programme changes the way logs are processed and delivered to customers. It harvests, sorts and stores logs more efficiently and safely than current landing-based methods. The result is a move away from less skilled labour towards total mechanisation and introduction of automation based on highly skilled labour. This programme brings together participants from the whole forestry value chain in a cooperative approach to change, in a systematic prioritised manner. This is a significant step for a sector where collaboration towards innovation has traditionally been difficult to achieve.

The programme is in two parts: firstly, the total redesign of log sorting and handling processes in harvesting operations (robotic log sort yard); and secondly, based on the requirements of the sort yard, the automation of machinery and incorporation of new technology on the log landing. This will halve the number of times a log is handled during the manufacturing process, improve the flow of wood and information from forest to customer, reduce human exposure to risk and reduce costs. Implementation will require new systems with new functions and new products to be manufactured to deliver these innovations. The programme will achieve this by a close partnership model based around project teams comprising forest owners, contractors and the manufacturing developers.

An important innovation is to design the systems and products with the worker in mind. Designing the human-machine interface and minimising the impact on workers will be a cornerstone of the design process. Further, the programme has a major focus on developing the training required not only for the new systems but also for the future workforce.

The Forest Value Chain Consortium will lead the programme. The foundation members of the Consortium are a mix of large and small forest management companies, their key harvesting and logistics contractors, and the forestry equipment manufacturing partners. This Consortium has engaged Forest Growers Research Ltd (FGR) to manage the development and commercialisation programme.

The Consortium plans to establish five new logistics systems throughout the North Island, supplied by 40 harvesting crews. This will provide a reliable initial market for the manufacturers and reduce their market risk. The impact of these initial systems will be a potent demonstrator to the industry and will enable the participant individual companies to realise tangible benefits. As with the earlier Steepland Harvesting PGP, which catalysed increased mechanisation of harvesting, it is expected that this step change in logistics will catalyse widespread adoption of log sort yards.

Outcome Measures by 2030

- New forestry value chain created:
    - Five new robotic log sort yard systems operating integrated sort yard and landing operations
    - Eight new automated products in the market, with total sales of 1242 units by 2030
- Improved labour market:
    - Reduced average harvesting contractor crew size by 50% (from 8 workers to 4), increasing labour productivity from 38 m^3/worker-day to 65 m^3/worker-day (+70%)
    - About 200 new roles are created using mechanised and automated harvesting technology

        - Active training and retraining programmes developed around future needs and the new systems
        - Fewer serious harm incidents, from 75 p.a. in 2017 to less than 10 p.a. by 2030
- Improved competitive advantage:
    - Harvesting of small forests are more viable economically, resulting in the expansion of the annual harvest to 35 million m^3
    - Forestry value chain costs have reduced by \$9.71/m^3 against the base case (-12%)
    - Over \$100 million per year of added value injected into the New Zealand economy
- A more sustainable business:
    - Chemical fumigation volume has been reduced by 1.2 million m^3 of export logs p.a.
    - Log landing construction area is reduced by 75% per landing
    - 15,000 fewer truck trips on the public highway every year due to increased use of HPMV.

Rationale for PGP investment

The PGP investment not only motivates the collaborative nature of this programme (as Government support for change has a positive effect on industry uptake), but also is critical to the implementation of this radical new logistics solution. The programme creates opportunities for a more coordinated approach across industry training and educational institutions to identify future training needs of the industry and develop the workforce of the future. This programme will collaborate with these institutions (such as Toi Ohomai Institute of Technology, University of Canterbury and Competenz, the forestry Industry Training Organisation, or ITO) to undertake this task. In the absence of PGP funding, progress in this area will be slow.

The wider public benefits of the programme include improving safety and environmental outcomes through eliminating hazardous manual tasks, reducing soil disturbance with smaller log landings, and taking trucks off the road with increased use of HPMV. This will improve forestry's social licence to operate, so the community sees that harvesting and log transport is a good safe and sustainable business and one that is looking after its people. The programme provides opportunities for labour productivity improvements and vital social, environmental and regional development benefits, which would be foregone without this coordinated "whole of value chain" approach. This change cannot be achieved, and the automation innovations implemented, in a piecemeal manner.

The five first adopters of this new design will incur significant costs and risks which subsequent implementers will not face. The extent of the change and the upfront costs and risk means that the planned changes are unlikely to happen without the combination of PGP and industry funding. With no PGP investment these developments would not go ahead as designed. Because of the interdependencies between the planned projects, a large scale programme is required to generate the significant benefits forecast (over \$100 million per year by 2030). That is, because this development requires a complete system change it is largely an "all or nothing" initiative.

The most immediate consequence if this programme does not happen will be the heightened risk of lack of profitability and consequent harvest of the small-scale forest resource. Under current costs and prices, increasing harvesting costs by \$10/m^3 (equivalent to the operational cost savings delivered by this programme) could result in an increase in the area of small forest resource becoming uneconomic to harvest by 9-11% more than currently forecast. In 2025 this could amount to 1.65 million m^3 per year that may not be harvested. The reduced economic activity is likely to be in excess of \$190m p.a. by 2025.

The combined consequences of not addressing both the supply chain issues as proposed, and the future training needs of the market, will continue to constrain industry growth, risking the increased harvest of the small forest estate (due to labour shortages and high costs). Long term, improving the attractiveness of forestry as a career for skilled workers using new technology will be essential to assisting the government achieve its ambitious forest planting programme, and climate change targets.

2. Proposal

2.1. Vision

This programme develops a revolutionary change to the forestry value chain bringing a number of interdependent parts together into one system based around a relocatable centralised robotic log sort yard. This will effectively redesign the harvesting and log manufacturing, processing and logistics process.

This vision is encapsulated in the statement: "No boots on the ground, no hands on the log". Our goal is that by 2030, more than 20% of all harvesting operations will be fully automated. By achieving this vision this programme will realise significant growth for the New Zealand forest industry by: enabling the harvest of small forest holdings across New Zealand; creating a more sophisticated and diverse workforce; a step change in labour productivity; increased safety; improved environmental outcomes; and providing new product opportunities.

2.2. Current situation

Plantation forestry covers 7% of New Zealand's total land area. Forestry is New Zealand's third largest primary industry export, with wood products exported to over 50 countries. In the year to June 2017 forestry exports were worth $5.47 billion (11% of New Zealand's total merchandise trade) and this is forecast to reach nearly $5.7b in 2018.

The forestry value chain comprises forest growing, harvesting, log processing and transportation to either domestic wood processing customers or an export port. Key players in the value chain are the forest owners and forest management companies (both large-scale and small-scale) who own the wood and control the value chain until delivery of logs to the customer at domestic mill or port.

Significant economic flows are associated with wood production, harvesting, transport, port handling and wood processing activities. The annual forest harvest has risen from 10 million m^3 in 1987 to 33.0 million m^3 in the year to 31 December 2017. The large areas of forest planted in the mid-1990s, now 19 to 25 years old, will begin reaching harvest age from 2019 onwards. The sustainable forest harvest is expected to exceed 35 million m^3 per year from 2023 through to 2035, dependent on market forces, such as log prices, market demand, and harvesting and logistics costs. Significantly to the sector structure and cost profile, over 50% of the current harvest is from steep terrain (18 million m^3 per year), which has much higher harvesting costs. This proportion of steep terrain harvest is likely to rise to 70% by 2025.

One-third of the plantation forests are in the central North Island, with 37% in other regions in the North Island and the balance in the South Island. Forestry is a big contributor to New Zealand's regional economies. For example, almost 15% of New Zealand log exports come from the Gisborne-Tairāwhiti region and forestry contributes $262 million p.a. to the East Coast economy. Log exports from Eastland port have grown from less than 0.5 million tonnes to over 2.0 million tonnes in the last 10 years mainly due to increasing forestry harvests.

The plantation forest estate is mainly privately owned or in registered public companies (96%), with 70% in foreign ownership. Māori are significant owners of forest land (40% of total) and also of plantation forest (150,000 hectares). While there are over 15,000 individual forest owners, just 100 large-scale forest owners (with 1,000 hectares or more) own 70 percent of the national forest estate. Over 14,000 small-scale forest owners own less than 100 hectares each.

As in ownership, the bulk of the forestry management (60% by area) is undertaken by the largest 15 forestry companies (each managing over 20,000 hectares of forest). The majority of small scale owners sell either to, or through, a forest management company.

The key market for New Zealand logs is China, comprising almost three-quarters of log exports. New Zealand has become the largest softwood log supplier to China, supplying 36.3% of Chinese softwood

log imports. Log prices in New Zealand are at a 20 year high, 11% above last year's level and 21% higher than the five year average. The log market is strongly cyclical and prices are expected to ease in late-2018. The industry needs to develop new more efficient supply chains to protect it from future vulnerability to the next market downturn.

The forest and wood industry employs 18,000 people, in forest growing and harvesting, log transport, sawmilling and wood manufacturing. Significant economic flows are also associated with expenditure of wages and other forest costs. The harvesting contractors and log transport companies are the main suppliers to the forest managers. Equipment companies, their agents and servicing companies and local machine shops are in turn very important suppliers to the contractors. The contractors – some 470 crews – employ over 3,700 harvesting workers. As the industry continues to grow and respond to the increase in new technology, the tertiary sector will have an increasingly important role in training the skilled operators needed by the sector.

Forestry has an important role to play in many of the Government's priority areas – enhancing regional development, improving water quality, reducing carbon emissions and creating jobs. However the New Zealand forestry business environment has a number of constraints. Foremost are:

- Harvesting and roading capacity – the industry faces significant labour shortages. The serious harm incident rates, while diminishing, exacerbate these shortages by decreasing the appeal of working in forestry.
- Infrastructure and log transport capacity – there is a shortage of logging truck drivers.
- Congestion at ports. Turnaround times at ports commonly consume up to 25% of available daily truck driver hours.
- Higher harvesting costs as the proportion of steep terrain forests in remote locations increases.
- Regulatory changes (such as the release of chemical fumigants to the atmosphere after 2020) leading to increased costs.

Long term issues include:

- Sustainability of new forest planting – recent political decisions should ease this concern.
- The increasing need to create positive social and environmental results that will maintain both social licence to operate and political support for forestry.
- Long term competitive advantage on the world stage – the high proportion of steepland and the increasing proportion of harvest from small forests puts New Zealand at a disadvantage to countries with large areas of forest on flat land (such as Australia, Chile and North America).
- The log market is cyclical in nature. While log prices are at the top of the cycle at present, as international prices ease in future, cost issues will become critical.

2.3. Opportunities

The major opportunities for the forest industry are:

- Major growth in international demand for logs now, and in the longer term, growth of the bio-economy with increasing demand for renewable materials and low carbon inputs, and demand for new timber and wood fibre products.
- A major increase in the national annual harvest. Forestry is poised for a big lift in growth in both log exports and local milling as New Zealand plantation forests mature. The sustainable wood volume available for harvesting will grow from 33 million m^3 in 2017 to over 35 million m^3 in 2025.
- To build on an international trend to introduce new technologies into harvesting processes to alleviate the shortage of workers, improve safety and increase competitive advantage.
- A greater focus on education and training for introduction of new technologies to build a safer work environment and better paid, more productive and more diverse workforce in the regions. The forestry sector has started working together more cohesively and this programme will build on that collaboration.
- To continue to grow the forestry machinery manufacturing sector by developing viable commercial products that provide opportunities for domestic and export sale.

2.4. Challenges

The forestry sector faces some major challenges that are inter-related and will need to be overcome in order to capture the opportunities:

- Labour shortages both in harvesting and log transport are a major constraint on the industry. The increased harvest will require around 100 extra contracting crews and 700 additional workers from current levels (a 20% increase).
- Rising costs leading to marginal forest profitability (especially in small-scale forests). Recent research by Crown Research Institute Scion indicates that, under current costs and prices, increased harvesting costs of $\$10/m^3$ could result in 9-11% more of the small forest resource becoming uneconomic to harvest. These areas are unlikely to be completely harvested without a change in approach and technology.
- The sector's social licence to operate is threatened due to its poor safety record and environmental impact. This makes the sector less attractive for employment.
- Regulatory changes, especially in 2020 when recapture of chemical log fumigants (methyl bromide) becomes a requirement. This could double the cost of export log fumigation.
- Constraints on overall harvesting system productivity. While the earlier PGP Steepland Harvesting programme has achieved increased felling and extraction productivity, the current harvest process (Figure 1) is bottlenecked at the landing by the log sorting function. The number of log types sorted and stored on the landing drives construction of large log landings, with significant volumes of soil displacement, which on steep terrain is a major environmental risk. Wood residues from the log manufacturing process, which are currently unmerchantable, result in loss of productive area and pose a risk in terms of mobility downslope during high intensity rainstorms.

As we face these challenges, doing things differently will be crucial.

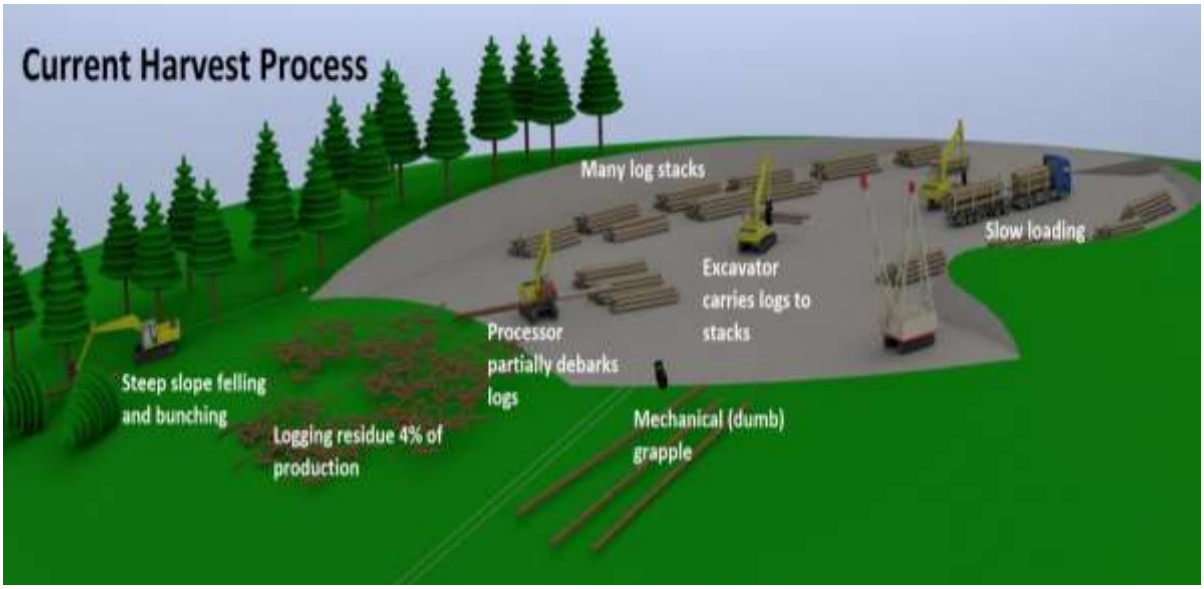

Figure 1: Current harvest process and issues to address

2.5. Solution – Primary Growth Partnership programme

The earlier PGP Steepland Harvesting programme and related activities catalysed a level of change within the forest industry in New Zealand as initiatives were developed and uptake occurred. This new PGP programme "Te Mahi Ngahere I te Ao Hurihuri – Forestry Work in the Modern Age" proposes a new wood logistics solution, initially in five regions of New Zealand, to build on this momentum and improve long term sustainability across the entire forestry value chain.

The current forestry value chain is a set of interdependent systems of people and equipment operated as separate parts. This programme develops a new forestry value chain solution, enabling a more flexible, efficient total system approach to the harvesting and transportation of logs. The key to the proposed new system is an optimised 'hub and spoke' approach, based on a relocatable robotic log

sort yard (the hub) which could handle over 2,400 m^3 of log input per day. It will receive unsorted grades of logs from up to eight different harvesting landing sites (the spokes) and it will dispatch sorted grades of logs to diverse customer destinations.

The programme will redesign the log sorting and handling processes in harvesting operations, and implement new log production and sorting facilities in regions such as Waikato, King Country, Hawkes Bay, Manawatū-Whanganui, and the Wairarapa over the next seven years. Based on the requirements of each sort yard, automation of forest harvesting machinery will be achieved through incorporation of new technology at the log landing (as well as new transport alternatives).

Fully implemented these innovations could handle over 2.8 million m^3 of wood per annum by 2025. Greater use of HPMVs to move logs from sort yards to customers is part of the proposal. Early feasibility work indicates the logistics solution could result in the creation of around 200 new job roles in automated harvesting operations and log sorting facilities and inject over $32 million p.a. into New Zealand's economy by 2025, rising to $100 million p.a. by 2030.

This new approach to the forestry value chain will address multiple goals:

1. Reduced labour shortage constraints
    - Reduced harvest crew sizes
    - More diverse work force
    - Higher labour productivity and better wages translates to more attractive employment conditions
    - Greater ability to redeploy and train staff as the nature of work changes
2. Reduced costs and increased competitive advantage
    - Reduced log manufacturing and logistics costs
    - Increased capital productivity
    - Avoided cost increases especially for chemical fumigation
    - Improved sorting of logs to meet customer needs
3. Improved long term sustainability
    - Increased sector attractiveness:
        - Improved safety through automation of manual tasks
        - Lower physical work load jobs
        - More skilled workforce
        - Improved forest investment viability
    - Significantly reduced environmental impact:
        - Reduced impact on waterways through smaller landings and log residue management
        - Reduced chemical fumigation through in-forest debarking
        - Reduced volume of trucks on major roads
4. Improved viability of small forest holdings
    - Easier access to small forests with smaller harvesting crews with less machinery
    - Improved logistics
    - Reduced harvesting cost per m^3
5. Growth of NZ forest machinery manufacturing sector

The new automated harvesting and logistics system (Figure 2) will eliminate hazardous manual tasks on the landing (such as log quality control, log branding, stocktaking, and truck load securing). Individual log identification and tagging will replace log branding and stocktaking and improve dataflow from production to customer. The improved processes will extract more value from the forest resource through in-forest debarking and reduced log wastage through improved residue management. The programme will teleoperate some functions, such as truck loading, to make tasks safer. It will automate functions such as log sorting, log tagging, residue chipping and load securing, to make jobs quicker and less repetitive. The new system will incorporate semi-automation into other functions to make tasks easier and more efficient:

- Semi-automated log extraction using a 'smart' grapple and hauler control system

- Semi-automated in-forest debarking and log processing (including individual log ID)
- Automated log residue management system

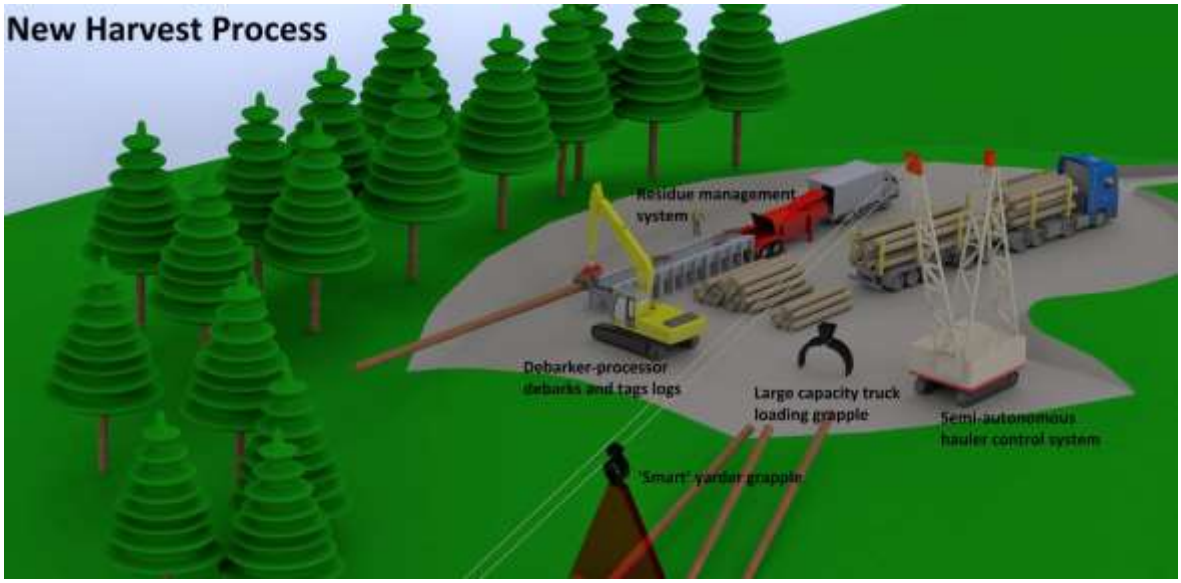

Figure 2: Improved on-landing harvesting processes

A key difference to existing hauler operations is relocating log sorting to in-forest sort yards (Figure 3), reducing machinery and space requirements on log landings and lowering overall costs.

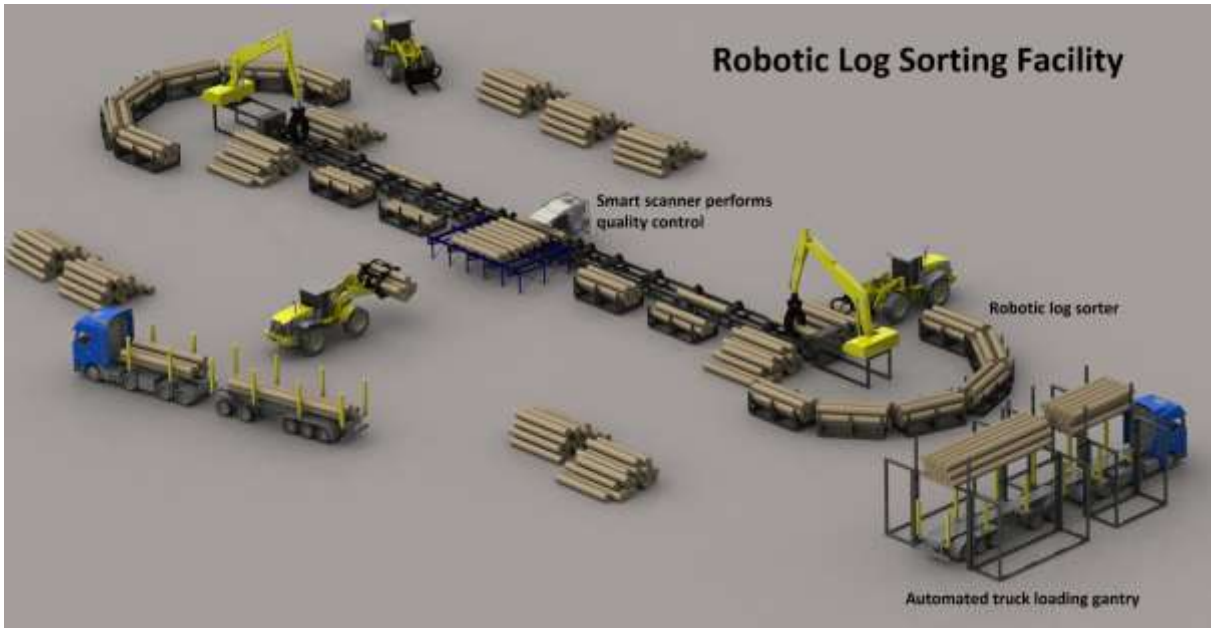

Figure 3: Improved log sorting, handling and loading processes

At the sort yard improved log sorting, handling and loading processes will occur:

- A robotic log sorter will scan and sort mixed grade logs from the hauler log landings. A shape recognition log scanner will calculate true cubic volume (eliminating manual log measurement) and perform log quality control.
- An automated truck loading gantry will load sorted logs direct to HPMV trucks. This will halve the number of times logs are handled during the current log manufacturing process. The truck loading gantry will load HPMVs in less than 10 minutes per load, down from over 40 minutes currently.
- Automated log load securing system. The 58-tonne gross HPMV truck and trailer units will have their loads automatically secured and will cart logs from the sort yard to the market (either domestic mill or port).

2.6. Programme partners

This programme brings together participants from all parts of the forestry business to collaborate in a Forest Value Chain Consortium, comprising:

- forest owners and management companies, which control the entire forestry value chain, as specifiers;
- manufacturers and technology developers as suppliers of the new technology; and
- harvesting and log transport contractors as buyers and users of the new technology.

The nine Consortium forestry companies (Table 1) are a mix of large and small forest management companies and their key harvesting and logistics contractors. They comprise many of the leading forest owners and managers in New Zealand as well as companies that service and manage small forest owners' harvest and operations:

- PF Olsen Ltd (will establish a log sort yard in King Country)
- Rayonier Matariki Forests (will establish a log sort yard in Hawkes Bay)
- Forest Enterprises Ltd (will establish a log sort yard in Wairarapa)
- Forest Owner Marketing Services Ltd, or FOMS (will establish a log sort yard in Whanganui)
- Wood Marketing Services Ltd, or WMS (will establish a log sort yard in Waikato)
- Hancock Forest Management (NZ) Ltd
- Timberlands Ltd
- Ernslaw One Limited
- Port Blakely Ltd.

The industry contribution to the programme from the Consortium forestry companies and their participating contractors is **$15.921 million**, made up of **$6.542 million** in cash from the Forest Growers Levy Trust (FGLT), **$7.617 million** in co-investor cash and **$1.762 million** in-kind contributions from the first adopter Consortium forestry companies and harvesting contractors.

The Forest Value Chain Consortium has engaged Forest Growers Research Ltd (FGR) to manage this PGP programme on behalf of all investors and provide project management expertise. FGR, formerly Future Forests Research Ltd (FFR), is a private forestry innovation company made up of 29 member companies, and represents the interests of both Forest Grower Levy paying stakeholders and other investors in forest growing research. FGR associate members comprise:

- harvesting contractors
- harvesting machinery manufacturers and service providers
- forest industry consultants
- forestry training and education organisations (University of Canterbury, Toi Ohomai Institute of Technology (Rotorua), and Competenz, the forest industry ITO); and
- The NZ Farm Forestry Association (representing small forest growers).

FGR, and its predecessor FFR, has been operating successfully since 2007. The primary purpose of FGR is to help the New Zealand forest growing and harvesting sector to raise its profitability through the delivery of well targeted, relevant, world class innovation programmes. FGR is governed by a Board which collectively has deep industry knowledge and substantial governance experience in achieving forest industry strategy, especially where multiple companies, such as the various members of the Consortium, need to be aligned to achieve those outcomes.

Table 1: Forestry company members of the Consortium

Name of Organisation	Location	Dimensions	Industry Role	Programme Role
PF Olsen Group	Across NZ	Large forest management company and leading provider of independent professional forestry services in NZ. Harvests and markets of over 3.3 million m^3 of wood annually.	Manages forests on behalf of smaller forest owners. CEO is President of Executive Council of NZ Forest Owners Association (NZFOA).	**Establishing sort yard in King Country.** Product specifier, foundation role in sort yard design and will nominate its key contractor(s). Has taken a leading role in developing programme (see Appendix 5.3 for letter of support). Industry representative on PGG.
Rayonier Matariki Forests	Across NZ	Third largest forest owner in New Zealand, owning 132,000 hectares of plantations, and harvesting over 2.4 million m^3 of wood per year, with its 90 employees and over 700 contractors and workers	Large forest owner and manager of harvesting and marketing of wood on behalf of smaller forest owners. Member of Executive Council of NZFOA.	**Establishing sort yard in Hawkes Bay.** Product specifier, foundation role in sort yard design and will nominate its key contractor(s). Has taken a leading role in developing programme (see Appendix 5.3 for letter of support). Industry representative on PGG.
Forest Enterprises Ltd	East Coast North Island	Owns 20,000 ha of forest in 75 forests in the Wairarapa and Gisborne regions. Manages harvest of 370,000 m^3 of logs annually and has developed a rail hub at Waingawa, south of Masterton.	NZ's leading direct forestry investment company with over 6,400 small forest investors.	**Establishing sort yard in Wairarapa.** Product specifier, foundation role in sort yard design and will nominate its key contractor(s). Has taken a leading role in supporting programme (see Appendix 5.3 for letter of support).
Forest Owner Marketing Services Ltd	Southern North Island	Manages an annual harvest of over 1.0 million m^3 of logs with 40 harvesting crews throughout the North Island	One of the largest independent forest harvesting and marketing service providers to private forest owners.	**Establishing sort yard in Whanganui region**. Product specifier, foundation role in sort yard design and will nominate its key contractor(s). Has taken a leading role in supporting programme (see Appendix 5.3 for letter of support).
Wood Marketing Services Ltd	Waikato and Bay of Plenty	Manages an annual harvest of 700,000 m^3 of wood, and a workforce of 17 harvesting crews throughout the Waikato and Bay of Plenty regions.	Large independent forest harvesting and marketing service provider to private forest owners.	**Establishing sort yard in Waikato.** Product specifier, foundation role in sort yard design and will nominate its key contractor(s). Has taken a leading role in supporting programme (see Appendix 5.3 for letter of support).
Hancock Forest Management Ltd	Northland, Central North Island and eastern Bay of Plenty	NZ's largest forest owner with 219,000 ha of forest, harvesting 4.2 million m^3 of wood annually	Member of Executive Council of NZFOA.	Has a key role in the rollout of potential future log sort yards in Northland, Kinleith or eastern BOP. Will nominate its key contractor(s) when it establishes a sort yard.
Timberlands Ltd	Central North Island	Forest Management company for Kaingaroa Timberlands, second largest forest owner in NZ, including 189,000 ha in Kaingaroa Forest. Harvests 4.0 million m^3 of wood annually	Member of Executive Council of NZFOA and Forest Research Committee of NZFOA.	Has a key role in the rollout of potential future log sort yard(s) in CNI. Will nominate its key contractor(s) when it establishes a sort yard.
Ernslaw One Ltd	Across NZ	Fourth largest forest owner with over 112,000 ha of forest. Harvests 1.5 million m^3 of wood annually. Is a vertically integrated forest and wood products company.	Owns Winstone Pulp International Ltd (sawmill and pulp mill at Ohakune). Member of Executive Council of NZFOA.	Has a key role in the rollout of potential future log sort yards in Eastland region, southern North Island or Otago/Southland. Will nominate its key contractor(s) when it establishes a sort yard.
Port Blakely Ltd	Bay of Plenty and Canterbury	Owns 23,000 ha of forests and harvests 350,000 m^3 of wood annually	Small forest owner. Member of Executive Council of NZFOA. CEO is member of Forest Growers Levy Trust and Chair of Forest Research Committee of NZFOA.	Has a key role in the rollout of a potential future log sort yard in south Canterbury. Will nominate its key contractor(s) when it establishes a sort yard.

The contribution of the Consortium manufacturers to the programme is valued at **$1.695 million** in terms of design of the technology products **($1.295 million** in-kind contributions) and technical support during deployment **($0.400 million** in-kind contributions).

The final programme partner is MPI, whose proposed contribution is **$11.744 million**, making up the total programme investment of **$29.36 million** (Table 2).

Table 2: Summary of Programme Investment by Co-investor

Investor	Total Funding ('000) excl. GST
Forest Growers Levy	$6,542
For.Co./Contractor cash	$7,617
Consortium cash total	$14,159
Manufacturers in-kind	$1,695
For.Co./Contractor in-kind	$1,762
Consortium in-kind total	$3,457
Consortium total	$17,616 (60%)
MPI investment	$11,744 (40%)
TOTAL INVESTMENT	**$29,360**

The seven Consortium manufacturing partners are all existing suppliers to the forest industry and will develop, commercialise and supply the technology products arising from this programme:

- Southstar Equipment Ltd, Auckland
- Mural Town Engineering Ltd, Katikati
- Patchell Industries Ltd, Rotorua
- Engineering Services Rotorua Ltd
- Alpine Logging Equipment (NZ) Ltd, Rotorua
- Skookum Technology Ltd, Auckland
- Pocket Solutions Ltd, Lower Hutt.

Details of the manufacturing partners in the Consortium, are given in Table 3 overleaf.

Table 3: Forestry Manufacturing Partners in the Consortium

Name of Organisation	Skills contributed to programme	Project(s)	Track Record	Annual turnover ($)	No. of Employees	Distribution Channels
Southstar Equipment Ltd, Auckland.	Leaders in tree harvesting equipment. Design and manufacture of high quality forestry attachments that deliver efficient automated mechanized harvesting and processing for wood products.	Semi-automated log processor-debarker	Launched in 2007 by Dave Cochrane, founder of the Waratah Group in 1973. Currently producing 8 models of grapple processor, harvester and felling heads. Producing approx. 130 processor heads per year in NZ.	In excess of $30 million p.a.	Southstar Equipment consists of Dave Cochrane and Jeremy Disher from New Zealand. Marcel Payeur, Michael Klopp, Jeff Rankel, Mike Sampietro and Brad Matthews from Canada. Approx. 20 staff plus outsourcing of manufacturing.	Offices in Kamloops, B.C. Canada, and Auckland, New Zealand. Agents throughout Canada, and in U.S.A., Chile, Brazil, Argentina, Uruguay, Australia, Indonesia, and Africa.
Mural Town Engineering Ltd, Katikati.	Machine design, modelling, customising, mechanical and structural engineering, manufacturing, and commercialisation.	Automated log residue chipper / shredder / grinder	NZ-owned private company founded in 1997. Developed the Levelmax levelling product for excavators and feller bunchers (licensed to Volvo Construction Equipment Ltd). Developed All Terrain Elevated Platform (ATP85) for working on steep terrain (up to 25 degrees). Also manufactures a range of continuous rotation equipment, the PacGrapple combined bucket and heavy duty grapple with saw for tree felling, saw boxes, forestry booms, and guarding packages.	$2 million p.a.	The company's office and manufacturing facilities are in Katikati in the Bay of Plenty. The company has 4 Directors and 2 staff plus outsourcing of manufacturing.	Sales of MTEL products throughout New Zealand and Australia
Patchell Industries Ltd, Rotorua.	From design to fabrication of heavy transport products, trailers for the logging industry, stainless tankers for bulk transport, container handling, specialist transport trailers, plus the Swinglift® brand Container Side Loader.	Teleoperated truck loading gantry and automated load securing system	Established in 1972, Patchell Industries Ltd has grown to hold the No. 1 position in NZ for trailer registrations since 2010. One of few manufacturers to invest in robot technology for fabrication process. Services include HPMV conversions, bolster attachment, load anchorage and load restraint components.	Group turnover in excess of $35 million p.a.	The company's Head Office is located in Rotorua and its manufacturing facilities occupy 9 nearby sites. It employs a strong team of 210 staff across its sites. Uses the latest design software and has a team of 13 highly qualified designers.	Patchell Group comprises Patchell Industries Ltd; Patchell Stainless Ltd; Patchell Repairs and Maintenance Ltd; SI Lodec NZ Ltd; SI Lodec South Island Ltd. Distribution throughout NZ and Australia
Engineering Services Rotorua Ltd., Rotorua.	Design and mechanical and structural engineering in steel.	Large capacity truck loading grapple	Manufactures the Woodsman line of log processors, plus heavy duty grapples, track and undercarriage modifications, forestry booms, and cab guarding packages.	In excess of $25 million p.a.	The company's Head Office and manufacturing facilities are located in Rotorua.	Branches in Rotorua and Gisborne
Alpine Logging Equipment (NZ) Ltd, Rotorua.	Design, manufacture and installation of a range of harvesting equipment, including shovel yarders, grapple carriages, and cameras. The firm has a strategy to automate harvesting equipment.	'Smart' yarder grapple & semi-autonomous hauler control	Founded in 2018 as a start-up joint venture company between Alpine Equipment South Africa, Logpro Ltd and Total Hydraulic Solutions Ltd. The business is focussed on marketing the Alpine line of harvesting products in New Zealand, including the Alpine Grapple Carriage, a non-motorised grapple, and the Alpine Shovel Yarder an excavator-based yarder.	In excess of $10 million p.a.	The company's manufacturing facilities are based in South Africa and Rotorua (Total Hydraulic Solutions Ltd) The company has staff of 3 design engineers in its development team.	Dealers throughout New Zealand and South Africa.
Skookum Technology Ltd, Auckland.	Manufacturing and commissioning of state-of-the-art equipment such as log scanning systems, log bucking optimisation, debarkers, in-feed conveyors, and log sorters	Robotic log sorter (in-feed deck, scanner and sort bins)	Leading Australasian supplier of sawmilling, biofuel and bulk loading equipment to the NZ and Australian solid wood processing industry.	In excess of $10 million p.a.	The company is based in Auckland with 2 Directors and 12 staff (plus outsourcing of manufacturing).	Service and spare parts sales centres in Auckland and Christchurch. Sales throughout New Zealand.
Pocket Solutions Ltd, Lower Hutt, Wellington.	Designing, integrating, and installing a range of mobile computing technology solutions, Wi-Fi infrastructure design and installation, supply of custom barcode labels and RFID tags, scanners, portals and software.	Automated log tagging and tag reading technology	Formed in 1993, the company has extensive experience and capabilities in mobile computing and automated data capture solutions. Applications include wireless connectivity over wide and local area networks, automatic product identification using barcodes and RFID tags, and integration to databases.	In excess of $2.4 million p.a.	The company is based in Lower Hutt with satellite offices in Rotorua and Melbourne, Australia. It has 3 Directors and 8 staff.	Service, repair and spare parts sales centres in Wellington and Rotorua and in Melbourne, and Sydney Australia. Sales throughout New Zealand and Australia.

2.7. Benefits

2.7.1. Net direct economic benefits

Total net economic benefits from forestry value chain efficiencies and sales of new machinery and equipment within the programme timeframe (to 2025) are summarised in Table 4.

Table 4: Summary of Net Economic Benefits from programme to 2025 (median or 'realistic' scenario)

Cost / Benefit	Description	Annual Benefit in 2025/26 ($ million p.a.)	Cumulative Benefits to 2025/26 ($ million)	Savings ($/m³)
Labour productivity from automation	Reduced harvesting cost from smaller automated crews	$18.99	$54.18	$6.72
Value chain efficiencies	HPMV log cartage, elimination of log weighing and export log scaling	$6.44	$19.19	$2.28
Environmental sustainability	Improved harvest planning, smaller log landings, improved residue management, and reduced chemical fumigation	$2.02	$7.45	$0.71
Sub-Total	**Operational Cost Savings**	**$27.45**	**$80.82**	**$9.71**
Machinery Sales	Gross profit on domestic sales of machinery and equipment	$4.91	$22.77	
Total Benefit	**Total Gross Economic Benefits**	**$32.36**	**$103.59**	
Programme Costs	**Total Programme Costs**	**$0.00**	**$29.36**	
Net Benefits	**Total Net Economic Benefits**	**$32.36**	**$74.23**	

The initial customer base to 2025 is the 40 harvesting contract crews and operators of the initial five log sort yards. This translates to an early adopter market of 312 units. Subsequent developments in the following five year period after programme completion (from 2025 to 2030) will see further sales of 930 units (576 units in nine additional log sort yards and additional component sales of 354 units). The total NZ market in 2030 could be a maximum of 55 sort yards supplied by 440 harvesting contractors, which translates to a potential market of over 3,500 units. The international market for these technologies will be primarily North America, Chile and Australia. Collectively, these markets are at least five times the size of the New Zealand market.

The cumulative net economic benefits achieved by 2030 from forestry value chain efficiencies and sales of new machinery and equipment are $395 million ($100 million per year in 2030). Net economic benefits out to 2030, comprising operational cost savings and gross profit on machinery sales, are given in Table 5. Gross profit is the total sales revenue less the direct costs of production (cost of goods sold), not net profit. Detailed analysis of benefits is included in section 4.3. Benefits.

Table 5: Net Economic Benefits including post programme benefits ($ million)

Cost / Benefit	Cumulative to 2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	Total
Operational cost savings	80.82	32.92	38.41	49.38	60.36	76.82	338.72
Gross profit on sort yard machinery sales	22.77	4.91	4.91	9.82	9.82	14.74	66.98
Gross profit on additional machinery sales	0.00	0.76	1.51	3.01	5.38	8.58	19.25
Programme Costs	29.36	0.00	0.00	0.00	0.00	0.00	29.36
Net Economic Benefits	**74.23**	**38.59**	**44.83**	**62.22**	**75.57**	**100.14**	**395.59**

By 2030:

- Harvesting and logistics operational costs will be reduced by $9.71/m³ (12% of value chain costs) resulting in annual operational cost savings from value chain efficiencies of $76.8 million p.a.

- Gross profit on sales of machinery and equipment will total $23.3 million p.a. (based on sales of products to supply the log sort yard systems and additional sales).
- Cumulative gross operational cost savings by 2030/31 will total $338 million.
- Commercialisation of 1242 units of machinery (14 log sort yards plus additional machinery sales) is projected to result in cumulative equipment sales of $215 million and generate gross profit for the manufacturing partners of $86 million.
- Total cumulative economic benefits projected to 2030 that are directly attributable to the programme will be $425 million, less programme costs of $29.4 million, resulting in cumulative net economic benefits of $395 million.

The total investment in the development programme is $29.4 million (excluding GST). The net present value (NPV) of the programme costs and benefits to 2030, at 8% discount rate, is $50 million. The internal rate of return (IRR) is 14.9%.

2.7.2. Sustainability benefits

- On-going social license to operate through improved safety by eliminating hazardous manual tasks will reduce health and safety incidents (and associated costs and liabilities). It is expected that the number of serious harm incidents in forestry and logging as recorded by WorkSafe NZ will be further reduced from 75 incidents p.a. in 2017 to less than 10 incidents p.a. by 2030.

- The industry's environmental performance will also be improved, and this will enable the community to see that harvesting and log transport is a good safe and sustainable business and one that is looking after its people.

- The programme will address labour shortages through automation and process changes within the forestry value chain. Outcomes will be a reduction in overall labour demand and increased labour productivity. By creating lower physical workload jobs, with improved safety through automation, the sector will become more attractive as a career to a wider and more diverse base of employees.

- A strengthened manufacturing sector oriented to forestry equipment and resultant exports, ultimately far greater than the NZ market. Commercialisation of equipment will result in sales and generate gross profit for the manufacturing sector and future-proof the industry's move into new automated technology.

- The programme brings together participants in a more integrated systems approach to innovation which will increase the uptake and use of technology and improve the sector's competitiveness.

2.7.3. Spillover benefits

The benefits that the programme will enable alongside other initiatives include:

- The value to the economy by 2025 of enabling the harvesting of more of the small-scale forest resource, that otherwise would not be economic to harvest, is $190 million p.a. It is anticipated that a large proportion of these smaller forests will be marketed through harvesting and marketing companies, such as Consortium members PF Olsen Ltd, Rayonier Matariki Forests, Forest Enterprises Ltd, Forest Owner Marketing Services Ltd and Wood Marketing Services Ltd. In this way the benefits of this technology development programme will be extended to small scale forest owners.

- Adding value to domestic wood processing sector by addressing log supply and quality issues in some regions through the centralisation of log volume at in-forest sort yards, improved log manufacturing and individual log identification.

- Improved regional resilience. This programme will actively contribute to the economic well-being and sustainability of rural communities. It will increase employment opportunities and potentially attract workers back into these communities.

- Improved profitability makes new planting more attractive, which helps government achieve its objectives of more trees planted.

2.8. Rationale for investment

As illustrated in the Outcome Logic Model (Figure 4) the long term outcomes of the programme are a sustainable, profitable and internationally competitive forestry sector using leading edge technologies, delivering higher economic returns for New Zealand. The programme is necessary to stimulate sector step change, enable significant public good benefits from forestry that cannot be captured by individual or collective investors, improve the capacity of the sector to innovate that would not occur otherwise, and improve sustainability of an industry that has a big impact on rural economies in many regions of New Zealand.

2.8.1. Step change

This programme changes the way logs are processed and delivered to customers. It harvests, sorts and stores logs more efficiently and safely than current landing-based methods. The result is a move away from unskilled labour towards total mechanisation and introduction of automation based on skilled labour. This programme brings together participants from the entire forestry value chain in a cooperative approach to change in a systematic prioritised manner. This is a significant step for a sector where collaboration towards innovation has traditionally been difficult to achieve. The PGP investment not only motivates this approach (as Government support for change has a positive effect on industry uptake) but also is critical to the implementation of this radical new value chain. This change cannot be achieved and the automation innovations implemented in a piecemeal manner.

2.8.2. Public good

The wider public benefits of this programme are significant:

- There are economic sustainability benefits to many rural regions (such as Waikato, King Country, Hawkes Bay, Manawatū-Whanganui, and Wairarapa) arising from this programme, including downstream support to the forest sector.
- The wider public benefits of the programme include improving social and environmental outcomes. Without Government investment the vital social, environmental and regional development benefits will be foregone.
- The innovations will not be easy to protect and good innovations will be copied and deployed widely. One example of this from the PGP Steepland Harvesting programme is the development of the ClimbMAX winch-assisted feller buncher with Trinder Engineering Ltd, which was quickly copied by at least three other manufacturers across New Zealand. It is expected that there will be continued rollout of the new logistics solution proposed in this programme. It has been calculated that the entire New Zealand annual log harvest could be handled by 55 log sort yards in total (i.e. an additional 41 sort yards to those forecast to be implemented to 2030) based on single shift. This programme is leading the change, but it is expected that it will result in more significant process changes in harvesting and log logistics and catalyse further technology developments.

2.8.3. Improved capacity to innovate

The forestry sector has limited capacity to innovate for several reasons:

- Profit margins in the sector have historically been low and costs are rising. This reduces the ability of forestry companies and their contractors to invest in innovation.
- Investment risk for small-medium enterprises (SMEs) such as harvesting and log transport contractors is high. The products resulting from this programme are high risk developments as they are new products, even though they will be transformational for the forestry value chain.
- With PGP support the introduction of new practices and work systems can be streamlined with regulators such as WorkSafe NZ and NZTA, given the underlying acceptance of the need for change and approval of the concepts in the programme. Government support through MPI funding will garner support from other Government agencies and can reduce the time for effective change to occur.

2.8.4. Sustainability

The PGP investment will greatly reduce the environmental impact of forestry operations by:

- Better managing harvest residues and therefore reducing the risk of resulting detritus in water ways.
- Reducing soil displacement. In all New Zealand harvesting operations currently over 26 million m^3 of soil is displaced annually during landing construction. Adoption of smaller log landings will reduce the volume of soil excavated during landing construction by 2.8 million m^3 per year (equivalent to over 280,000 truckloads of soil).

- Reducing use of chemical fumigants (through increased in-forest debarking). As export volumes rise, current export saw log volumes to China and India requiring chemical fumigation are forecast to rise from 14.3 million m^3 per year to 17.3 million m^3. Fumigation costs are also expected to double after 2020 when release of methyl bromide into the atmosphere will be banned. In-forest debarking in this programme will reduce the volume of export logs requiring chemical fumigation by 1.2 million m^3 per year. Debarking on a wider scale (to supply all the China export volume) could reduce the required volume to be fumigated from 17.3 million m^3 per year to only 2.4 million m^3 per year (India volume only) – an 85% reduction.
- Reduced log transport on public roads using HPMV. With the current 50Max trucks each carrying 33 tonne payloads the log volume harvested in this programme requires 85,600 truck trips p.a. With the use of 58 tonne gross vehicle mass HPMV (40 tonnes payload) carting from the sort yards to the customer would take 70,600 truck trips, a reduction of 15,000 truck trips per year (-17%).

2.8.5. Outcome logic

The Outcome Logic Model for Te Mahi Ngahere i te Ao Hurihuri – Forestry Work in the Modern Age is detailed in Figure 4, showing the short term (to 2025), medium term (to 2030) and long term outcomes of the programme (beyond 2030). Measures for programme outcomes are given in Table 6.

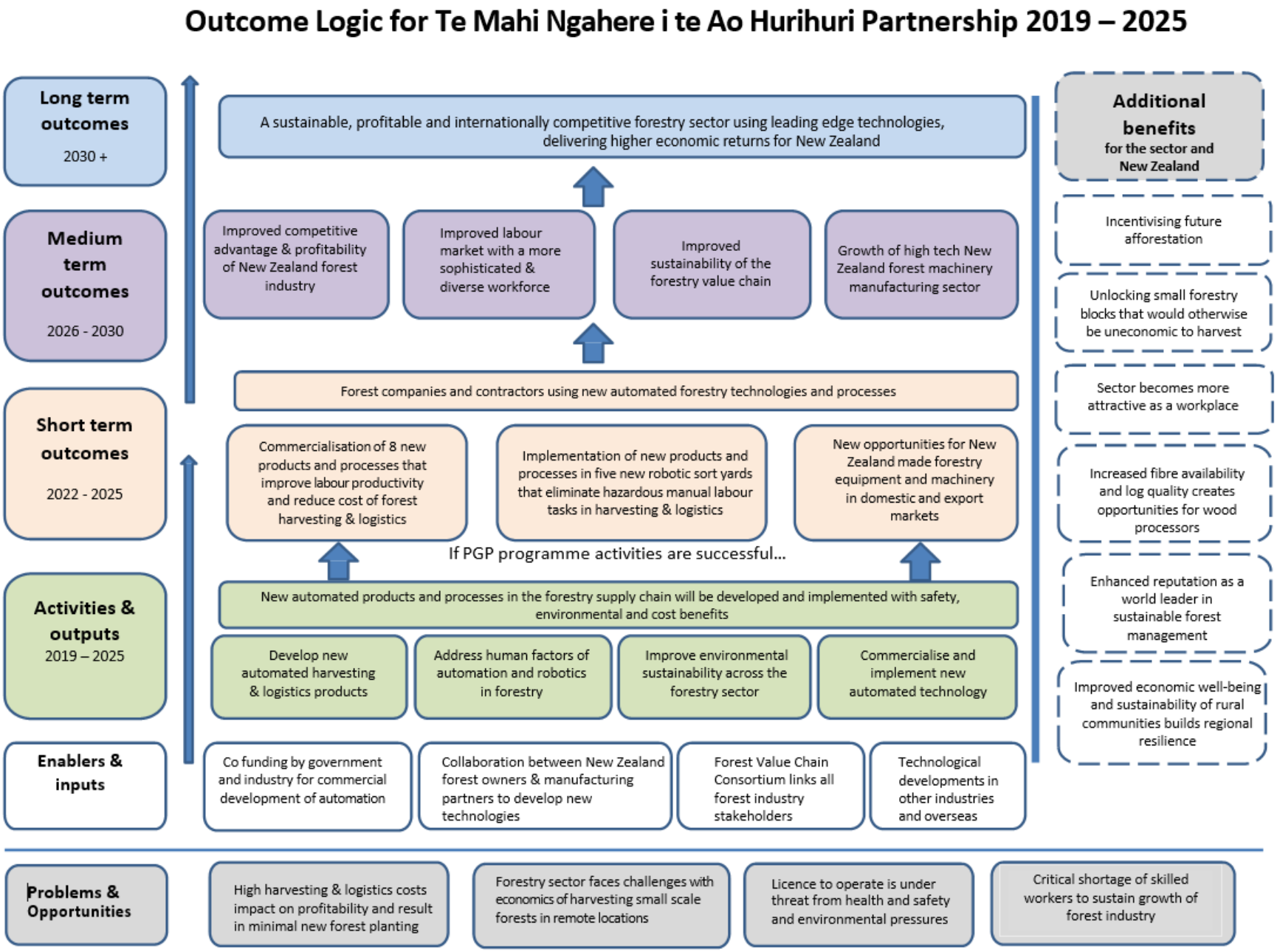

Figure 4: Outcome Logic Model for Te Mahi Ngahere i te Ao Hurihuri – Forestry Work in the Modern Age

Table 6: Outcome Measures for the programme

Outcomes	Short term outcome measures to 2025	Medium term outcome measures to 2030
Commercialisation of 8 new products that improve labour productivity and reduce cost of forest harvesting and logistics, leading to improved competitive advantage and profitability of forestry	Measures of commercialisation by 2025/26: • 39 commercial model semi-automated log processor-debarkers operating • 39 commercial model large capacity loading grapples operating • 44 commercial model automatic log tagging and tag reading systems operating • 34 commercial model semi-autonomous grapple & hauler control systems operating • 34 commercial model automated log residue chippers operating • 4 commercial model robotic log sorters operating • 4 commercial model automated truck loading gantries operating • Over 100 commercial model automatic truck load securing systems installed on logging trucks	Measures of improved competitive advantage and profitability by 2030/31: • Harvesting of small forests is viable economically resulting in annual plantation harvest exceeding 35 million m^3 p.a. • Forestry value chain costs have reduced by \$9.71/m^3 against 2017 levels • Over \$76 million p.a. of operational cost savings has been achieved by 2030/31 compared to 2017 levels.
Implementation of new products and processes in five new log sort yards that eliminate hazardous manual labour tasks in harvesting and logistics, leading to improved labour market and sustainability of the forestry value chain	Measures of implementation by 2025/26: • 5 new robotic log sort yards operating, handling over 2.8 million m^3 p.a. • 5 automated truck loading gantries operating • Up to 40 new harvesting crews supplying the 5 new log sort yards • Automatic truck load securing systems operating on over 100 logging trucks	Measures of improved labour market and more sophisticated and diverse workforce: • No manual labour roles in harvesting crews supplying log sort yards by 2030 • 50% reduction in crew size of automated harvesting crews (from 8 workers to 4) • Increased labour productivity from 38 m^3 per worker-day to 65 m^3 per worker-day for automated harvesting crews • 200 new automated job roles created by 2030 • Total harvesting workforce remains at current levels (3800 workers) while harvest volumes have increased • Fourteen (14) new robotic log sort yards operating by 2030/31, handling over 7.9 million m3 p.a. Measures of improved sustainability of the forestry value chain: • Log landings are 75% smaller in constructed area compared to 2017 • Chemical fumigation volume of export logs has reduced by 1.2 million m^3 p.a. from 2017 levels • Serious harm incident rates have reduced to less than 10 p.a. by 2030 • Over 15,000 fewer logging truck trips p.a. compared to 2017 levels • Log residue management is in place in all automated harvesting crews by 2030/31
New opportunities for NZ-made forestry equipment and machinery in domestic and export markets leading to growth of high tech NZ forestry machinery manufacturing sector	Measures of machinery sales (cumulative to 2025/26): • Sales revenue of \$17.9 million in semi-automated log processor-debarkers • Sales revenue of \$10.8 million in robotic log sorters • Sales revenue of \$8.5 million in semi-autonomous grapple & hauler control systems • Sales revenue of \$6.8 million in automated log residue chippers • Sales revenue of \$5.2 million in automatic log tagging and tag reading systems • Sales revenue of \$2.7 million in large capacity loading grapples • Sales revenue of \$2.6 million in automated truck loading gantries • Sales revenue of \$2.2 million in automatic truck load securing systems.	Measures of machinery sector growth: • By 2030/31 total sales revenue of new machinery and equipment exceeds \$215 million • By 2030 demonstrated growth of seven (7) NZ manufacturing partners building new forest harvesting and logistics equipment and machinery as measured by annual sales turnover.

2.8.6. Counterfactual scenario

The robotic sort yard system is a radical change compared to current landing practices. The cost and risk to the first adopters of the new system are prohibitive. Subsequent adopters will not bear these risks. Without this change practises are likely to stay as they are, albeit with some continuous improvements in conventional methods and techniques. There would continue to be an increase in mechanisation (as a result of the earlier Steepland Harvesting programme), and there will be expected growth in winch-assist felling machines from around 90 in 2017 up to over 130 machines by 2025. Harvesting costs will continue to rise at the current levels of around $1.00/m^3 per year (primarily due to demand for labour and the increasing proportion of steep terrain harvesting to about 70% by 2025). These rising costs will jeopardise the viability of harvesting of 15-20% of small forests (in remote locations with poor access) – up from current estimates of 6-9%. This means an additional 9-11% of the small forest resource will become uneconomic to harvest than in the intervention scenario. Some owners of small forests will not harvest their forests and the opportunity for the industry to expand to over 35 million m^3 per year will not be achieved.

As the proportion of steep terrain harvesting increases, labour productivity will continue to fall (as conventional hauler crews have larger crews and lower production compared to ground-based crews). Harvesting and log transport capacity will continue to constrain the growth of the industry. Harvesting and logistics job roles will stay very much the same with a high proportion of repetitive manual tasks (such as log quality control, log branding, stocktaking, and scaling of export logs). The opportunities to create harvesting and logistics jobs that are more automated, safer with lower workload, and therefore more appealing to a diverse future workforce will be missed.

More log debarking will be implemented by some larger scale forest owners, as a response to the regulatory changes regarding chemical fumigation in late 2020, through installation of large scale fixed debarking installations, but at a higher cost. There will be few opportunities for small forest owners to supply debarked logs to the China market as they will not have the capital available to install such facilities. The looming risks of poor environmental outcomes, tightening regulation and threats to forestry's social licence to operate will not be addressed.

Finally without PGP investment, the opportunities to develop New Zealand-made forestry machinery and equipment for both domestic and export sale will be lost. The existing forestry manufacturing companies will continue (due to ongoing mechanisation, especially of steep country harvesting). However the development of higher technology systems is too high a risk for many of these small and medium forestry machinery manufacturers (without supporting investment), and so few new systems will be developed. If left to individual machinery manufacturers the commercialisation of new technology will be undertaken in a more fragmented uncoordinated way. Opportunities to speed up the innovation process, reduce risk for both technology developers and forestry contractors (as buyers of the new technology) and to build cross-sector capabilities for the future will also be missed.

Key consequences of no PGP investment

If PGP does not invest:

- The programme would not go ahead as designed. Because of the interdependencies between the planned projects, a large scale programme is required to generate the significant benefits forecast ($100 million p.a. in 2030). Industry investment from FGLT would need to be rebid, as there is significant competition for industry development funding. That is, it is an "all or nothing" initiative.
- The planned changes are unlikely to happen without the combination of PGP and industry funding to de-risk the substantial financial investment in development of new technology. This is due to two reasons: the extent of the planned change across the whole forest value chain; and the significant upfront costs and risks that first adopters incur which subsequent implementers do not face. At the very least, lack of PGP funding would slow the rate of change – the sector will continue to develop but improvements will take much longer. Delivery of desired outcomes would be delayed by a minimum of 10 years.
- Any future change will be more costly as developments will be piecemeal, lacking the whole-of-value-chain vision of this programme, and any change will be less efficient and less likely to be successful (that is, there will be more failures).
- Opportunities for a more coordinated approach across industry training and educational institutions to identify future training needs of the industry and develop the workforce of the future will be missed. This programme will collaborate with these institutions (such as Toi Ohomai Institute of Technology, University of Canterbury and Competenz) to undertake this task. In the absence of PGP funding, progress in this area will be slow.

3. Programme Plan

3.1. Overview

The programme has three project objectives designed around development of new automated technology; human factors of automation and training, and product commercialisation and implementation (Figure 5).

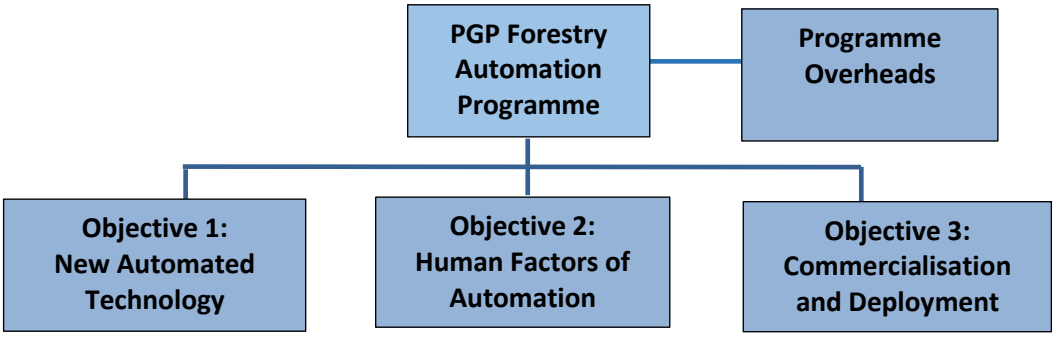

Figure 5: Structure of the Programme

This programme builds on the concepts of forestry mechanisation, remote control and teleoperation to develop new technology products to deliver new automated harvesting, log manufacturing and loading processes.

The programme plan is to establish five complete sort yard-based systems implemented by individual Consortium forestry companies across their forest estates, to develop, prove, customise, introduce, improve and promote the new system (Table 7).

Table 7: Consortium forestry companies implementing sort yards

Forest Owner/Contractors	Sort Yard Region
PF Olsen Group	King Country
Rayonier Matariki Forests	Hawkes Bay
Forest Enterprises Ltd	Wairarapa
Forest Owner Marketing Services Ltd	Whanganui
Wood Marketing Services Ltd	Waikato

The spread of systems across different regions, forests and harvesting systems, due to the variation in physical geographies, forest conditions and contractor mixes, will result in some variation between systems, ensuring that the full range of harvesting conditions will be demonstrated across the systems established. The additionality provided by each of the five sort yard systems is detailed in section 3.8 Ongoing delivery.

Objective 1, New Automated Technology, will design and develop all the equipment and machinery required for the change to the new sort yard system. Initially it will design and build a minimum viable prototype system for implementation by mid-Year 4 of the programme to test and improve the system for future deployment of the subsequent four sort yards (and associated log supply).

The design of the alpha prototype of each product will be mainly funded by each manufacturing partner (as in-kind contribution of up to one full-time equivalent, depending on the complexity of design of each product). There will also be initial input to engineering design by the development team and harvesting and log transport contractors as part of the Human Factors programme (Objective 2).

The development cost (materials and build) for the first set of 'alpha' prototypes will be co-funded in cash by the first adopter forest owner/contractor(s), industry funding from FGLT, and MPI cash funding. The cash funding by the first adopter forest owner/contractor(s) for the development of the 'alpha' prototypes deployed in the first log sort yard ($1.1 million) reflects the high level of risk the first adopters will take (due to the high level of interference to standard operations) over the first three years, the total level of investment required for the development of the alpha prototype machinery and equipment ($6.1 million) and the commitment the first adopters will make towards adopting this radical new logistics system.

The Consortium has not yet decided which forest owner/contractor(s) will be the first adopter, but this will be an early decision point in the programme. This 'alpha' prototype system will be sufficient to enable the initial move to take log sorting off the landing (for one harvesting contractor) and shift this function to the sort yard. This will demonstrate the operation of smaller harvest crews with fewer machines on small log landings and be the basis for establishing the new log logistics system for the balance of the supply to the first sort yard.
The minimum viable system prototype will include:

a. Landing products:
    - A semi-autonomous grapple and hauler control system
    - A log processor–debarker to debark and tag logs as they are manufactured
    - A log residue chipper/shredder/grinder attachment (to handle harvesting residues)
    - A large capacity log loading grapple (operated with an automatic quick coupler to reduce truck loading delays)
b. Sort yard products:
    - A mechanical log sorter with full scanning and sorting capabilities (the robotic component will be added subsequently)
    - A truck loading gantry to reduce truck loading delays
    - A truck load securing system (to ensure security of debarked logs on HPMV trucks)

'Beta' prototypes (or pre-commercial models) of each product will be developed as a result of trial and modification of the earlier 'alpha' prototypes. These 'beta' products will be deployed initially to the harvesting crews supplying the first log sort yard. The cost of development and deployment of the 'beta' prototypes for Sort Yard 1 will be co-funded by the first adopter forest owner/contractor(s) and FGLT as the Consortium cash contribution and by MPI funding.

Over the next three years (Years 4-6 of the programme) log sort yards #2 – #3 will be established by other Consortium forest owners and contractors. 'Beta' prototypes used in these systems will continue to be developed based on the knowledge gained from deployment and field testing of the prototypes in the first log sort yard. In addition to the prototype development costs, field trials will validate the expected economic benefits.

The basis of the calculation of cash and in-kind contributions in the development of the 'alpha' and 'beta' prototypes is detailed in section 4.5 Contributions.

Objective 2, Human Factors of Automation, will support the development of each product with a focus on human-machine interaction, training to use the new products and the best use of the whole system. Objective 2 will also include field testing of each product by harvesting and log transport contractors (as part of the Human Factors programme). This Objective will collaborate with manufacturing partners and FGR's tertiary education and training partners (Competenz, Toi Ohomai Institute of Technology and University of Canterbury School of Forestry). The aim is to integrate the operator into the machine design, develop initial job design for the new roles, standard operating procedures, training materials for workforce skills & development, recommendations for training programmes and appropriate unit standards for 'stair-casing' into new and improved forestry qualifications. This will enable retraining of workers in redundant manual labour roles and also attract new workers from a more diverse demographic to undertake new roles within the logistics system.

Objective 3, Commercialisation and Deployment, will focus on initial deployment of the new products across the first three new log sort yards and commercialisation of the technology. This Objective will establish the commercial framework for each product. This will be a process of engagement of each manufacturer with a specifier (forest owner) and a user (contractor). This engagement will ensure that market requirements and the product specification are understood and agreed by these parties. Objective 3 activities will include promotion and demonstration of the new system and the individual projects to build market awareness beyond the initial sort yard systems and so facilitate widespread technology adoption.

Table 8 summarises the overall budget for programme investment by co-investor.

Table 8: Total Programme Investment by Co-investor

Budget Funding ($'000 excl. GST)									
Investor	**2018/19 Year 1 half-year**	**2019/20 Year 2**	**2020/21 Year 3**	**2021/22 Year 4**	**2022/15 Year 5**	**2023/24 Year 6**	**2024/25 Year 7**	**2025/26 Year 8 half-year**	**Total Budget**
Consortium cash	300	1,399	2,494	3,613	4,066	1,547	480	260	14,159
Consortium in-kind	12	1,003	1,129	589	381	281	50	12	3,457
Consortium total	312	2,402	3,623	4,202	4,447	1,828	530	272	17,616
MPI Investment	208	1,601	2,415	2,801	2,965	1,219	353	181	11,744
TOTAL INVESTMENT	**520**	**4,004**	**6,038**	**7,003**	**7,412**	**3,047**	**883**	**453**	**29,360**

3.2. Objective 1: New automated technology

3.2.1 Project objectives

1. Develop new automated forest harvesting and logistics products to improve profitability of the forestry value chain.
2. Develop new forest engineering processes to improve environmental sustainability across the forestry sector through:
    - Moving the sorting function off the landing to reduce landing size
    - Managing log residues to reduce the risk of deposition into waterways
    - In-forest debarking to reduce the volume of wood treated with chemical fumigants
    - Introducing more 58-tonne gross HPMV to reduce the number of logging trucks on the public road.

3.2.2 Activities

1. Engagement of Forest Owners and Contractors
   The technology development will be a market-led exercise in conjunction with the Consortium forest owners and their contractors from inception. The key Consortium forestry companies implementing sort yards will develop a preferred system design for their sort yard and participating harvesting contractors. This will be the basis for confirming the Consortium forestry company implementing the first sort yard, the products to be developed, their priority and the teams to work with the specific manufacturers on each product development project. Arrangements with respect to roles and responsibilities and timeframes of the Consortium forestry company (and designated Sort Yard Project Leader) and FGR's Programme Manager will be agreed by each party and formalised in an agreement.
2. Establishment of Project Teams
   FGR will support establishment of project teams for each product and sort yard development. Each manufacturing partner will lead a product development project team (Product Development Project Leaders) for each product comprising representatives of the participating forestry companies and their key harvesting and log transport contractors (as product champions). The participating forestry company driving each log sort yard will lead a Sort Yard Development Project team, comprising relevant representatives of the participating forestry company, their key harvesting and log transport contractors and manufacturing partners. The capacity of each manufacturing partner to undertake each project and support the product roll out into the market, and the timetable and budget for each product development will be agreed, and will be confirmed by way of standard FGR Services Agreement. FGR will enter into an agreement with each Consortium manufacturing partner which will, among other things, include:
    - Development, commercialisation and sales and marketing roles
    - Funding by each party
    - IP management
    - Reporting
    - Time frames (aligned to Objective Milestones)
3. Technical and Economic Feasibility
   These activities include project planning, technical design (undertaken by manufacturing partner as in-kind contribution) and technical and economic feasibility analysis of each product.

4. Development of 'Alpha' Prototypes
   'Alpha' prototypes of each of the 8 new technology products for automated harvesting and logistics systems will be developed to efficiently supply the first robotic log sort yard. These activities include final design, and development of manufacturing prototypes. The budgeted materials and build cost of each 'alpha' prototype (except the log sorter) includes the cost to build two prototypes (manufacturing prototype and 'alpha' prototype) for each product.
5. Development of 'Beta' Prototypes for Sort Yard 1
   'Beta' prototypes of each of the new technology products for automated harvesting and logistics systems will be developed that efficiently supply the harvesting crews for the first log sort yard to ensure a viable system for testing and demonstration.
6. Developments for the subsequent log sort yards (#2 – #3) will include:
   a. Sort yard products
      i. Support for the development, refinement and installation of the robotic sort yard and loading system beta prototypes
      ii. Refinement of each system to suit diverse geographies and diverse range of forest types
   b. Landing products
      i. Further product improvements, including possible redesign in response to in-field testing
      ii. Addition of further features to improve worker experience from Objective 2 learnings
      iii. Further automation including teleoperation of landing tasks
   c. System developments
      i. Other value-add opportunities identified through the process changes will be evaluated including their impacts on road transport, port operations and wood processing.

A summary of the investment in prototype development by co-investor is given in Table 9.

Table 9: Development Plan Budget by Co-investor – Objective 1 New Automated Technology ($'000)

Activity	Manufacturing Partner In-Kind	First Adopter (Forestry Co. / Contractor) Cash	Industry (FGLT) Cash	Industry Investment total	MPI Investment total	Total Development Plan
Alpha Prototypes	1,295	1,107	1,264	3,666	2,444	6,110
Beta Prototypes (Sort Yard 1)	0	2,240	448	2,688	1,792	4,480
Beta Prototypes (Sort Yard 2)	0	2,135	427	2,562	1,708	4,270
Beta Prototypes (Sort Yard 3)	0	2,135	427	2,562	1,708	4,270
Other Projects	0	0	236	236	158	394
Project Mgt.	0	0	731	731	487	1,218
Total Objective 1	**1,295**	**7,617**	**3,533**	**12,445**	**8,297**	**20,742**

The introduction of the initial new log sort yards (up to 5 sort yards with associated log supply from up to 40 harvesting crews) into the forest operations of the first adopter Consortium members is integral to the planned commercialisation strategy, and will provide a reliable initial market for the manufacturing partners, reducing their risk. The programme development plan, which shows the timetable for the development of each product and the deployment at each log sort yard, is illustrated in Figure 6.

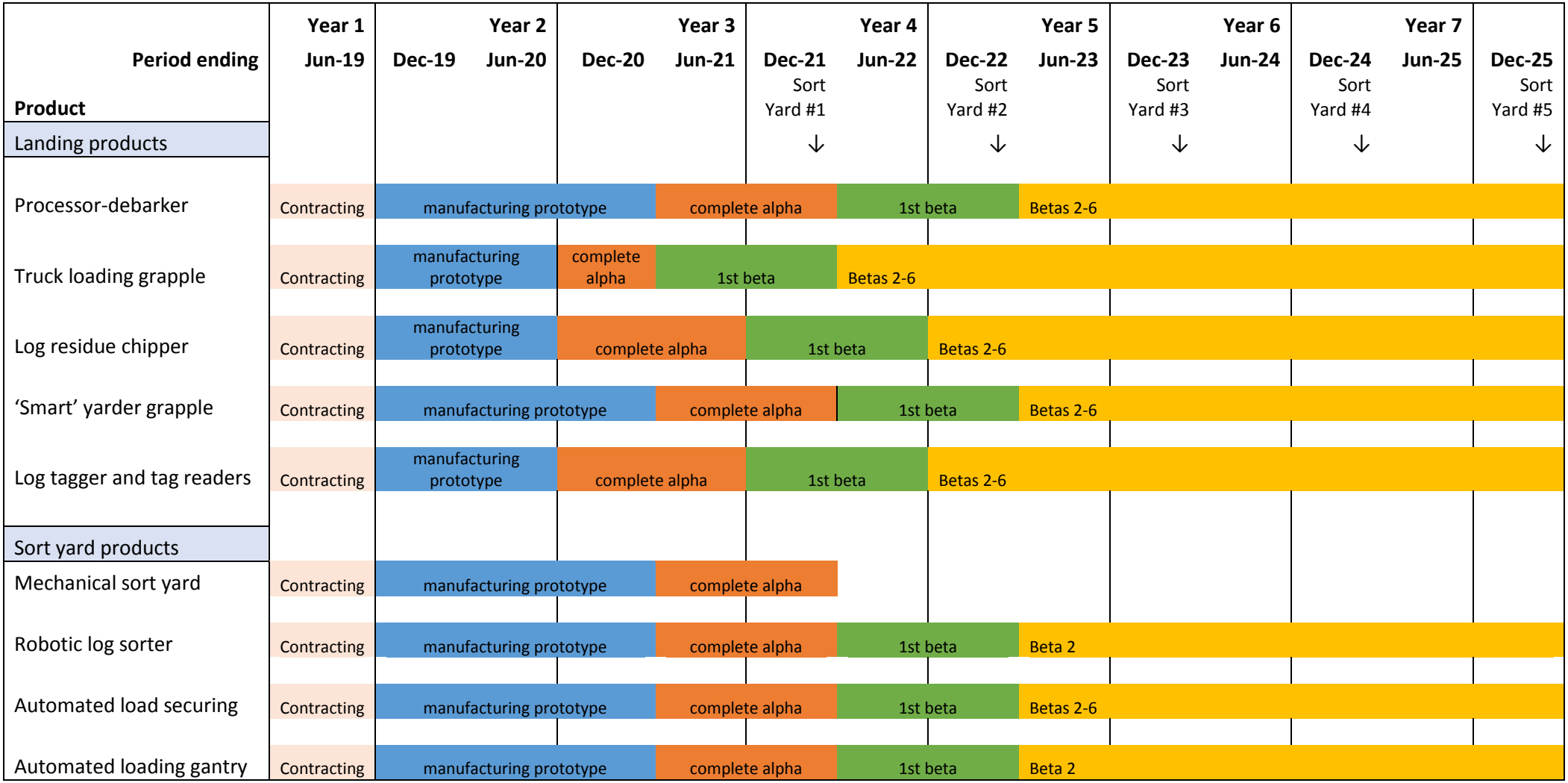

Figure 6: Programme Development Plan

3.2.3 Outputs

1. Final product specifications to automate manual tasks throughout the forestry value chain are developed for the following products:
    - semi-automated log processor-debarker
    - processor head-based log tagging technology (including tag readers at the log sort yards)
    - automated log residue chipper/shredder/grinder
    - large capacity log loading grapple (designed to work with an automated quick coupler)
    - semi-autonomous skyline grapple & hauler control system
    - automated truck loading gantry
    - automated log truck load securing system
    - a robotic log sorter (including in-feed deck, scanner and sorting bins)
2. One 'alpha' prototype of each of the eight new technology products has been completed ready for implementation in the first log sort yard by 31 December 2021.
3. The first 'beta' prototypes of the automated harvesting system supplying the first log sort yard have been completed and implemented by 31 December 2022.
4. Log sort yards #2 – #3 have been implemented by 30 June 2024.

3.2.4 Budget

The budget for Objective 1 New Automated Technology is detailed in Table 10.

Table 10: Investment by Co-investor – Objective 1 New Automated Technology ($'000)

Objective 1 Development Plan Funding ($'000 excl. GST)									
Co-investor type	**Year 1 2018/19**	**Year 2 2019/20**	**Year 3 2020/21**	**Year 4 2021/22**	**Year 5 2022/23**	**Year 6 2023/24**	**Year 7 2024/25**	**Year 8 2025/26**	**Total**
Consortium cash	165	1,111	2,157	3,170	3,547	991	4	6	11,150
Consortium in-kind	0	647	647	0	0	0	0	0	1,295
Consortium total	165	1,759	2,804	3,170	3,547	991	4	6	12,445
MPI cash	110	1,173	1,870	2,113	2,364	661	3	4	8,297
Total Objective 1	**275**	**2,931**	**4,674**	**5,283**	**5,911**	**1,652**	**7**	**9**	**20,742**

3.3 Objective 2: Human factors of automation

3.3.1 Project objectives

Over the next 10 years, the forest industry in New Zealand will need to adapt to changing markets and pressures. This objective, to address human factors issues of forestry automation and robotics, is focussed on preparing for tomorrow – assisting the development of new forestry machines which integrate with human abilities and limitations, and identifying the skills and knowledge required to operate these machines for the forestry industry of the future. Specific project objectives are to:

1. Improve process and product design with respect to safety, human performance and operation.
2. Understand, design and prepare for future workforce jobs and skills.
3. Improve work force sustainability by demonstrating the new work environment.

3.3.2 Activities

1. Benchmarking NZ harvesting sector
   Benchmark the gap between current workforce skill needs and future needs to guide the development programme and measure improvements by:
    - Surveying the forest industry to benchmark the base line state
    - Measuring the gap between the current state and required attributes (job design) to improve fit between worker attributes and future roles
    - Using the forest industry Incident Recording Information System (IRIS) to analyse injuries occurring in tasks that will be automated as a baseline for benchmarking progress.

2. Cognitive and Physical Human-Machine Interaction
   Provide input, based on robust science, to engineering design for automated equipment in Objective 1 (physical and cognitive ergonomics, machine layout and design, measurement of human limitations etc.) to minimise operator fatigue, enhance operator productivity and determine the right balance of automated functions with manual functions, as opposed to traditional productivity/cost benefit analyses which do not take into account the requirements of the operator.
3. New Job Design
   Determine the new roles (e.g. automated debarker-processor operator, semi-automated grapple yarder operator, robotic log sorter operator etc.) for the workforce of the future. Determine the impact these new roles will have on conventional harvesting jobs (such as manual tree faller, breaker-out, yarder operator, grapple processor operator, loader operator). Determine options for re-training existing workforce versus training new entrants. Determine how retraining will be achieved.
4. Operating Techniques
   Develop standard operating procedures for new machinery (interdependency with Objective 1) and associated job design and work organisation accounting for human abilities and limitations.
5. Workforce Skills and Development
   Develop training methods and materials (simulators, video, head up displays, VR, other 'hands-on' tools etc.) that can be used for trainee operators of the new machines.
6. New Standards and Qualifications
   Implement workshops and technical meetings in collaboration with education and training organisations to develop unit standards and qualifications that relate to the new roles.
7. Targeted Industry Projects
   Specific industry projects to address work force issues, e.g. human factors survey of industry operators to determine demographics, training experience, fitness, workload levels, and impact on fatigue, safety and work performance.

All activities will be undertaken in collaboration with appropriate combinations of staff from manufacturing partners, Scion, Toi Ohomai Institute of Technology, University of Canterbury School of Forestry and Competenz, leveraging organisational strength.

A summary of the investment in Objective 2 by co-investor is given in Table 11.

Table 11: Development Plan Budget by Co-investor – Objective 2 Human Factors of Automation ($'000)

Activity	Forestry Co. / Contractor In-Kind	First Adopter (Forestry Co. / Contractor) Cash	Industry (FGLT) Cash	Industry Investment total	MPI Investment total	Total Development Plan
Benchmarking	32	0	149	181	121	302
Cognitive & Physical Human-Machine Int.	91	0	419	511	341	851
New Job Design	29	0	132	161	108	269
Operating Techniques	32	0	149	181	121	302
Workforce Skills	49	0	226	276	184	459
Standards & Qualifications	24	0	110	134	90	224
Targeted Projects	37	0	171	208	139	347
Project Management	0	0	240	240	160	400
Total Objective 2	**296**	**0**	**1,598**	**1,894**	**1,262**	**3,156**

3.3.3 Outputs

1. Baseline of forest industry human factors issues measured and reported.
2. Best practice health and safety and ergonomics implemented in development of new automated machinery and equipment products to eliminate manual tasks throughout the forestry value chain.
3. New safe high productivity workplace roles described and developed. The following changes to work organisation are anticipated at deployment of the first log sort yard (mid-Year 4):

a) Ground-based harvesting crews at landing:
   - Reducing from seven to five workers
   - One new processor-debarker-loader operator using an automated quick coupler to switch attachments. Skills include operation and maintenance. Log quality control will be part of this function
   - Foreman – knowledge of new technologies, use of electronic production data systems, skills to balance harvesting and schedule trucking operations, electrical/electronic engineering and data management skills.

b) Hauler harvesting crews at landing:
   - Reducing from eight to four workers
   - New hauler computer control, semi-automated grapple with sensing technology.
   - One operator for new processor-debarker-loader using a quick coupler to switch attachments. Skills include operation and maintenance. Log quality control will be part of this function.
   - Operation of new chipper/shredder device for processing log residue, and associated operation and maintenance skills required.
   - Foreman – knowledge of new technologies, use of electronic production data systems, skills to balance harvesting and schedule trucking operations, electrical/electronic engineering and data management skills.

c) Sort yard operators:
   - Job rotation between unloading mixed grade logs from harvesting crews, loading log sorter in-feed deck, clearing log sorter bins and loading truck gantry.
   - Loader operations
   - Log Sorter operator
   - Yard management. Roles include: Maintenance of yard, buildings and machinery management; logistics scheduling and management (for site with annual throughput exceeding 550,000 m^3); possibly including scheduling and dispatch of HPMV trucks to multiple customer destinations.

4. Impact of these new roles on worker safety, workload, job satisfaction, retention and recruitment in the forest industry has been evaluated.
5. Training systems and packages for new roles developed. This includes Operating Manuals for the new products (in collaboration with manufacturing partners).
6. Gap between current skills of the workforce (training, levels of achievement and numbers of works in each role) and future requirements determined in order to evaluate skill development needs for workforce of the future.
7. Development of training recommended to forest industry training and education providers through a variety of tested methods (on the job training, workshops, virtual reality, etc.)
8. Practical on-job training and off-job workshops and training implemented.

3.3.4 Budget

The budget for Objective 2 Human Factors of Automation is detailed in Table 12.

Table 12: Investment by Co-investor – Objective 2 Human Factors of Automation ($'000)

Objective 2 Development Plan Funding ($'000 excl. GST)									
Co-investor type	**Year 1 2018/19**	**Year 2 2019/20**	**Year 3 2020/21**	**Year 4 2021/22**	**Year 5 2022/23**	**Year 6 2023/24**	**Year 7 2024/25**	**Year 8 2025/26**	**Total**
Consortium cash	80	190	191	241	249	313	216	118	1,598
Consortium in-kind	12	24	50	50	50	50	50	12	296
Consortium total	92	214	240	291	299	362	265	130	1,894
MPI cash	61	143	160	194	199	241	177	87	1,262
Total Objective 2	**153**	**357**	**401**	**485**	**498**	**604**	**442**	**217**	**3,156**

3.4 Objective 3: Commercialisation and deployment

3.4.1 Project objectives

1. Commercialise eight new technology products arising from the programme.
2. Develop and deploy up to five relocatable robotic log sort yard systems and up to 40 associated harvesting log supply crews.
3. Assist the business development of the manufacturing partners and the deployment of the new technology for the above systems.
4. Build awareness across the Consortium forestry companies and the wider forest owner and contractor communities of the technology products, the new logistics systems and their benefits.

3.4.2 Activities

1. Commercial frame work
   Establishment of the commercial frame work for each product will be conducted in parallel with the engagement process (Objective 1). It is the initial business case for the product development. Product specification, development and testing will all have their roots in the market place. Each Commercialisation Plan will include:
   - A review of the business environment
   - Market research to confirm customer needs
   - Competitor and alternative options analysis including drawing on the international technology watch
   - Identifying anticipated product benefits and competitive advantage
   - Estimating likely initial market demand
   - Preparation of a market situation report

2. Intellectual Property (IP)
   An IP strategy will be developed for each product developed as part of the programme. For all products, other than the robotic log sort yard, prior IP remains with the holder but will be licensed for use if required. Any new discrete IP funded by the programme will be owned by FGR. The IP strategy will form part of the commercialisation plan. This plan will include performance objectives. Where required, FGR will conduct a freedom to operate search, normally during the design phase. IP will be secured and managed as detailed in section 3.6.4. Intellectual property.

3. Business Development Support
   Business development comprises a set of activities by the manufacturing partner with support from FGR to ensure the proposed product is appropriate and that uptake is likely. These activities will encompass:
   - Confirming initial product champions (contractors)
   - Commercial review at each stage of development including market engagement
   - Promotion at events and conferences and through social media (refer deployment)
   - Determining route to market in NZ and internationally (i.e. through the manufacturer's existing distribution or alternatives)
   - Business strategy for each product formed (which becomes a living document). This will include investigation of the most appropriate sales model such as rental, lease, or financed purchase.
   - Additional grant funding (e.g. Callaghan Innovation, Kiwinet or other) or investment for commercialisation, if required.

4. Commercialisation
   The 'alpha' prototypes (including design, materials, build and installation in the first sort yard) will be co-funded at an agreed proportion of the materials and build cost by the manufacturing partners and the first adopter forestry company/contractor(s) to reflect their 'alpha prototype' status. Development of the 'beta' prototypes for the log sort yards will be co-funded by the Consortium forest owners and their contractors at a higher proportion, to reflect the reduced risk.

   The robotic log sorter will be the central component of the new logistics solution. It is expected and logical that each sorter will be tuned to the local conditions of each log sort yard. Depending on the Consortium forest owner's requirements, once the first sort yard is established, specialist contractor(s) will be trained to operate it and to demonstrate the system and participate in a structured technology transfer programme. The widespread adoption of the technologies developed will be greatly boosted by the uptake of the robotic log sorter. Therefore the commercialisation strategy is to make the sorter technology widely available but to

provide exclusivity to the Consortium manufacturing partner(s) as an incentive for them to enter the market. FGR will support, not lead, the manufacturing partners in these activities.
For each product, activities will include:

- Completion of commercialisation plan, and sign off by PGG
- Preparation of training programme, user manuals, SOPs and sales materials
- Product in play with first adopter, or product champion
- Product launch at an appropriate industry event.

5. Deployment
   This activity will create awareness of the products and technology to the target NZ market, demonstrate the benefits, to initiate and speed up the market uptake. Activities will include:
   - An active website and social media campaign to provide information about the programme and its products throughout their development
   - Preparation and use of video (YouTube) and printed material once the first prototype is tested to prepare the market
   - Presentations at industry tradeshows, conferences and workshops throughout New Zealand and overseas.
   - Regional technical workshops to forest owners and contractors (in conjunction with Forest Industry Contractors Association).
   - Deployment into five log sort yard systems
   - Field demonstration of each logistics system after commissioning (organised by FGR).

A summary of the investment in Objective 3 by co-investor is given in Table 13.

Table 13: Development Plan Budget by Co-investor – Objective 3 Commercialisation and Deployment ($'000)

Activity	For. Co. / Contractor In-Kind	First Adopter (For. Co. / Contractor) Cash	Industry (FGLT) Cash	Industry Investment total	MPI Investment total	Total Development Plan
For. Co. Engagement	28	0	7	35	23	58
Comm. Framework	106	0	26	132	88	220
Intellectual Property	154	0	38	192	128	321
Business Development	421	0	104	525	350	875
Commercialisation	343	0	85	429	286	714
Deployment	478	0	119	597	398	995
Reporting & Mgt.	160	0	40	199	133	332
Program Promotion	176	0	44	220	146	366
Project Management	0	0	208	208	139	347
Total Objective 3	**1,866**	**0**	**671**	**2,537**	**1,691**	**4,228**

3.4.3 Outputs

1. Each product has a commercial manufacturing partner and commercialisation plan
2. IP is secured and used to provide advantage to the benefit of New Zealand and the forestry sector.
3. Five robotic log sort yards have been implemented with associated harvesting operations to supply same.
4. Product champions for each product have been confirmed.
5. Industry field demonstration of each new log sort yard and logistics system (five field demonstrations).

3.4.4 Budget

The budget for Objective 3 Commercialisation and Deployment is detailed in Table 14.

Table 14: Investment by Co-investor – Objective 3 Commercialisation and Deployment ($'000)

Objective 3 Development Plan Funding ($'000 excl. GST)									
Co-investor type	**Year 1 2018/19**	**Year 2 2019/20**	**Year 3 2020/21**	**Year 4 2021/22**	**Year 5 2022/23**	**Year 6 2023/24**	**Year 7 2024/25**	**Year 8 2025/26**	**Total**
Consortium cash	41	12	6	19	69	164	237	124	671
Consortium in-kind	0	332	432	539	331	231	0	0	1,866
Consortium total	41	344	438	558	401	396	237	124	2,537
MPI cash	27	229	292	372	267	264	158	82	1,691
Total Objective 3	**68**	**573**	**730**	**930**	**668**	**659**	**394**	**206**	**4,228**

3.5 Programme budget

3.5.1 Programme overheads

Programme overheads are calculated at 5% of development cash expenses and comprise the following: a share of FGR management and office expenses, FGR attendance at Programme Governance Group meetings, and costs of the independent Chair of the PGG. The budget for programme overheads is given in Table 15.

Table 15: Investment by Co-investor – Programme Overheads ($'000)

Programme Overheads Funding ($'000) excl. GST									
Co-investor type	**Year 1 2018/19**	**Year 2 2019/20**	**Year 3 2020/21**	**Year 4 2021/22**	**Year 5 2022/23**	**Year 6 2023/24**	**Year 7 2024/25**	**Year 8 2025/26**	**Total**
Consortium cash	15	86	140	183	201	79	24	13	740
Consortium in-kind	0	0	0	0	0	0	0	0	0
Consortium total	15	86	140	183	201	79	24	13	740
MPI cash	10	57	94	122	134	53	16	8	493
Total Overheads	**24**	**143**	**234**	**305**	**335**	**132**	**40**	**21**	**1,233**

3.5.2 Total programme expenditure

The summary of the total programme expenditure budget by objective is given in Table 16.

Table 16: Budget by Objective – Total Programme Expenditure Summary ($'000)

Total Programme Expenditure ($'000) excl. GST									
Objective	**Year 1 2018/19**	**Year 2 2019/20**	**Year 3 2020/21**	**Year 4 2021/22**	**Year 5 2022/23**	**Year 6 2023/24**	**Year 7 2024/25**	**Year 8 2025/26**	**Total**
Objective 1 New Automated Technology	275	2,931	4,674	5,283	5,911	1,652	7	9	**20,742**
Objective 2 Human Factors of Automation	153	357	401	485	498	604	442	217	**3,156**
Objective 3 Deployment and Commercialisation	68	573	730	930	668	659	394	206	**4,228**
Programme Overheads	24	143	234	305	335	132	40	21	**1,233**
Total Expenditure	**520**	**4,004**	**6,038**	**7,003**	**7,412**	**3,047**	**883**	**453**	**29,360**

3.6 Management and governance

3.6.1 Forest Value Chain Consortium

The Forest Value Chain Consortium will lead the programme and drive implementation of the new technology. This new Consortium addresses the strategic forest industry objectives to improve efficiency and safety in operations and value chain logistics. Its purpose is to bring together the requirements of, and opportunities arising from, the forest owners and forest management companies and key contractors of both large and small holdings, and the manufacturers of forestry equipment (through FGR) to refine and finalise the strategy of this programme, review progress towards that strategy, to ensure implementation of the technology and delivery of the PGP outcomes.

Initially all foundation members of the Consortium have been invited to be part of the Consortium Board but they may decide to form a smaller one subsequently. Mr. Peter Clark (B. For. Sc. (Hons), MNZIF) is foundation Chair of the Consortium. He is Director of PF Olsen Group Ltd, ex-President of the NZ Forest Owners Association, recent board member of the NZ International Business Forum and the New Zealand China Council, and member of the Business Leaders' Health & Safety Forum.

The forest owners and forest management companies investing in the five log sort yards have given their written support for this programme (Appendix 5.3). Through FGR, the Consortium will finalise commercial arrangements with these forest companies and with the manufacturing partners, regarding investment (cash and in-kind contributions), final machinery specifications, IP, development and deployment, marketing and further commercialisation.

Figure 7 describes the programme governance processes and relationships between the parties.

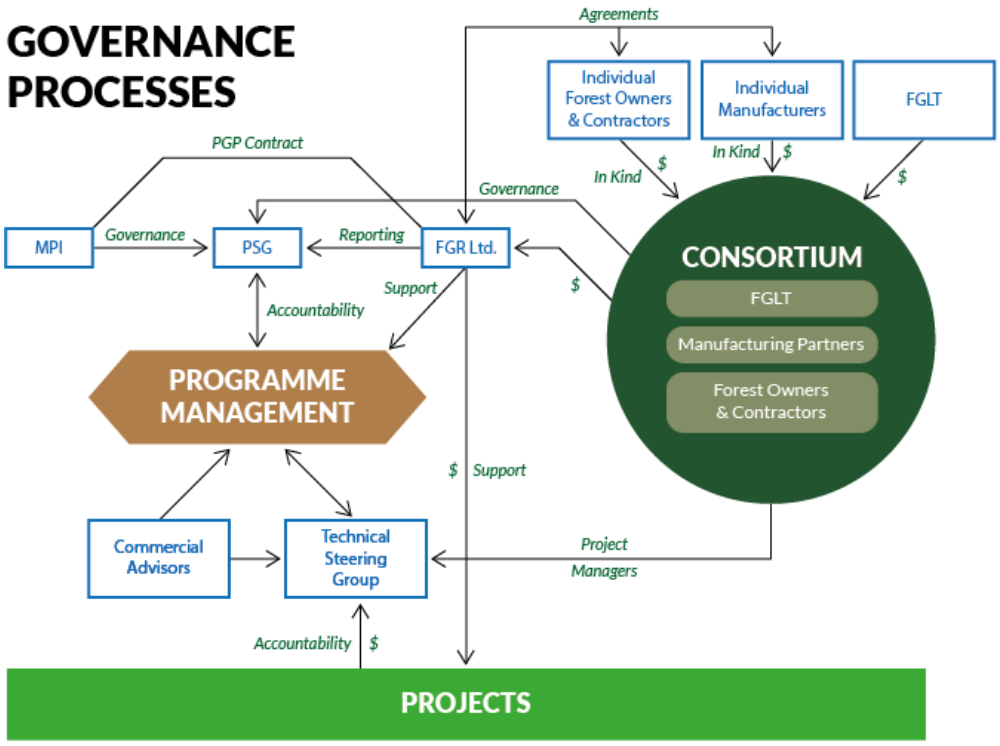

Figure 7: Programme Governance and Relationships

3.6.2 Programme Governance Group

A Programme Governance Group (PGG) will be appointed to maintain oversight and governance of the programme. It will comprise two representatives of the Consortium, one representative of FGLT, two representatives of MPI, and an independent Chair, to be mutually agreed between FGR and MPI.

3.6.3 Programme management

FGR Ltd will be the contracted party for this PGP programme and will manage and support the programme on behalf of the Consortium, provide project management expertise, enter into commercial arrangements and hold IP.

Mr. Russell Dale, CEO of FGR, will have overall responsibility for managing the programme, and expanding investment in the programme. The Programme Leader, Mr. Keith Raymond, FGR Harvesting and Logistics Programme Manager, will have day-to-day control, managing all Product Development Project Leaders of the Consortium manufacturing partners, and Sort Yard Project Leaders of the Consortium forest owners in each sort yard development, and ensuring

all targets are delivered. All technology developers and research providers, including manufacturing partners, will be engaged by way of FGR Services Agreements. There will be no staff employed specifically for the programme.

The Technical Steering Group (TSG) will be the technical advisory group for the Consortium. It will also monitor and guide operations and make all recommendations to the PGG including acceptance of Objective milestones. The TSG will comprise representatives of Consortium forestry companies and contractors, and project leaders from the Consortium. The TSG members will have a role in passing on to their respective organisations updates and new knowledge gained in the programme and act as advocates for the new approaches developed. All findings will be reported to the TSG.

Programme management process for each of the development projects will be:

1. Each project will comprise staff from a forest owner, contractor(s), manufacturing partner and a representative of FGR. This is to ensure alignment of interests.
2. Overall system requirements will be developed with the planned sort yard owners and their nominated contractor(s). This will include system specification, design capacity, and targeted throughput efficiencies.
3. Individual product specifications will be developed to fulfil assigned tasks and performance standards. Specifications will define the minimum acceptable performance of an economically viable machine. Performance standards will include: operating speed, productivity, capital cost and life of machinery, operating costs per day, human support for operation, maintenance and repair. Forest industry partners will be key to defining the requirements of a feasible system.
4. Analysis of current practices, operating techniques and planning will inform the design and operation of each product. Human factors such as anthropometrics, ergonomics, cognitive sciences, and operational research (work science) will be incorporated in the design and operation of each machinery product (interdependency between Objective 1 and Objective 2).
5. Review alternative solutions and products available internationally.
6. Complete design and optimise using simulation techniques.
7. Determine technical and economic feasibility based on design.
8. Prepare feasibility report including market situation report (interdependency between Objective 1 and Objective 3).
9. Stop/go decision point at this stage. If successful, the next step is to build a proof of concept prototype (designated ‘manufacturing prototype’), and test it, firstly in the workshop then in the field. Modify/improve design for the ‘alpha’ prototype.
10. Review design and on-going economic feasibility.
11. Construct and install ‘alpha’ system at the first sort yard of a forest owner Consortium member.
12. Test the system, solve engineering faults, review design and finalise design for ‘beta’ products.
13. Develop, build, implement and support further ‘beta’ systems for the first sort yard and commission over a period of 6 months. Review and confirm final production design for second and subsequent sort yards.

3.6.4 Intellectual property

Intellectual property (IP) will be developed as part of the programme, and managed to maximise benefits to all the investors. The process for developing the IP strategy for each product has been detailed in section 3.4 Objective 3 Commercialisation and deployment.

The development of IP in most of the projects will not have a significant new science component. In other words it is unlikely that new IP will be of a fundamental nature with broad applicability. The new IP will build strongly on the pre-existing IP of each developer, who in most cases will be the manufacturer and supplier of the resultant product. Unless the IP is discrete and formal, such as a patent, it is unlikely that FGR will be able to on-license the IP.

Most of the innovations will not be easy to protect, and good innovations will be copied and deployed widely. One example of this from the PGP Steepland Harvesting programme is the development of the ClimbMAX winch-assisted feller buncher with Trinder Engineering Ltd, which was quickly copied by at least three other manufacturers across New Zealand. While this is an excellent example of technology transfer, the result does act as an effective disincentive for private investment.

The following IP plan reflects the situation described above. The key ownership principles for all products, other than the robotic log sort yard, are as follows:

- Prior IP remains with the holder but will be licensed for use if required.

- The default position is that new IP funded by the programme will be owned by FGR (for the benefit of the industry and to capture spill over benefits).
- FGR product IP will be licensed exclusively to the manufacturing partner on agreement to deploy the product in NZ and against performance criteria.

Where required, FGR will conduct a freedom to operate search, normally during the design phase. IP will be secured and managed as follows:

- Software. Developers will agree to assign the IP for code to FGR. Copies of code will be held by FGR and dated on receipt. Unless otherwise agreed code will be held on a secrecy basis.
- Design. Copies of all new designs will be held and dated by FGR. The rights will be assigned to FGR. The manufacturing partner and FGR may agree to secure a registered design if commercially sensible.
- Patentable IP – inventors will assign their IP in line with the principles above. At filing of the provisional patent, FGR and the manufacturing partner will agree a patent strategy

3.7 Capability to deliver

The capabilities of the partners in this programme are summarised in section 2.6 Programme partners. The Consortium driving this programme is composed of the largest forestry companies in New Zealand, several of the most active independent harvesting and marketing companies providing services to small forest growers, their most innovative contractors, and the most appropriate forestry machinery manufacturers. The Consortium manufacturing partners all currently service the New Zealand forest industry and have proven capabilities and distribution networks. The programme has captured the enthusiasm and commitment of the sector's key opinion formers and leaders.

All technology development will be managed by the Consortium manufacturing partners through designated Product Development Project Leaders. The Consortium forestry companies and their key contractors will partner with these manufacturers to develop the initial 'manufacturing prototypes'. This will ensure the manufacturers properly understand market requirements and will build an understanding of the dimensions of the market opportunity. The co-development approach is demonstrated in Figure 8.

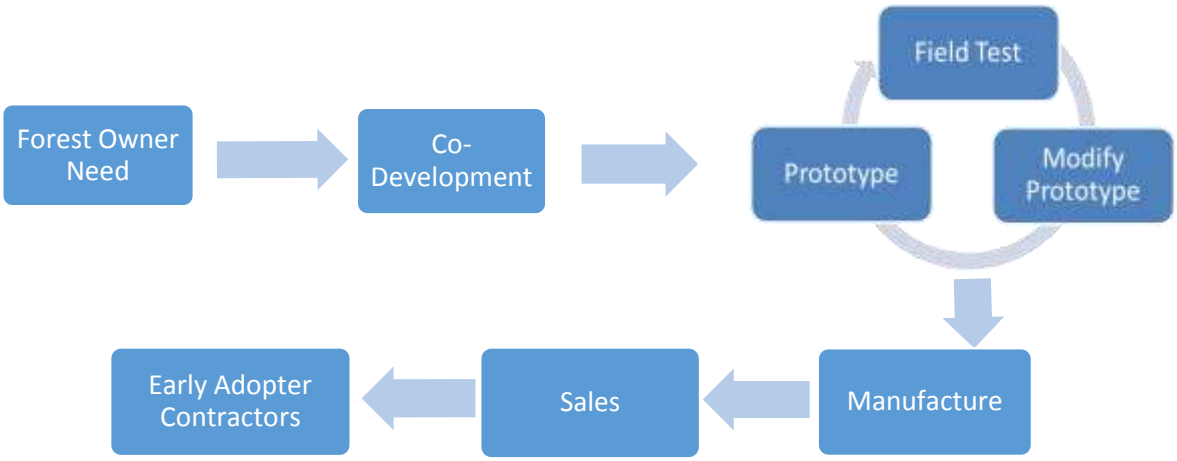

Figure 8: Path to Market

The relevant manufacturing partner and technology development support for each product development project is detailed in Table 17.

Research and development support for Objective 1 will be provided by Scion the forestry CRI, University of Canterbury Schools of Forestry and Engineering (Mechatronics programme) and Lincoln Agritech Ltd. Other consultants, such as Applied Teleoperation Ltd, Awdon Technologies Ltd, Margules Groome Ltd, and G.E. Murphy and Associates Ltd, will be engaged as required for independent technology support.

Table 17: Products and Product Development Partners

Product	Primary Manufacturing Partner	Technology Development Support
Robotic log sorter	Skookum Technology Ltd	Awdon Technologies Ltd; Applied Teleoperation Ltd
Automatic truck load securing system	Patchell Industries Ltd	Mechatronics Programme, University of Canterbury; Log Transport Safety Council
Automated truck loading gantry	Patchell Industries Ltd	Forest Distribution Ltd; Log Transport Safety Council
Semi-autonomous grapple and hauler control	Alpine Logging Equipment (NZ) Ltd	Lincoln Agritech Ltd; Applied Teleoperation Ltd; Awdon Technologies Ltd; Margules Groome Ltd.
Large capacity loading grapple	Engineering Services Rotorua Ltd	
Semi-automated log processor-debarker	Southstar Equipment Ltd	Lincoln Agritech Ltd; G.E. Murphy and Associates Ltd; Margules Groome Ltd.
Automated log residue chipper	Mural Town Engineering Ltd	Forestry School, Univ. of Canterbury
Automated log tagging	Pocket Solutions Ltd	G.E. Murphy and Associates Ltd; Cumberland Systems Ltd

Development of each log sort yard will be managed by each of five Consortium forest owners through designated Sort Yard Project Leaders. Each sort yard will be designed, developed, owned and controlled by these Consortium members, with each yard supplied by both hauler and ground-based harvesting crews, as required by each forest owner. These yards and their crews will demonstrate and use the innovations from this programme. Each yard will be in itself an innovation and will create new functions.

In Objective 2 the skills development, training, machine-human interface design and cognitive sciences activities to develop the workforce of the future will be led by Dr Richard Parker of Scion in Christchurch, assisted by Brionny Hooper of Scion and collaborating with staff at University of School of Forestry (Dr Rien Visser and Dr Hunter Harrill), Toi Ohomai Institute of Technology (Mr James Broadley and Mr Richard Stringfellow) and Competenz (Mr Mark Preece and Mr Richard Cowper).

In Objective 3 the Commercialisation Team working with the manufacturing partners comprises Mr Geoff Todd and Dr Sunil Vather. Mr Geoff Todd was the Commercialisation Team Leader for the successful PGP Steepland Harvesting programme. Both Mr Geoff Todd and Dr Sunil Vather have extensive experience commercialising technology from research in New Zealand and abroad. Geoff currently is Managing Director of Viclink and as such manages the commercialisation of an extensive portfolio of technology and start-ups from IP developed at Victoria University of Wellington.

Brief biographical information of key members of the development team is given in Appendix 5.2.

3.8 Ongoing delivery

The commercialisation processes are detailed in Section 3.4 Commercialisation and deployment, and market uptake is described in Section 4.2 Market analysis.

The implementation of the initial market of five sort yards and up to 40 harvesting systems (eight contractor crews per sort yard) will give the manufacturers the chance to hone their products and create enough momentum in the market to lead to broader uptake. The commercial plan for this programme includes providing regular communications using video clips of the products and conference presentations to build awareness in the forestry sector of the upcoming products and their benefits. This, together with the engagement of many of the sector's key opinion leaders in the programme, will create awareness well before the products are available for sale. FGR will assist manufacturing partners in this process of implementation with field demonstrations throughout the country.

Beyond the implementation of the first log sort yard, the next four sort yard systems will be spread around the country (according to the requirements of the Consortium forest owners) and will address a range of sites and conditions that are representative of the whole of New Zealand. These situations include: terrain (ground based vs steep country); forest volume (remote small woodlots vs large plantations); soils (wet and dry climates); tree size (ranging from 30-100cm diameter); and local infrastructure (roading access and proximity to markets). This will give the programme an excellent opportunity to demonstrate the benefits to the forest industry. The expected financial, productivity, safety and logistics improvements achieved by the new systems, together with physical evidence, will provide a compelling

basis for further investment. The manner in which this programme has been developed by the entire forestry value chain provides confidence that this will be achieved.

Establishment and implementation of the first five sort yards, and up to 40 automated harvesting and logistics operations, represents approximately 8% of the national annual plantation harvest, and will be the catalyst for further rollout across the industry, both during the programme and post-programme, as evidenced by the impact of the earlier Steepland Harvesting PGP programme. In the five year period beyond programme conclusion (2025-2030) it is forecast that a further nine log sort yards will be implemented, bringing the total to 14, or 22% of the national annual plantation forest harvest.

It has been estimated that, excluding the existing central processing yards (CPYs) in New Zealand, approximately 55 log sort yards (or 41 sort yards in addition to the 14 forecast to be implemented by 2030) could process the entire annual plantation harvest.

In terms of forestry machinery and equipment the total NZ market in 2025 will be approximately 440 harvesting contractors which translates to a potential market of over 3,500 units. The international market for these technologies will primarily be North America, Chile and Australia. Collectively, these markets are estimated to be at least five times the size of the NZ market.

4. Analysis

4.1. Strategic fit

4.1.1. Industry fit

The focus on automation and mechanisation implicit in this programme fits well, and builds on, the strategic direction of the forest growing sector as articulated in the NZ Forest Growers Science and Innovation Plan. This plan identifies five strategic objectives for the industry to work towards, two of which are:

- To improve the efficiency and safety in operations and value chain logistics; and
- To sustain and enhance forestry's social licence to operate.

As discussed the sector currently has a widespread labour shortage problem, which is constraining the growth of the industry. This is a result of multiple issues; strenuous nature of the work, increasing labour demand, reduced population in regional New Zealand, poor safety performance, drug testing of the workforce acting as a barrier to entry, and poor public perception of career opportunities for young people. This programme addresses these issues.

4.1.2. Company strategy

The enthusiasm of forest owners and forest management companies to invest in this very new idea is an excellent demonstration of their strategic imperatives to improve the forestry value chain and their management processes, and address costs and labour force and safety issues.

Contractors' objectives are to reduce costs, improve profitability and secure long term contracts. This programme will make it easier for innovative contractors to lock in long term contracts to supply a log sort yard.

4.1.3. Alignment to local and central Government strategy

Forestry has an important role to play in many of the Government's priority areas – enhancing regional development, improving water quality, reducing carbon emissions and creating jobs. The programme is central to the Regional Growth Programme of the Ministry of Business, Innovation and Employment, the Business Growth Agenda and the new Government's regional development and forest planting agenda and climate change targets. The programme also meets the objectives of the Primary Growth Partnership to enhance economic growth. It is related to, and supportive of, multiple current governmental activities:

- It is an initiative that contributes to regional economic development
- It has an important role in improving forestry's environmental performance through reduced soil displacement, logging residues, chemical fumigation and trucks on the public highway.
- It will improve profitability of forestry and incentivise further investment in afforestation.
- It assists in growing the machinery manufacturing sector and advanced technologies such as IT, communications, automation and robotics.

4.2. Market analysis

4.2.1. Background to market trends

Over the last five years the industry has driven a massive increase in forest mechanisation. Table 18 summarises the rates of change in mechanised tree felling and log processing since 2009, based on data from the FGR Harvesting Cost and Productivity Benchmarking database maintained by University of Canterbury.

Table 18: Rise in forest mechanisation

Year	Mechanised Tree Felling			Mechanised Log Processing		
	Ground-based	Hauler	All Harvesting	Ground-based	Hauler	All Harvesting
2009	49%	0%	23%	25%	40%	33%
2010	51%	0%	24%	24%	62%	44%
2011	49%	3%	26%	20%	68%	44%
2012	47%	3%	24%	24%	68%	48%
2013	47%	3%	25%	28%	65%	48%
2014	65%	12%	38%	57%	78%	68%
2015	83%	23%	51%	83%	92%	88%
2016	84%	28%	53%	92%	97%	95%

These trends, and stated industry strategic direction, indicate strong support for continued mechanisation and extension of technology towards automation to improve the safety and efficiency of all operations along the forestry value chain.

4.2.2. Market drivers for the programme

The market situation and key constraints are described in section 2.2 Current situation. The key market drivers for this programme are:

1. Continued and growing international demand for wood coupled with a significantly growing harvest volume availability
2. A change in the make-up of the harvest to increased small holdings on steeper lands, driving the need to improve forest profitability
3. Increasingly severe labour shortages
4. Continued need to improve safety and respond to regulatory changes for health and safety (including the use of methyl bromide fumigation of export logs).

With these drivers in mind, the specific activities proposed have been derived from agreed industry objectives (NZ Forest Growers Science and Innovation Plan) and a series of industry workshops held in 2014-15 with wide consultation among stakeholders across the industry and country as the basis for this programme development (Table 19).

Table 19: Stakeholder groups involved in programme development

Stakeholder Type	Number of participants
Forest Owners	27
Industry Associations / Researchers	22
Consultant / Government Organisations	16
Integrated Forest Products / Wood Processors	13
Harvesting / Transport Contractors	10
Machinery Suppliers / Developers	6
Training / Education Providers	6
Farm Forester / Log Trading Companies	5
Total Industry Stakeholder Participants	**105**

From this market research, 45 projects were identified and circulated back to the industry for prioritisation. The top priorities from that process form the basis for this programme.

4.2.3. User demand and uptake

Demand

The current strong log market and the rapid increase in wood volume availability creates big incentives to address the labour shortages, the difficulties and costs of harvesting small forests and woodlots on steep slopes, and increasing regulatory pressures. The forest owners and managers drive the requirement for solutions, and this is reflected in their contracts with their harvesting contractors. This user demand will be driven by forest owner specifications for harvesting contracts (requests for proposals, tenders etc.), the forest owners' contractor evaluation processes and the contractors' business goals to secure long term contracts with reasonable margins.

The equipment purchases in this programme are well within the normal bounds of existing equipment purchases, given the increasing capital requirements of mechanised harvesting operations. Contractors normally secure debt finance for these purchases on the back of their contracts. The forest owners can support the contractors' investments in multiple ways, for example:

- Longer term contracts
- Providing some flexibility in harvesting rates for a period after new technology is introduced
- Direct financial support (co-funding)

The demand for the proposed developments is proved by the number of forest management companies committed to implementation, and their enthusiasm for establishing the planned sort yards. The commitment by forest owners

to see the new products implemented is evidenced in the letters of support from the forest owner Consortium members (Appendix 5.3), for example:

"…*we will look to implement such a log sorting hub in the King Country region of the North Island, and potentially elsewhere…*" Peter Clark, Chief Executive Officer, PF Olsen Ltd.

"…*On proven success, we would look to implement these developments across our contractor workforce to capture the benefits…*" Brendan Slui, Operations Director, Rayonier Matariki Forests.

"…we will look to implement automated harvesting systems across all our harvesting and transport operations…" Dan Gaddum, Managing Director, Forest Owner Marketing Services Ltd.

"…These engineered products will allow good change to occur in the supply chain and as such we would implement these products immediately on their success…" Duncan Mills, Director, Wood Marketing Services Limited.

Uptake

The log sort yards are the corner stone for the entire programme. Consortium forestry companies have agreed to implement five sort yards as part of the programme. The establishment of each yard and associated systems will create its own requirements for the new technologies. Each yard could have up to eight contractor crews associated with it. These crews will be the initial adopters of the programme developments. Therefore the initial forecast customer base is up to 40 harvesting crews supplying the initial five sort yards. This translates to commercialisation of eight new automated products and an early adopter market of 312 units of new machinery and equipment by 2025.

The Consortium members are confident of achieving the required technology uptake due to:

1. The expressed initial demand to implement five log sort yards.
2. The urgency created by the market drivers.
3. The engagement of the forest managers and their contractors in the technology specification, development and trialling.

Forecast uptake of new equipment and machinery in the post-programme period from 2025 – 2030 is divided into uptake of complete log sort yard systems and uptake of components of the system as individual units.

1. Complete log sort yard systems
   Likely new system establishment in the five years following the conclusion of the development programme are:
   A. Four new log sort yards from Consortium members that have not installed a new system as part of this programme:
      - Ernslaw One Ltd – first sort yard in Gisborne/East Coast or Otago/Southland region
      - Hancock Forest Management Ltd – first sort yard in Kinleith or eastern BOP or Northland region
      - Timberlands Ltd – first sort yard in Central North Island region
      - Port Blakely Ltd – first sort yard in South Canterbury/North Otago region

   B. Implementation of a second sort yard system by three of the largest companies amongst the five first adopters in the programme:
      - PF Olsen Ltd – second sort yard in Gisborne/East Coast or Northland region
      - Rayonier Matariki Forests – second sort yard in Otago/Southland region
      - Forest Enterprises Ltd – second sort yard in Gisborne/East Coast region

   C. Two new log sort yards from forestry companies outside the Consortium. Given the expansion in wood availability in several regions of New Zealand beyond 2025, likely locations are:
      - Northland (excluding above = 1.7 million m^3 p.a. harvest available)
      - Central North Island (excluding existing CPYs + above = 8 million m^3 p.a. harvest available)
      - Gisborne/East Coast (excluding above = 1.7 million m^3 p.a. harvest available)
      - Southern North Island (excluding Wairarapa = approx. 1.4 million m^3 p.a. harvest available)
      - Otago/Southland (excluding above = approx. 0.7 million m^3 p.a. harvest available)

The forecast uptake of new log sort yards out to 2030/31 is summarised in Table 20.

Table 20: Forecast uptake of new log sort yards 2025/26 – 2030/31

New Sort Yard Systems	New Sort Yard System Sales 2026-2030						
	To 2025/26	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031	Total
New systems by other consortium members		1	1	1	1		4
Additional systems by first adopters	5			1	1	1	8
New systems by other forest companies					0	2	2
Total sort yard system sales	5	1	1	2	2	3	14
Cumulative sort yard systems	5	6	7	9	11	14	14

2. Additional sales of new landing-based machinery and equipment
   The forecast of component sales of individual landing-based products to harvesting crews after the programme concludes in 2025 is given in Table 21. This excludes sales of machinery and equipment that are part of complete log yard system implementations, but includes other sector-wide developments of this equipment ("copycat" products).

Table 21: Forecast additional component sales of individual products not part of a new log sort yard system

Equipment Sales - Components	Additional component sales p.a. 2025/26 – 2030/31						
	To 2025/26	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031	Total
'Smart' yarder grapple / control system	0	1	2	5	10	18	36
Semi-automated processor-debarker	0	2	4	8	14	22	50
Automated load securing	0	6	12	24	42	66	150
Large capacity loading grapple	0	4	8	12	16	24	64
Log residue chipper	0	1	2	4	8	12	27
Automated log tagging	0	1	2	4	8	12	27
Robotic log sorter	0	0	0	0	0	0	0
Automated truck loading gantry	0	0	0	0	0	0	0
Total additional component sales	**0**	**15**	**30**	**57**	**98**	**154**	**354**

The assumptions behind these projections include:

- A projected available New Zealand market of 440 harvesting crews
- The uptake of automated harvesting machinery and equipment is forecast to occur as a progression from existing mechanised harvesting crews
- Conservative adoption rates based on previous data
- The 'smart' yarder grapple and hauler control system would be an 'after-market' addition and does not require the purchase of a new hauler.
- The processor-debarker provides cost savings given forecast increased log fumigation costs
- Crews purchasing the semi-automated processor-debarker would also implement a load securing system for each truck servicing that crew. A minimum of 3 trucks doing 3 trips per day would be required to service each crew, given that the trucks would be limited to 50Max (33 tonnes payload) as the crews are not part of a log sort yard.
- The large capacity grapple could lead to immediate truck loading productivity gains.
- The market driver for the residue chipper is increasingly stringent environmental requirements for log residue management, not cost savings.

4.3. Benefits

4.3.1. Summary of benefits

The benefits of forestry equipment automation technologies are varied and will include: improved safety, better fuel efficiency, increased productivity, reduced unscheduled maintenance, improved working conditions, better machine utilisation and reduced operator fatigue and attrition. Automation technologies are an efficient way to mitigate the effects of widespread labour shortages for harvesting roles such as grapple processor operators, loader operators, grapple yarder operators, and log truck drivers. All forestry companies are looking for ways to dramatically reduce

labour and overhead costs while still maintaining work site safety and integrity; teleoperation, semi-automation and robotics provide a clear direction for the future.

As the outputs of the programme are successfully implemented, the core benefits of the programme will be:

- increased labour productivity and workforce shortages are alleviated through reducing crew size and automating functions in harvesting operations
- reduced forestry value chain operational costs through new process efficiencies
- improved environmental sustainability
- growth in the forestry machinery manufacturing sector through domestic sales of machinery and equipment

In addition spillover benefits include:

- Improving overall profitability of small forest harvests to enable the sector to grow annual harvest to over 35 million m^3 p.a. This will have an economic impact of over $190 million p.a.
- Roll out of the new harvesting and logistics system across the rest of the forestry sector (55 log sort yards handling 31.4 million m^3 p.a. (in addition to existing Central Processing Yards). The potential is for 41 additional log sort yards (in addition to the 14 log sort yards forecast in this programme, handling 7.9 million m^3 p.a.). At annual volumes of 570,000 m^3 p.a. this would generate further operational cost savings of $227 million p.a.

4.3.2. Net direct economic benefits

Total cumulative economic benefits over the life of the programme (to 2025/26) will be $103.6 million, comprising operational cost savings and gross profit on domestic sales of machinery and equipment. Deducting programme costs of $29.36 million results in cumulative net benefits of $74.2 million to 2025/26.

Value Chain Cost Savings in 2025/26

Annual direct economic benefits to New Zealand attributed to operational cost savings across the forestry value chain in 2025/26 total $27.45 million p.a., or $9.71/$m^3$ of volume automated (Table 22).

Table 22: Total Value Chain Costs and Benefits in 2025/26

Part of Value Chain	Base Case Costs ($M)	Realistic Intervention Costs ($M)	Benefit / Cost 2025/26 ($M p.a.)	Base Case Costs ($/$m^3$)	Intervention Costs ($/$m^3$)	Savings ($/$m^3$)
Harvest Planning	$1.84	$1.66	$0.18	$0.65	$0.59	$0.06
Roading Engineering	$27.48	$27.41	$0.07	$9.73	$9.70	$0.03
Harvesting	$130.17	$111.18	$18.99	$46.07	$39.35	$6.72
Log Cartage	$52.47	$49.78	$2.69	$18.57	$17.62	$0.95
Bark off Transport	$0.00	-$1.09	$1.09	$0.00	-$0.39	$0.39
Additional Load Securing	$0.00	$1.20	-$1.20	$0.00	$0.43	-$0.43
Truck Load Weighing	$2.69	$0.00	$2.69	$0.95	$0.00	$0.95
Export Log Scaling	$4.14	$0.00	$4.14	$1.46	$0.00	$1.46
Log Tagging	$0.00	$2.97	-$2.97	$0.00	$1.05	-$1.05
Debarking	$0.00	$13.78	-$13.78	$0.00	$4.88	-$4.88
Export Log Fumigation	$17.99	$2.44	$15.54	$6.37	$0.87	$5.50
Sub-total: Harvesting costs	$130.17	$111.18	**$18.99**	$46.07	$39.35	**$6.72**
Sub-total: Logistics costs	$59.30	$52.86	**$6.44**	$20.99	$18.71	**$2.28**
Sub-total: Environmental costs	$47.31	$45.29	**$2.02**	$16.74	$16.03	**$0.71**
Total Value Chain Cost (At Mill/Wharf Gate)	**$236.78**	**$209.33**	**$27.45**	**$83.80**	**$74.08**	**$9.71**

Value chain cost savings in 2025/26 comprise:

- Harvesting operational cost savings of $18.99 million p.a., or $6.72/$m^3$ of volume automated. This is additional to the savings gained from the counterfactual scenario (Steepland Harvesting Programme), which would occur anyway. Further details of the counterfactual scenario is given in section 4.3.5 Analysis of benefits. Harvesting operational cost savings are achieved by increased labour productivity on a per tonne basis through smaller crews, automated machinery, no QC/branding/stocktaking etc. in harvesting operations. The harvesting benefits are based on:
    - In the Base Case average harvesting labour productivity is static at 37m^3/worker-day. With intervention of automation, average labour productivity increases to 65 m^3/worker-day (+70%)

- Base Case requirement for extra harvesting workers is from 3700 to 4400 = ~700 workers (or +20% in 2025). With intervention, the requirement for extra harvesting workers is reduced to only +80 workers in 2025 (+2%).

- Logistics operational cost savings from efficiencies down the forestry value chain are $6.44 million p.a., or $2.28/m^3 of volume automated. These savings arise from: centralising the log sorting function, enabling increased use of HPMV log cartage, elimination of log weighing and export log scaling through using log scanners at the sort yard, and improved loading, reducing truck delays both in the forest and at the sort yard.
- Environmental cost savings from improved performance are $2.02 million p.a., or $0.71/m^3 of volume automated. Although not the main driver of the need to improve environmental sustainability, minor economic benefits are achieved through improved harvest planning (traded off by additional roading to hauler landings), smaller log landings (by shifting the log sorting and storage functions to the sort yard), improved residue management, and reduced chemical fumigation (traded off against additional in-forest debarking cost).
- Total value chain costs in 2025 will reduce from $83.80/m^3 in the Base Case to $74.08/m^3 with the intervention of automation, down $9.71/m^3 over the 2.825 million m^3 total volume automated. This equates to total value chain cost savings of $27.45 million p.a. in 2025/26 (Table 22).

Sales of Machinery and Equipment to 2025/26

Commercialisation of 312 units of new machinery and equipment in the new sort yard systems (excluding 'alpha' prototypes) is projected to result in total sales revenue of over $56 million by 2025/26 (Table 23).

Table 23: Annual and Cumulative Machinery and Equipment Sales to 2025/26

Source of Sales		Unit Price $M	Year 4 2021/22	Year 5 2022/23	Year 6 2023/24	Year 7 2024/25	Year 8 2025/26
Automated log debarker-processor	Units Cum	$0.460	7	15	23	31	39
Domestic Sales	$M Sales		3.22	6.90	10.58	14.26	17.94
'Smart' yarder grapple control system	Units Cum	$0.250	6	13	20	27	34
Domestic Sales	$M Sales		1.50	3.25	5.00	6.75	8.50
Processor-based log tagging technology	Units Cum	$0.120	8	17	26	35	44
Domestic Sales	$M Sales		0.96	2.04	3.12	4.20	5.28
Automated log residue chipper	Units Cum	$0.200	6	13	20	27	34
Domestic Sales	$M Sales		1.20	2.60	4.00	5.40	6.80
Large capacity log grapple	Units Cum	$0.070	7	15	23	31	39
Domestic Sales	$M Sales		0.49	1.05	1.61	2.17	2.73
Robotic Log Sorter	Units Cum	$2.700	0	1	2	3	4
Domestic Sales	$M Sales		0	2.70	5.40	8.10	10.80
Automated truck loading gantry	Units Cum	$0.650	0	1	2	3	4
Domestic Sales	$M Sales		0	0.65	1.30	1.95	2.60
Automated load securing system	Units Cum	$0.020	22	45	68	91	114
Domestic Sales	$M Sales		0.44	0.90	1.36	1.82	2.28
Annual Sales	Units p.a.		56	64	64	64	64
Annual Sales Revenue	**$M p.a.**		**7.81**	**12.28**	**12.28**	**12.28**	**12.28**
Annual Gross Profit	**$M p.a.**		**3.12**	**4.91**	**4.91**	**4.91**	**4.91**
Cumulative Sales	Units total		56	120	184	248	312
Total Sales Revenue	**$M**		**7.81**	**20.09**	**32.37**	**44.65**	**56.93**
Cumulative Gross Profit	**$M**		**3.12**	**8.03**	**12.95**	**17.86**	**22.77**

Annual sales of new equipment and technology (domestic market only) are $12.28 million p.a. from mid-2022 (Year 5) to 2025/26 (Year 8).

Regarding the new product opportunities, the benefits from sales of new machinery and equipment are calculated as 40% gross margin on sales revenue. Gross margin is the sales revenue less cost of goods sold), divided by sales revenue. The cost of goods sold is the cost to manufacture the product (cost of materials and direct labour, but not including distribution, overheads or selling expenses. The average equipment manufacturer's gross margin varies between 25 percent and 35 percent. Butler Consultants lists the gross profit margin of the equipment manufacturing industry as 32 percent. The average net profit before tax in the sector is 9% of sales revenue. It is expected that new automated equipment will have a higher gross margin. At 40% gross margin on sales revenue the cumulative sales of $56 million by 2025/26 will generate gross profit for machinery manufacturing partners of $22.7 million over the life of the programme, or $4.91 million p.a. in 2025/26 (Table 23).

Post Programme Benefits

Forecast projections for all machinery sales out to 2030/31 are summarised in Table 24. Unit sales and assumptions behind this are provided in section 4.2.3 User demand and uptake. These forecast sales include other sector-wide developments (sales of "copycat" machines by competitor machinery manufacturers).

Table 24: Forecast of Machinery and Equipment Sales to 2030/31 (5 Years post-Programme)

Total Revenue Equipment Sales ($ million)	To 2025/26	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031	Total
Log Yard equipment sales	56.93	12.28	12.28	24.56	24.56	36.84	167.45
Component equipment sales	0	1.89	3.78	7.53	13.46	21.46	48.12
Total Revenue all sales	56.93	14.17	16.06	32.09	38.02	58.30	215.57
Gross profit on sales (@ 40% gross margin)	**22.77**	**5.67**	**6.42**	**12.84**	**15.21**	**23.32**	**86.23**

Total net economic benefits, including operational savings from forecast post-programme uptake of new log sort yards and additional sales of machinery and equipment (as forecast in Tables 20 and 21) are summarised in Table 25.

Table 25. Net Economic Benefits to 2030/31

Benefits ($ million)	To 2025/26	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031	Total
Operational cost savings	80.817	32.923	38.411	49.385	60.359	76.821	338.717
Gross profit on system machinery	22.772	4.912	4.912	9.824	9.824	14.736	66.980
Gross profit on additional machinery	0	0.756	1.512	3.012	5.384	8.584	19.248
Programme Costs	29.360	0	0	0	0	0	29.360
Net Economic Benefits	**74.229**	**38.591**	**44.835**	**62.221**	**75.567**	**100.141**	**395.585**

The cumulative net economic benefits of the programme total $395 million out to 2030/31. This is from forestry value chain efficiencies of $338 million and gross profit on total machinery sales of $86 million less programme costs of $29.3 million. Annual benefits in 2030/31 are forecast to be $100 million p.a. – made up of operational cost savings of $76.8 million p.a., and gross profit on annual machinery sales of $23.3 million p.a.

4.3.3. Sustainability benefits

Sustainability benefits include:

1. Improved on-going social licence to operate through providing safer jobs for the workforce. Non-market impacts include reduced number of worker injuries or deaths, and associated costs and liabilities. It is expected that further improvements can be made to worker safety by automation to eliminate manual tasks such as log quality control (using statistical process control on grapple processors), log branding and stock taking and export log scaling (through individual log identification), and manual truck load securing (through automated load securing devices). This will reduce serious harm incidents to less than 10 p.a. by 2030.

2. Labour shortages will be addressed through automation. The sector will also become more attractive to a wider and more diverse base of employees, through lower physical work load jobs opening up opportunities.

3. Better environmental record. The environmental sustainability benefits are four-fold:

    - Replacing chemical fumigation with in-forest debarking. Debarking logs is an acceptable alternative treatment to chemical fumigation of export logs to China (but not for India). Currently over 1.0 million m^3

of export logs are debarked at ports and other debarkers and exported to China. Increasing the volume of debarking by 2.825 million m^3 (the volume handled in this programme) has an estimated additional cost of $14.37 million in 2025 (including cost of additional load securing). However it is forecast that the cost of chemical fumigation will double from the current cost of $6.25/$m^3$ to $12.50/$m^3$ after 2020, when recapture or other technologies will have to be employed. The forecast cost of fumigation for 1.37 million m^3 (export volume through the sort yards that would require fumigation) is estimated to be $16.27 million. In total replacing chemical fumigation with debarking is estimated to reduce the volume of export logs requiring fumigation by 1.2 million m^3, and make cost savings of $0.73 million in 2025.

- Reducing harvest residues through improved residue management. Debarking tree stems prior to log manufacturing opens up opportunities to produce clean chip from log manufacturing residues. If the debarker-processor is not feasible or development is delayed, logging residues will be handled by a residue comminution attachment rather than a chipper. Due to this uncertainty, no benefits have been ascribed to the production of clean chip, and the cost of the residue comminution device is assumed to be equal to the current cost of disposal of logging residues.
- Smaller log landings through relocation of log sorting from landings to the sort yards. Log landing area will be able to be reduced from 2400m^2 to 600m^2 per landing. This will reduce total area of landings required in 2025 by 65ha (-75%) and reduce the volume of soil displaced by 2.88 million m^3 in 2025. The benefits of easier harvest planning (landing location) and reduced cost of excavation are traded off by extra roading to hauler pads (+200m per landing). However the reduction in landing size has a positive environmental impact and the reduced loss of productive area (two years growth of trees on landing sites) has a value of about $0.3 million per year.
- Reduced log truck traffic on public highways. Increased use of HPMV log transport routes from in-forest sort yards to mills and ports will reduce the number of trucks on public roads, which is a significant environmental benefit in terms of reduced carbon footprint and community safety. As the axle loadings of HPMV are the same as trucks with lower gross vehicle mass, these benefits will be achieved without increased road damage and will result in over 15,000 fewer truck trips per annum on the public highway by 2025 (-17%).

4. A strengthened manufacturing sector oriented to forestry equipment, ancillary to the products developed in this programme is expected. Resultant exports, ultimately far greater than the sales into the NZ market, are also expected.

5. Collaboration of programme participants in a new approach to innovation which will improve the sector's competitiveness.

4.3.4. Spillover benefits

Non-quantified benefits are also a significant output of this PGP programme:

1. Improvement to the economic viability of harvesting the small scale forest resource. If the direct economic benefits of $10 per cubic metre operational cost savings are rolled out across the entire small-scale forest estate, it has been calculated that this improvement to forest profitability will make 9-11% more of the area of the small forest resource viable, that otherwise would not be economic to harvest. At the expected small forest harvest of 15 million m^3 p.a. by 2025 this is between 1.35-1.65 million m^3 p.a. of wood that otherwise may not be harvested. Based on current log prices, this has an average value to the economy of $190 million per year. This opportunity is traded off to a much smaller degree by the increase in carbon credits earned through the retention of the area of forest unharvested (3,300 hectares) which at 30 NZU/ha p.a. and $25/NZU would be valued at $2.5 million p.a.).

   It is anticipated that, due to increasing complexity of compliance requirements, a large proportion of the small scale forest resource will be marketed through the major forest management companies with trading arms, such as PF Olsen, Rayonier Matariki Forests and Forest Enterprises, or through smaller harvesting and marketing companies such as FOMS and WMS, all partners in this programme. In this way the benefits of this technology development programme will be extended to small scale forest owners.

2. Better quality and increased supply of fibre, and security of supply to the NZ wood processing sector. Improved profitability will increase the annual harvest and therefore supply of logs to domestic wood processors. Improvements to grapple processors and in-forest debarking will supply a better quality log product and create

opportunities for local sawmills. Individual log identification will also improve data flow from forest to customer.

3. Regional resilience - this programme will actively contribute to the economic well-being and sustainability of rural communities. It will increase employment opportunities and potentially attract workers back into these communities.

4. Improved profitability makes planting more attractive which helps government achieve its objectives of more trees planted. Historically there has been a strong correlation between the rate of afforestation and log price, a key determinant of forest profitability (Figure 9). A reduction in harvesting cost of $10/m³ (equivalent to an increase in average log price of $10/m³) could result in about 12,000 ha of new afforestation per year.

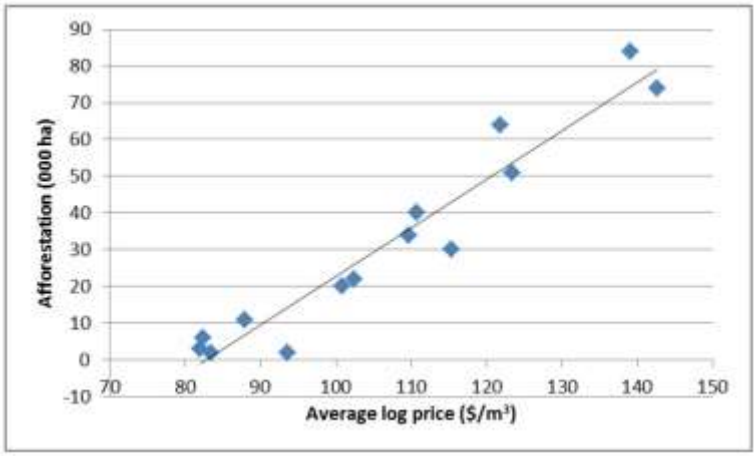

Figure 9: New Zealand afforestation rate from 1995 to 2008 vs. average log price

($/m³ Real March 2015; Source: Manley 2016)

4.3.5. Analysis of benefits

In this Business Plan, assessment of benefits considered the following dimensions:

- extent of improvement in the counterfactual scenario
- the initial benefit value
- uptake of the new and improved products and processes
- operating and set-up costs, and prices charged
- appraisal period and benefit growth.

Extent of improvement that would have occurred in the counterfactual scenario

Economic assessment has been undertaken comparing the intervention with the 'counterfactual' scenario, which is the likely state of the industry if the intervention was not undertaken. In the benefits case this is referred to as Base Case. The impact of the analysis is a comparison between the factual (the forest industry with the intervention) and the counterfactual over each year of the programme out to 2025.

The PGP programme business case analysis has considered the counterfactual including:

- productivity improvements that would continue to occur over time anyway. This includes the increasing level of mechanisation in harvesting, and the continued introduction of winch-assisted tree felling machinery (from 90 operations in 2018 to over 130 operations in 2025). The number of hauler crews would have to increase by about 100 crews (+700 workers) and productivity of harvesting would reduce due to the lower labour productivity of hauler crews.
- issues that prevent a profitable venture (such as for example, log processing at central processing and sort yards, or debarking logs at other locations than in the forest) from being done anyway by forestry companies (especially small forest owners).
- relationship between inputs and outputs in the development initiative. This PGP programme is a development initiative with increasing returns to scale whereby a large scale project is required to generate the significant benefits calculated. Removing the 40% Crown contribution would have a large detrimental effect on calculated benefits. If the Crown did not invest, the programme would have to be significantly downsized. Some of the automation innovations would probably still be developed but the implementation of the new logistics solution comprising automated harvesting operations and the robotic log sorting facilities would be delayed significantly.

Value of benefit – mid-point or upper range?

The benefit value reported is that of an expected mid-point (median or 'realistic') outcome, rather than upper range ('optimistic'). The reported benefit values are therefore conservative, and do not assume a high level of uptake (up to 40 harvesting systems out of about 470 harvesting crews, or about 8%, over a period of five years of deployment). The full benefits of the PGP programme on an annual basis are reported for the five years after the programme is completed, rather than up to programme completion only.

Uptake of the new and improved products and processes

Uptake is a crucial issue when considering the benefits of a new product or process as it is the actual implementation and on-going use of the innovation that leads to economic impacts. In this programme the members of the Forest Value Chain Consortium have committed, subject to the success of the technical developments and their economic viability, to implement the innovations through their normal business processes. They control their forestry value chains from forest growing through to delivery of log products to customers. They will invite proposals from the contractor community as primary users to implement the automated equipment and sort yard processes. This provides a business opportunity to prospective contractors to implement the innovations and tender competitive harvesting and transport rates to enable the full economic benefits to be realised.

Operating and set-up costs and prices charged

New and improved products and processes such as proposed in this programme will be associated with fixed set up costs and variable operating costs (in addition to the original PGP investment cost). For example, getting contractors to purchase new automated equipment and change their practices to implement the second and subsequent sort yards will require additional capital, time and effort in upskilling workers. These machine purchase costs and operating costs are built into the machine costings and operational costings on which the benefits case is based.

Appraisal period and benefit growth

The appraisal period is from programme commencement in 2018/19 to 2030/31 (five years after programme completion in December 2025). An 8% discount rate is used for the calculation of net present value (NPV) of the investment. This is a standard discount rate used for long term forestry investments. The total investment in the development programme is $29.36 million and the cumulative net economic benefits achieved to 2030/31 total $395.58 million. The NPV of the programme costs and benefits, to 2030/31, at 8% discount rate is $50.11 million. The internal rate of return (IRR) over this investment period is 14.9%.

4.3.6. Sensitivity of benefits

In this Business Plan sensitivity analysis was undertaken around the benefits case. In the benefits case the 'counterfactual' scenario, which is the likely state of the industry if the intervention was not undertaken, is referred to as the base case.

Three scenarios were developed comparing base case with three different scenarios of intervention: Pessimistic, Realistic and Optimistic. Machine costs, labour costs, operational truck delays and future forecasted fumigation costs were determined to be the most significant drivers of costs and benefits. These factors were altered in each of the three scenarios, as detailed in Table 26.

Table 26: Input data to the three scenarios

Scenario	Finance Rate (% p.a.)	Labour Cost ($/worker-day)	Truck Delays, HPMV & in-forest (min/trip)	Fumigation cost in 2025 ($/m^3)
Base Case	7.0%	350	20 min / 5 min	$12.50
Pessimistic Intervention	9.0%	385	30 min / 10 min	$15.63
Realistic Intervention	7.0%	350	20 min / 5 min	$12.50
Optimistic Intervention	5.0%	350	Zero truck delay	$6.25

The results of the sensitivity analysis are given in Table 27.

Table 27: Outputs of the sensitivity analysis

Scenario	2025 Value Chain Costs $M	2025 Value Chain Savings $M	2025 Value Chain Costs $/m3	2025 Value Chain Savings $/m3
Base Case	$236.78	-	$83.80	-
Pessimistic Intervention	$219.98	$16.80	$77.85	$5.94
Realistic Intervention	$209.33	$27.45	$74.08	$9.71
Optimistic Intervention	$200.65	$36.12	$71.01	$12.79

The total annual forestry value chain savings ($ million p.a.) of the three scenarios versus the base case are illustrated graphically in Figure 10.

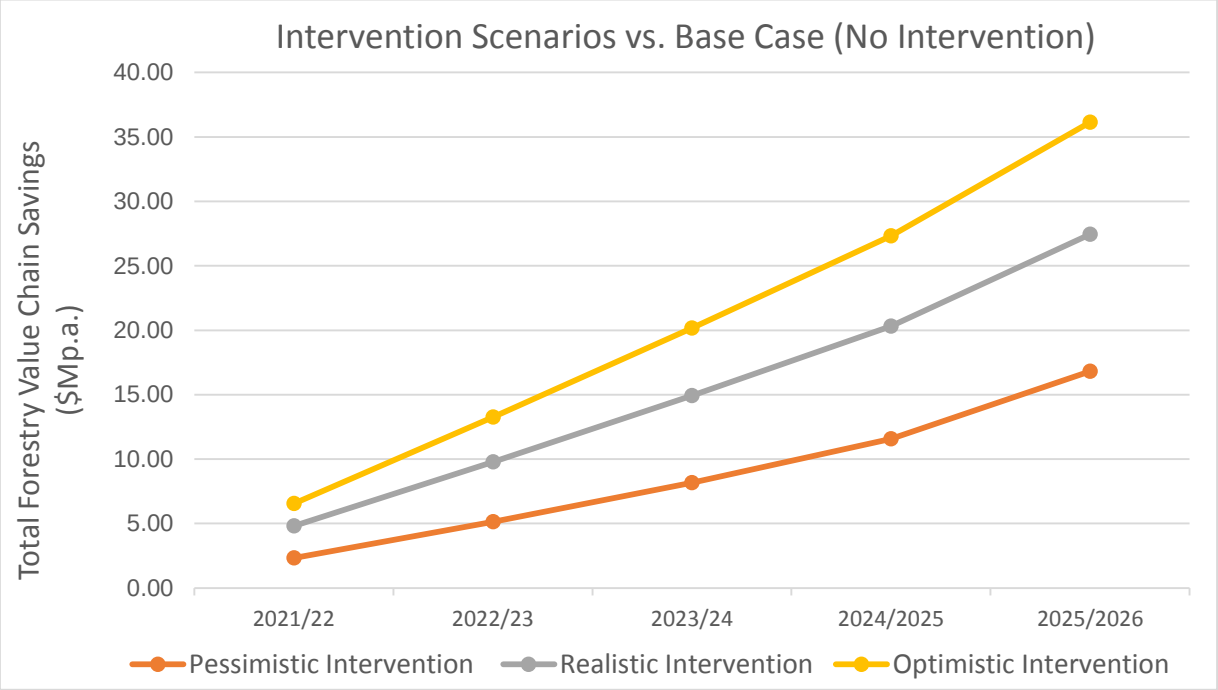

Figure 10: Total value chain savings ($M p.a.) for the three scenarios against base case

4.4 Risks and mitigations

The key risks for the programme are detailed in Table 28, with the estimated likelihood of occurrence, the impact on the programme, the threat to programme outcomes if realised, and the mitigation strategy for each risk.

Table 28: Key Risks and Mitigation Strategies in the Programme

Risk	Likelihood	Impact	Threat	Mitigation
The programme is too ambitious with the available resources.	Low	Low	Very Low	This is a development programme at the applied end of research and entirely based in industry. The engagement of the forest management companies in establishing sort yards will ensure that outcome as their investment in changing to the new logistics system and related infrastructure is large in comparison to the equipment costs.
The Forest Growers Levy is not renewed in 2019.	Low	Low	Very Low	Major efforts are being made to ensure that the Forest Growers Levy is of value to all forest owners. In the unlikely event it is not renewed the NZ Forest Owners Association will continue to support the on-going programme on behalf of the industry at large. The track record of the industry in funding multi-year programmes to completion is excellent. As each project is developed stakeholders will be updated on feasibility, early results and benefits to ensure its potential is clear, and progress towards achieving industry priorities is demonstrated.
The growth in demand for existing NZ wood products does not develop as forecasted.	Low	Medium	Low	This programme will help the forest value chain/wider wood products sector to meet and capitalise on the growing consumer demand for New Zealand wood products and improve its fundamental competitive advantage.
China log market does not accept the debarking approach.	Low	High	Medium	Debarking is already an acceptable phytosanitary treatment for the China market. This is evidenced by the fact that in 2015 China accepted 1.123 million m^3 of debarked logs from NZ. Debarking in the forest could increase this volume to 2.8 million m^3 by 2025. Costs will be lower than debarking at ports and could provide cost advantages to the China market.
The technologies don't get uptake by industry.	Low	High	Medium	The process of co-development will reduce the risk of non-implementation. Participating forestry companies have confirmed their support in implementing the new technology. The establishment of five complete systems will create market momentum.
The current economic boom could result in some manufacturing partners being too busy to progress projects early enough.	Medium	Medium	Medium	The contracting process will address this possibility. There are other potential engineering companies available to join the development team and other development capacity is available in the sector.
Skilled logging workers are difficult to source now and this could limit change.	High	Medium	Medium	The developments proposed will lead to a different workforce. Productivity changes will enable some crews to be the basis to build two teams. The changing nature of work and planned training will attract a more diverse and skilled workforce.
No forestry company commits to implementing a new log sort yard	Low	High	Medium	Five companies have expressed their willingness to implement a sort yard system. These companies will be involved in the initial system design and benefits analysis. The programme has an early stop / go milestone to address limiting this risk.

4.5 Contributions

Contributions are based on proposed programme start date of 1 January 2019. The total Programme funding is based on:

- investment in co-investor cash and in-kind contribution, and MPI investment, totalling $29.36 million (excl. GST)
- Consortium co-investment in the programme totalling $17.616 million (60% of total programme investment).

- MPI funding sought of $11.744 million (excl. GST), based on 40% of the total programme investment.

4.5.1. Consortium cash contributions

Cash contributions from the Consortium total **$14.159 million** over the life of the programme (Table 29), comprising:

- Cash contributions on behalf of Consortium forest owners and contractors from Forest Growers Levy Trust (FGLT) of **$6.542 million** (Table 29). The FGLT was established in 2013 to manage the forest commodity levy paid by 100% of forest owners in New Zealand when they harvest their trees. The levy funds forest grower investment in activities that will advance New Zealand forestry, both domestically and overseas. The funding of this programme has been approved by the FGLT and is included in the 2018 FGLT Annual Work Programme.

Table 29: Programme Investment by Co-investor

Budget Funding ($'000 excl. GST)									
Investor	**2018/19 Year 1 half-year**	**2019/20 Year 2**	**2020/21 Year 3**	**2021/22 Year 4**	**2022/15 Year 5**	**2023/24 Year 6**	**2024/25 Year 7**	**2025/26 Year 8 half-year**	**Total Budget**
Forest Growers Levy	300	845	820	1,425	1,932	480	480	260	6,542
For.Co./Contractor	0	554	1,674	2,188	2,135	1,067	0	0	7,617
Consortium cash	300	1,399	2,494	3,613	4,066	1,547	480	260	14,159
Consortium in-kind	12	1,003	1,129	589	381	281	50	12	3,457
Consortium total	312	2,402	3,623	4,202	4,447	1,828	530	272	17,616
MPI Investment	208	1,601	2,415	2,801	2,965	1,219	353	181	11,744
TOTAL INVESTMENT	**520**	**4,004**	**6,038**	**7,003**	**7,412**	**3,047**	**883**	**453**	**29,360**

- Cash contributions of Consortium forest owner/contractor(s) of **$7.617 million** (Table 29). This is cash investment from the first adopter Forest Owner/Contractor(s) that co-invest in the development and implementation of prototypes for the first three log sort yards (Table 30).

Table 30: Cash co-investment by first adopter forest owner/contractor(s)

Product	First Adopter investment in Alpha Prototypes ($'000)	First Adopter investment in Beta Prototypes ($'000)	Total First Adopter Cash Investment ($'000)
Semi-autonomous grapple and hauler control	76	750	826
Semi-automated log debarker-processor	140	1,380	1,520
Automated log residue chipper	61	600	661
Automated log tagging and tag reader system	100	360	460
Large capacity loading grapple	22	210	232
Automated load securing system	49	60	109
Robotic log sorter	460	2,500	2,960
Automated truck loading gantry	199	650	849
Total Co-investment by First Adopters	**1,107**	**6,510**	**7,617**

This investment contributes to the development of one 'alpha' prototype of each machinery product (costed at approximately 25% of the materials and build cost) totalling $1.107 million, plus six 'beta' prototypes of each machinery product for the harvesting crews supplying the first three sort yards (based on 50% of development cost of 'beta' prototypes) totalling $6.510 million.

4.5.2. Consortium in-kind contributions

Consortium in-kind contributions total **$3.457 million** over the life of the programme, which is just under 20% of total industry funding. This level of in-kind is similar to the earlier PGP Steepland Harvesting programme (budgeted 17% of total industry funding).

In-kind contributions comprise the following:

- Objective 1 New Automated Technology:
  Consortium manufacturing partners' in-kind contributions total **$1.295 million** (shaded area in Table 31). These manufacturing partner in-kind contributions were derived as varying proportions of the total development cost of each 'alpha' prototype depending on the product, and have been agreed with each manufacturing partner. This investment comprises engineering technology design time and resources during the technology development phase. All of this in-kind investment will be made in the first three years of the programme.

Table 31: Co-investment in 'Alpha' Prototypes Development ($'000) – Objective 1

Product	Manufacturer In-kind Contribution (Design Cost)	First Adopter Investment (Materials & Build $)	FGLT Investment (Materials & Build $)	Consortium Total Investment	MPI Investment (Materials & Build $)	Total Alpha Prototype Development Cost
Semi-autonomous grapple & hauler control system	275	76	12	363	242	605
Semi-automated log debarker-processor	200	140	146	486	324	810
Automated log residue chipper	0	61	98	159	106	265
Automated log tagging & tag reader system	330	100	29	459	306	765
Large capacity loading grapple	45	22	17	84	56	140
Sub-total Landing Products	**850**	**399**	**302**	**1,551**	**1,034**	**2,585**
Automated load securing system	185	49	6	240	160	400
Robotic log sorter	75	460	710	1,245	830	2,075
Automated truck loading gantry	185	199	246	630	420	1,050
Sub-total Sort Yard Products	**445**	**708**	**962**	**2,115**	**1,410**	**3,525**
TOTAL	**1,295**	**1,107**	**1,264**	**3,666**	**2,444**	**6,110**

- Objective 2 Human Factors of Automation:
  - Consortium forest owners' in-kind contributions total **$0.168 million** (Table 32). In-kind activities by Consortium forestry companies involve project management through the Technical Steering Group. Annual costs are based on one representative of each of 10 companies attending quarterly meetings at market daily rate of $800 per day plus GST (including overheads).
  - Consortium harvesting and log transport contractors' in-kind contributions total **$0.128 million** (Table 32). These activities involve technical input to manufacturing partners during the design phase, and provision of plant and equipment and skills/labour by contractors during field testing of prototype machinery during development, in conjunction with human factors projects. This is based on one trial per product @ 4 days per trial p.a. Man-day rates are costed at market daily rate of $800 per day plus GST (including overheads).

- Objective 3 Commercialisation and Deployment:
  - Consortium manufacturing partners' in-kind contributions total **$0.400 million** (Table 32). This investment comprises engineering time and resources for technical support of prototype products

during the implementation and deployment phase. Contributions are based on 0.25 FTE per product spread over years 4-6 at market annual cost of $200,000 plus GST (including overheads).

- Consortium harvesting and log transport contractors' in-kind contributions total **$0.176 million** (Table 32). These activities involve provision of plant and equipment and skills/labour by contractors during operational production trials of new machinery. This is based on one trial per product @ 5 days per trial during development (Year 2 and 3) then one full operational production trial (60 man-days for each of Sort Yards 1, 2 and 3 in Years 4-6 (Implementation). Man-day rates are costed at market daily rate of $800 per day plus GST (including overheads).
- Consortium forest owners' in-kind contributions total **$1.290 million** (Table 32). In-kind activities by Consortium forest owners and managers involve contribution of Sort Yard Project Leader time and resources for planning establishment of sort yards (1.25 FTE per sort yard at market annual cost of $200,000 plus GST (including overheads) spread over three years = $0.75 million); plus design and development of the first prototype log sort yard (based on civil engineering estimate of 20% of development cost = $0.54 million). This also includes input of technical information and resource management data by forestry company staff, use of raw materials (trees) owned by forestry companies for field testing and operational production trials;

Table 32: Annual Budget In-kind Contributions ($'000)

In-kind Contribution	2018/19 Year 1	2019/20 Year 2	2020/21 Year 3	2021/22 Year 4	2022/23 Year 5	2023/24 Year 6	2024/25 Year 7	2025/26 Year 8	TOTAL
Design Time (% of total)	0%	50%	50%	0%	0%	0%	0%	0%	100%
Manufacturer Design $	$0	$647	$647	$0	$0	$0	$0	$0	$1,295
Objective 1 Total	**$0**	**$647**	**$647**	**$0**	**$0**	**$0**	**$0**	**$0**	**$1,295**
TSG (man-days)	15	30	30	30	30	30	30	15	210
For. Co. TSG ($)	$12	$24	$24	$24	$24	$24	$24	$12	$168
Trials (man-days)	0	0	32	32	32	32	32	0	160
Contractor trials ($)	$0	$0	$26	$26	$26	$26	$26	$0	$128
Objective 2 Total ($)	**$12**	**$24**	**$50**	**$50**	**$50**	**$50**	**$50**	**$12**	**$296**
Tech. Support (man-days)	0	0	0	160	160	160	0	0	480
Manufacturer support $	$0	$0	$0	$133	$133	$133	$0	$0	$400
Trials (man-days)	0	20	20	60	60	60	0	0	220
Contractor trials ($)	$0	$16	$16	$48	$48	$48	$0	$0	$176
Yard Planning (man-days)	0	120	240	300	180	60	0	0	900
For.Co. Yard Planning $	$0	$100	$200	$250	$150	$50	$0	$0	$750
For.Co. Yard Develop. $	$0	$216	$216	$108	$0	$0	$0	$0	$540
Objective 3 Total ($)	**$0**	**$332**	**$432**	**$539**	**$331**	**$231**	**$0**	**$0**	**$1,866**
TOTAL In-kind ($)	**$12**	**$1003**	**$1129**	**$589**	**$381**	**$281**	**$50**	**$12**	**$3,457**

Consortium in-kind contributions will be recorded by each member of the Consortium as they are made and will be monitored against the in-kind contributions annual budget by the Programme Manager. Approved in-kind contributions will be reported quarterly to the Programme Governance Group.

The annual programme investment budget by co-investor and objective is detailed in Table 33.

Table 33: Annual Programme Investment Budget by Co-investor and Objective ($'000)

	Annual Programme Investment ($'000) excl. GST								
Co-investor	**Year 1 2018/19**	**Year 2 2019/20**	**Year 3 2020/21**	**Year 4 2021/22**	**Year 5 2022/23**	**Year 6 2023/24**	**Year 7 2024/25**	**Year 8 2025/26**	**Total**
Industry cash									
- Objective 1	165	1,111	2,157	3,170	3,547	991	4	6	**11,150**
- Objective 2	80	190	191	241	249	313	216	118	**1,598**
- Objective 3	41	12	6	19	69	164	237	124	**671**
- Overheads	15	86	140	183	201	79	24	13	**740**
Industry cash	**300**	**1,399**	**2,494**	**3,613**	**4,066**	**1,547**	**480**	**260**	**14,159**
In-kind									
- Objective 1	0	647	647	0	0	0	0	0	**1,295**
- Objective 2	12	24	50	50	50	50	50	12	**296**
- Objective 3	0	332	432	539	331	231	0	0	**1,866**
- Overheads	0	0	0	0	0	0	0	0	**0**
In-kind	**12**	**1,003**	**1,129**	**589**	**381**	**281**	**50**	**12**	**3,457**
MPI cash									
- Objective 1	110	1,173	1,870	2,113	2,364	661	3	4	**8,297**
- Objective 2	61	143	160	194	199	241	177	87	**1,262**
- Objective 3	27	229	292	372	267	264	158	82	**1,691**
- Overheads	10	57	94	122	134	53	16	8	**493**
MPI Cash	**208**	**1,601**	**2,415**	**2,801**	**2,965**	**1,219**	**353**	**181**	**11,744**
Total									
- Objective 1	275	2,931	4,674	5,283	5,911	1,652	7	9	**20,742**
- Objective 2	153	357	401	485	498	604	442	217	**3,156**
- Objective 3	68	573	730	930	668	659	394	206	**4,228**
- Overheads	24	143	234	305	335	132	40	21	**1,233**
Total	**520**	**4,004**	**6,038**	**7,003**	**7,412**	**3,047**	**883**	**453**	**29,360**

5. Appendices

5.1 Programme work plan and milestones

Forestry Work in the Modern Age: Outcome Summary

Intermediate Outcome: Key Indicators of Success	
IO Statement	*The PGP programme 'Te Mahi Ngahere i te Ao Hurihuri – Forestry Work in the Modern Age' aims to create value, improve profitability and enhance sustainability across the forestry value chain through development of a radical new wood logistics solution. The programme will create a new forest value chain that redesigns the harvesting, log manufacturing, and logistics process, through the implementation of automated harvesting technology at the log landing and shifting the log sorting function to robotic log sorting yards. The cumulative gross economic benefit of the programme will be $103.5 million by 2025/26 from forestry value chain efficiencies and sales of new forestry machinery and equipment. Sustainability benefits will include improved safety enhancing sector attractiveness, reduced environmental impact from smaller log landings, improved residue management, reduced chemical fumigation, fewer logging trucks on the public highway, and growth of the forestry machinery manufacturing sector. Spill-over benefits will include improved economic viability of harvesting small forest holdings, improved log supply to the wood manufacturing sector and improved regional resilience.* *Key success measures are:* • *Implementation of 3 robotic log sort yards operating in various parts of New Zealand by 30 June 2024.* • *Commercialisation of 8 new automated technology products in the market by 31 December 2025.*
Start Date	1 January 2019
End Date	31 December 2025
Leader	Keith Raymond, Programme Manager

Objective 1

Objective 1: New Automated Technology	
Objective Description	1. Develop new forest harvesting and logistics products and processes to automate manual tasks and reduce costs. 2. Develop new forest engineering processes to reduce environmental impact of forest operations through: • Reducing landing size. • Minimising log residues and risk of deposition into waterways. • Reducing the use of chemical fumigants through in-forest debarking. • Reducing the number of trucks on the road by further implementation of 58 tonne gross High Productivity Motor Vehicles (HPMV).
Objective Achievement Measures	1. Agreements have been reached with each Consortium forest owner regarding establishment of a log sort yard within their forest estate. 2. All products have development teams encompassing forest owner (specifier), contractor (user) and manufacturing partner (supplier). 3. Planning for the development of each new log sort yard has been completed. 4. The 'alpha' and 'beta' prototypes of the 8 technology products have been developed. 5. Other value-add opportunities have been evaluated through the process changes.
Start Date	1 January 2019
End Date	31 December 2025
Leader	Keith Raymond, FGR

Milestone 1.1: Forest Owner Agreement for Sort Yard 1	
Milestone description	FGR concludes an agreement with the first adopter forest owner/manager that wishes to establish Sort Yard 1 under this programme. This will entail forming a broad understanding with this forest owner and their nominated contractor(s) as to their desired system specification.
Achievement measures	1. A services agreement is in place with the first Forest Owner planning a sort yard under this programme 2. A system specification has been agreed with this Forest Owner 3. PGG signs off Forest Owner Sort Yard Agreement. **THIS IS A CRITICAL STOP/GO POINT**.
Start date	1 January 2019
End date	31 December 2019
Links to other milestones	Dependent on 1.3 Contributes to 1.2, 1.4, 1.8, 3.1, 3.4

Milestone 1.2: Product Development Project Teams for Alpha Prototypes (Sort Yard 1)	
Milestone description	Project teams for the development of each alpha prototype product will be established comprising the relevant manufacturing partner, Sort Yard Project Leader representing the forest owner, and key contractor(s). The manufacturing partner will designate a Product Development Project Leader who will lead the team to develop the product requirement specifications.
Achievement measures	1. Commercial and project agreements including IP arrangements in place with manufacturing partners for each project. 2. The Project Team has agreed the operating parameters and broad product requirement specifications for each development product. 3. The PGG approves the product requirement specifications for each development product
Start date	1 January 2019
End date	30 June 2019
Links to other milestones	Dependent on 1.1 Contributes to 1.3, 1.4, 1.8, 3.1 Associated with 2.2

Milestone 1.3: Technical and Economic Feasibility	
Milestone description	Complete the initial design for each product, optimise the value chain using Scion simulation software, review alternatives and competing products in international markets, conduct economic feasibility, incorporation of market situation report and prepare technical and economic feasibility report for sign off to progress project to prototype development.
Achievement measures	1. Validation of expected benefits using Scion's Value Chain Optimisation Model. 2. Sign off by the relevant Consortium partners and PGG. **THIS IS A CRITICAL STOP/GO POINT.**
Start date	1 January 2019
End date	30 June 2019
Links to other milestones	Dependent on 1.1, 1.2 Contributes to 1.4, 1.5, 3.1, 3.2 Associated with 2.1, 2.2

Milestone 1.4: Technical Project Planning	
Milestone description	The sort yard forest owners and their contractors work with FGR and the manufacturing partners to develop product requirement specifications.
Achievement measures	1. The relevant Consortium partners and PGG approve the technical specifications for each development product. 2. Comprehensive review undertaken of residue management and biomass processing alternatives (University of Canterbury). 3. Improved roading infrastructure has been planned using tools such as RoadEng and LiDAR applications (University of Canterbury)
Start date	1 January 2019
End date	31 December 2019
Links to other milestones	Dependent on 1.1, 1.2, 1.3 Contributes to 1.5, 1.6 Associated with 2.1, 2.2

Milestone 1.5: Manufacturing Prototype Design and Development	
Milestone description	Construct manufacturing prototype for each product, test under operational conditions, review and improve design for 'alpha' prototype, confirm economic feasibility and recommend next step
Achievement measures	1. Each manufacturing partner has completed design of a manufacturing prototype 2. Manufacturing prototype for each product has been constructed and tested in the field 3. The relevant partners and PGG sign off on investment to construct the 'alpha' prototype
Start date	1 July 2019
End date	31 December 2020
Links to other milestones	Dependent on 1.4 Contributes to 1.6, 1.8, 3.2 Associated with 2.2

Milestone 1.6: Sort Yard Planning (Sort Yard 1)	
Milestone description	The first adopter forest owner and its contractors work with FGR and the development team to plan the establishment of the first log sort yard, road and landing construction, and associated logistics processes to supply the first log sort yard.
Achievement measures	1. Planning the establishment of the first log sort yard has been completed. 2. The relevant Consortium partners and PGG approve the specifications and design for the first log sort yard. 3. The first log sort yard has been implemented by 30 June 2021.
Start date	1 July 2019
End date	31 December 2021
Links to other milestones	Dependent on 1.1, 1.2, 1.3, 1.4 Contributes to 1.8 Associated with 1.5, 2.2, 2.3

Milestone 1.7: Forest Owner Agreements for Sort Yards 2 - 3	
Milestone description	FGR concludes an agreement with the second and third forest owner/managers that commit to establishing Sort Yards 2 and 3 under this programme. This will entail signing a letter of intent with each forest owner and their nominated contractor detailing their broad understanding as to their desired system specification.
Achievement measures	1. A system specification has been agreed with the second adopter Forest Owner planning Sort Yard 2 under this programme 2. A letter of intent is in place with this Forest Owner by 30 June 2020 3. A system specification has been agreed with the third adopter Forest Owner planning Sort Yard 3 under this programme 4. A letter of intent is in place with this Forest Owner by 30 June 2021. 5. PGG signs off both Forest Owner Sort Yard letters of intent. **THIS IS A CRITICAL STOP/GO POINT**.
Start date	1 January 2020
End date	30 June 2021
Links to other milestones	Dependent on 1.2, 1.3, 1.4 Contributes to 2.0, 3.1, 3.4

Milestone 1.8: Sort Yard Planning (Sort Yards 2 – 3)	
Milestone description	Second and subsequent forest owners and their contractors work with FGR and the development team to plan the establishment of log sort yards 2 – 3, including road and landing construction, and associated logistics processes to supply the log sort yards.
Achievement measures	1. Planning the establishment of the each log sort yard has been completed. 2. The relevant Consortium partners and PGG approve the specifications and design for each log sort yard. 3. Log sort yard 3 has been implemented by 31 December 2023.
Start date	1 July 2020
End date	31 December 2023
Links to other milestones	Dependent on 1.3, 1.4, 1.7 Contributes to 1.5 Associated with 2.2, 2.3

Milestone 1.9: 'Alpha' Prototype Construction and Testing (Sort Yard 1)	
Milestone description	Construct prototype, install in first log sort yard and harvesting crew, test, modify and further develop, solve operating issues, review design for 'beta' prototypes.
Achievement measures	1. The relevant Consortium partners and PGG sign off on investment to construct the 'beta' products. **THIS IS A CRITICAL STOP/GO POINT**.
Start date	1 January 2021
End date	31 December 2021
Links to other milestones	Dependent on 1.5 Contributes to 1.7, 1.8, 3.1, 3.2 Associated with 2.2, 2.3, 2.4

Milestone 1.10: First 'Beta' prototype construction (Sort Yard 1)	
Milestone description	Build 7 'beta' systems for the balance of the first log sort yard and log supply harvesting crews, implement and test over longer time frames and provide engineering support for initial operations and demonstrations
Achievement measures	1. First log sort yard is fully operational with 'beta' prototypes installed by 31 Dec 2023. 2. An order for further 'beta' products has been received by each manufacturing partner
Start date	1 January 2022
End date	31 December 2022
Links to other milestones	Dependent on 1.6 Contributes to 1.8, 3.1, 3.2, 3.3, 3.4, 3.5 Associated with 2.3, 2.4, 2.5, 2.6

Milestone 1.11: Subsequent 'Beta' prototypes (Sort Yards 2 – 3)	
Milestone description	Build 'beta' systems for Log Sort Yards 2 - 3 and log supply harvesting crews, on the basis of earlier experience with the first log sort yard, modify hardware and software as required on the basis of location, terrain and crop factors. Implement and test over longer time frames and provide engineering support for initial operations and demonstrations.
Achievement measures	1. Log sort yard 2 is fully operational with 'beta' prototypes installed by 30 June 2023. 2. Log sort yard 3 is fully operational with 'beta' prototypes installed by 30 June 2024.
Start date	1 January 2023
End date	30 June 2024
Links to other milestones	Dependent on 1.10 Contributes to 1.12, 3.1, 3.2, 3.3, 3.4, 3.5 Associated with 2.3, 2.4, 2.5, 2.6

Milestone 1.12: Other Value Add Opportunities	
Milestone description	Other value-add opportunities will be identified through the process changes undertaken, that will be evaluated for their technical and economic feasibility, and their impacts on road transport, port operations and wood processing. If inside programme scope and feasible they will be budgeted and presented to the PGG for approval for inclusion in the programme.
Achievement measures	1. Value-add opportunities related to the programme have been identified 2. Opportunities have been evaluated by the Technical Steering Group for their technical and economic feasibility, budgeted and recommended to the PGG for approval. 3. PGG has approved value-add opportunities for inclusion in the development programme.
Start date	1 July 2019
End date	31 December 2025
Links to other milestones	Dependent on 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7 Contributes to Objective 3

Objective 2

Objective 2: Human Factors of Automation

Objective description	This objective is about preparing for tomorrow – identifying the skills and knowledge required for the forestry industry of the future, developing the training for those needs and specific training for the new systems developed
Objective achievement measures	1. All new machine designs and systems incorporate modern human/machine interface design that improves worker safety and productivity, reduces fatigue and improves industry attractiveness to a more diverse workforce 2. Recommendations for future focused training established with tertiary sector
Start date	1 January 2019
End date	31 December 2025
Leader	Dr Richard Parker, Scion

Milestone 2.1: Benchmarking NZ forest harvesting sector

Milestone description	Benchmark the workforce to guide the development programme and measure improvements by: 1. Forest Industry Census of harvesting machinery and people (University of Canterbury/Scion) 2. Measuring the gap between the current state and required attributes to improve person/machine fit; and 3. Use forest industry Incident Recording Information System analysis of injuries occurring in tasks that are to be automated for benchmarking progress.
Achievement measures	1. Input into the overall robotic log sort yard system design 2. Benchmarking to establish base line in 2018 to track changes and progress in the forest sector workforce
Start date	1 January 2019
End date	31 December 2025
Links to other milestones	Contributes to 1.3, 1.4, 2.2, 2.3, 2.7, 3.1 Associated with 1.4

Milestone 2.2: Cognitive and physical human-machine integration

Milestone description	Provide input to engineering design for each product to improve the operator experience, effectiveness, productivity and safety.
Achievement measures	1. Recommendations to machine designers and manufacturers 2. Successful and sustainable integration of human/machine interface in each product design accommodating human requirements.
Start date	1 January 2019
End date	31 December 2025
Links to other milestones	Dependent on 2.1 Contributes to 2.3, 2.4, 2.5, 2.7 Associated with 1.2, 1.3, 1.4, 1.5, 1.6

Milestone 2.3: New Job Design	
Milestone description	Determine the new roles arising from implementing the new systems, address retraining approaches for dislocated staff and new training programmes for the new roles.
Achievement measures	1. New job roles established 2. Likely role changes confirmed 3. Retraining programmes determined 4. Training requirements for new roles identified and an 'expert' crew is trained for operating and demonstrating the 'alpha' prototype sort yard system installation 5. Recommendations made to manufacturers, industry training organisations and tertiary providers.
Start date	1 July 2020
End date	30 June 2024
Links to other milestones	Dependent on 1.4, 2.1, 2.2 Contributes to 2.4, 2.5, 2.6, 2.7 Associated with 1.6, 1.7

Milestone 2.4: Operating techniques for new system	
Milestone description	Develop operating techniques for each new machine including integration with the overall work system
Achievement measures	1. In conjunction with each manufacturing partner, standard operating techniques and a training/operational manual has been documented for each new product
Start date	1 July 2020
End date	30 June 2024
Links to other milestones	Dependent on 2.2, 2.3 Contributes to 2.5, 2.6, 2.7, 3.4 Associated with 1.6, 1.7

Milestone 2.5: Workforce skills and development	
Milestone description	Improve workforce sustainability by improving the work environment and identify the skills and trained requirements in a future more automated forest environment
Achievement measures	1. A report identifying skills required for new roles in forest machine operation 2. Using a harvester simulator, actual versus simulated harvest will be compared to determine benefits of automated harvesting. Learning curves of operators will also be determined and the role of harvesting simulators in training for automated machines will be determined (University of Canterbury in conjunction with Toi Ohomai Institute of Technology) 3. A developed suite of innovate training techniques and materials for these new roles is implemented in the tertiary sector 4. Forestry is seen as an attractive, exciting and stable career. A report identifying skills required for new roles in forest machine operation
Start date	1 July 2021
End date	31 December 2025
Links to other milestones	Dependent on 2.2, 2.3, 2.4 Contributes to 2.6, 2.7, 3.4 Associated with 1.7

Milestone 2.6: New Standards and Qualifications	
Milestone description	Development of unit standards and qualifications to equip a more diverse forestry workforce
Achievement measures	1. A series of cross-sector workshops has been formed to develop new unit standards and qualifications. 2. New unit standards and qualifications are in place and supported by the sector.
Start date	1 July 2022
End date	31 December 2025
Links to other milestones	Dependent on 2.3, 2.4, 2.5 Contributes to 2.7 Associated with 1.7

Milestone 2.7: Targeted Industry Projects	
Milestone description	Targeted industry projects to address work force issues chosen each year. The investigation will provide recommendations to industry
Achievement measures	1. By 30 June 2018 complete a survey of mechanical log processor operators to determine training, experience, work hours, fitness, workload, levels of fatigue and impact on safety, quality and work experience. 2. Each year conduct and report on a relevant industry project determined by TSG.
Start date	1 July 2019
End date	31 December 2025
Links to other milestones	Dependent on 2.1, 2.2, 2.3, 2.4, 2.5, 2.6

Objective 3

Objective 3: Commercialisation and Deployment	
Objective description	To ensure that all the products are implemented in the marketplace.
Objective achievement measures	1. The commercial framework for each development product has been established including development and commercialisation plans, IP strategy, and business development support for manufacturing partners and product commercialisation. 2. All products are implemented as required within each log sort yard system. 3. Associated landing-based harvesting systems and logistics processes have been developed and implemented for efficient supply of logs to each robotic log sort yard. 4. All products are demonstrated to the forest owner and contractor community within New Zealand.
Start date	1 January 2019
End date	31 December 2025
Leader	Geoff Todd

Milestone 3.1: Establishment of Commercial Framework	
Milestone description	Confirm the market opportunity and initial business case
Achievement measures	1. Completed market situation report – encompassing market dimensions, environment, dimensions, NZ customer needs, competition, product advantages and economic feasibility confirmed. 2. A Commercialisation Plan for each product is approved by the PGG.
Start date	1 January 2019
End date	31 December 2020 (with minor updates in Year 4 for Sort Yard #2 and in Year 6 for Sort Yard #3)
Links to other milestones	Dependent on 1.1, 1.2, 1.6, 1.7 Contributes to 3.2

Milestone 3.2: Intellectual Property	
Milestone description	All aspects of developing, securing, protecting IP, confirming freedom to operate and agreeing an IP strategy for each project
Achievement measures	1. Processes for identifying and securing IP are in place. 2. Freedom to operate has been confirmed. 3. IP strategy, including protection of IP, has been approved by the PGG.
Start date	1 January 2019
End date	31 December 2025
Links to other milestones	Dependent on 1.4, 1.5, 1.6, 1.7, 3.1 Contributes to 3.3

Milestone 3.3: Business Development Support	
Milestone description	Initial engagement with market, first customers and applications
Achievement measures	1. Initial product champion identified and involved for each product 2. Pre-commercial tests and product demonstration completed and results used to determine next prototype and confirm opportunity. 3. Commercialisation Plan reviewed and updated. 4. Route to market identified, reviewed and revised (if necessary). 5. Preliminary business strategy summarised and reviewed.
Start date	1 July 2019
End date	31 December 2025
Links to other milestones	Dependent on 1.7, 3.2 Contributes to 3.4

Milestone 3.4: Commercialisation of each product	
Milestone description	The plan, materials and arrangements to commence selling the products in NZ
Achievement measures	1. Commercialisation plan completed. 2. User information, guidance for training programmes available and SOPs published. 3. Sales material prepared. 4. Product champion has product in his system. 5. Product launch at an appropriate industry event.
Start date	1 July 2021
End date	31 December 2025
Links to other milestones	Dependent on 1.7, 2.4, 2.5, 3.3 Contributes to 3.5

Milestone 3.5: Deployment for each product/system and programme promotion	
Milestone description	Provide information on the programme and its products to create awareness of the products and their benefits to the NZ market and to increase uptake of the new logistics system.
Achievement measures	1. Video and printed material promoting the programme is available on social media and FGR web site. 2. Presentations at industry tradeshows (such as HarvestTECH) and international conferences 3. A series of regional technical workshops in each of years 4-6 to present the outputs of the programme and promote uptake of each product. 4. Deployment of all products in 3 log sort yards by 30 June 2024. 5. FGR completes a field demonstration of each log sort yard and supplying harvesting crews (3 field demonstrations in total, in mid-2022, mid-2023 and mid-2024). 6. At least 100 NZ harvesting and log transport contractors will have attended the FGR field demonstrations and have gained a good understanding of all the products and the system.
Start date	1 July 2019
End date	31 December 2025
Links to other milestones	Dependent on 1.7

Objective 4

Objective 4: Programme Management and Overheads

Objective Description	Effective programme management through appropriate resourcing and strategic management to ensure: timely and within budget delivery to a high standard of outcomes from the programme and contractual requirements; reliable cost accounting and financial reporting; effective management of all contracted suppliers and services; and appropriate and effective communication with all stakeholders and with MPI.
Objective Achievement Measures	1. Financial Management: Milestone Summary report detailing all Objective milestones and progress towards delivery, financial management, and forecasting is developed by Programme Manager and communicated to TSG and PGG each year by 31 May and updated on a quarterly basis. 2. Additional Costs: In-Kind contributions are recorded by project leaders and reported in the In-Kind Contribution Report each Quarter by Programme Manager. 3. Meetings: PGG meetings are held quarterly within 1 month of periods ending 30 September, 31 December, 31 March and 30 June each year. 4. Reporting: A Quarterly Report (QR) is prepared by Programme Manager and submitted to the PGG within one month of the periods ending 30 September, 31 December, 31 March and 30 June each year. 5. Cash flow forecast: Updated quarterly and Year End Forecast to end of programme is approved by the PGG each quarter. 6. Material changes: Amendments that are within programme scope and budget are identified by the Programme Manager, approved by the PGG and notified to MPI on a quarterly basis. 7. Annual Plan: The Annual Plan (AP) is approved by the PGG by 30 April each year. 8. Programme Outcomes: Programme outcomes are reviewed by the PGG annually. 9. Contract Variations: Any contract variations relating to Annual Plan are approved by the PGG and incorporated into Schedule 5 of the PGP contract by 31 August each year. 10. Mid-Programme Review: An independent review of the programme to be held mid-programme by 31 December 2021. 11. Final Programme Report: A final report is prepared by Programme Manager and submitted to the PGG within two months of the end of the programme, detailing achievements of the programme by 31 December 2025. 12. Programme Evaluation: MPI will engage an independent expert within 6 months of programme completion to undertake an evaluation, at MPI's cost, of the benefits and outcomes to date of the programme. 13. Post-Programme Reports: An annual programme report will be prepared by FGR and submitted to MPI within one month of the periods ending 31 December 2026, 31 December 2027, and 31 December 2028, detailing progress towards short term and medium term outcomes from 2026.
Start Date	1 January 2019
End Date	31 December 2025
Leader	FGR Chief Executive
Linkages	Objectives 1,2,3: Project Management and Overheads support all objectives

5.2 Biographical information – Development team and technical support

Keith Raymond
Key roles relating to the Programme:

- Harvesting and Logistics Programme Leader, Forest Growers Research Ltd, 2017-present
- Programme Manager, PGP Steepland Harvesting Programme, 2010-2017
- Management consultant, Raymond Management Services Ltd 2007-present
- Central Region Manager, Carter Holt Harvey Forests Ltd 2006-2007
- Manager Wood Supply Contracts, CHH Woodproducts and Tenon Industries Ltd 2004-2006
- Sales and Operations Planning Manager, Fletcher Challenge Forests Ltd, 1996-2004
- Clearfell Harvesting Manager, Forestry Corporation NZ Ltd, 1994-1996

Dr. Richard Parker
Key roles relating to the Programme:

- Objective Leader, Human Factors in Automation, Forest Growers Research Ltd, Rotorua.
- Research Team member, PGP Steepland Harvesting Programme, Forest Growers Research Ltd
- Human Factors Team Leader, Scion (NZ Forest Research Institute), 2010-present
- Designer of Tree-to-tree robot and development lead for 'beta' prototype
- Programme Leader Centre for Human Factors and Ergonomics (COHFE), Scion, 2000-2010
- Researcher, Human Factors, Logging Industry Research Organisation, 1991-2000

Geoff Todd
Key roles relating to the Programme:

- Objective Leader, Commercialisation and Deployment, Forest Growers Research Ltd
- Commercialisation Team Leader, PGP Steepland Harvesting Programme, Forest Growers Research Ltd, 2016-present
- Managing Director, Viclink, Victoria University of Wellington technology transfer office
- Director of the MacDiarmid Institute and Kiwinet
- Director, Seatoun Enterprises Ltd, Wellington
- History of technology commercialisation since 1985 starting in DSIR. Previously, General Manager Business Development from 1992-2000
- Deployed technology into companies from the public sector through contracts, joint developments, licenses and start-ups. Key participant in 4 start-ups, and stimulated or supported angel investment into over 9 more companies.
- Expertise in engineering/manufacturing. Worked at a senior level with a private U.S. technology company to extract and commercialise technology from U.S. public sector.

Dr Sunil Vather
Key roles relating to the Programme:

- Commercialisation Team member, Forest Growers Research Ltd, Rotorua.
- Director, Im-Able Ltd, Nusam Ltd, White Lotus Ltd, and Crablink Ltd
- Chairman, SOS NZ
- Consultant to Viclink Ltd, providing business development support for Kiwinet
- Focused on global commercialisation of innovations derived from research and development organisations.
- Mentor to five start-up companies, 2010 to present: Greenbuild Ltd, Kruse Commentary Systems Limited, Damping Systems Ltd; White Lotus Limited, and Westmedic Limited

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Brionny Hooper
Key roles relating to the Programme:

- Human Factors Team member, Forest Growers Research Ltd, Rotorua.
- Inaugural winner of Young Scientist of the Year, 2016 Forest Growers Science Awards
- Human Factors Scientist, Scion (NZ Forest Research Institute).
- Master of Arts with Distinction - Aviation Psychology & Human Factors, University of Otago
- Bachelor of Arts (Hons, First Class) – Psychology, University of Otago

- Certificate IV Training and Assessment, Ascet Institute of Technology, Victoria, Australia
- Internal Lead Auditors Course, Southpac Aerospace, Queensland, Australia
- Learning and Development Facilitator, Business Central and Wellington Employers' Chamber of Commerce

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Dr. Xiao Qi Chen

Key roles relating to the Programme:

- Automation Development Team member, Forest Growers Research Ltd
- Associate Professor, Director of Mechatronics Engineering Programme, University of Canterbury
- Fields of Research: Mobile robotics, Human-robot interface and Industrial automation

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Dr. Rien Visser

Key roles relating to the Programme:

- Project Leader, Harvesting Cost and Productivity Benchmarking Project, Forest Growers Research Ltd, Rotorua.
- Associate Professor, Director of Forest Engineering, School of Forestry, University of Canterbury, 2009-present
- Associate Professor, Industrial Forest Operations, Department of Forestry, Virginia tech, Blacksburg, Virginia, USA, 2000-2009
- Scientist, NZ Forest Research Institute, 1998-2000
- Doctor of Philosophy, Forest Engineering, Bodenkultur University, Vienna, Austria, 1998

Dr. Clive Marsh

Key roles relating to the Programme:

- Automation Development Team member, Forest Growers Research Ltd
- Principal Scientist, Lincoln Agritech Ltd, member of the sensing technologies team.
- Various roles at LincLab (subsequently Canesis then AgResearch) specialising in industrial consulting, and Keraplast Research (commercialising new biotechnology products).
- Lecturer, Technology and Engineering Department, Massey University 1993-1999.
- BSc (Hons) Mathematical Engineering at Loughborough University, and Doctor of Philosophy on "Methodologies for designing control strategies for active suspension systems".

Rob Prebble

Key roles relating to the Programme:

- Harvesting Project team member, Forest Growers Research Ltd, Rotorua, 2018–current.
- Consultant, providing advisory services to forest companies, FISC, Lincoln University and ACC, aimed at reducing accident frequency in forest operations, 2009 – 2017.
- Managing Director and part owner of LFITB Ltd, a private training establishment (PTE) providing training and assessment services to the primary industries, 1998 – 2009.
- Project manager, Operations Manager and Acting General Manager for the Logging and Forest Industries Training Board, the standards setting body for forestry qualifications in New Zealand, 1996 – 1998.
- Harvesting Manager & Consultant for Kolombangara Forest Products Limited, Solomon Islands, 1994 – 1996.
- Researcher, Logging Industry Research Association (LIRA), involved in accident prevention, development of protective equipment, motor manual tree felling techniques and cable logging systems & machinery, 1980 – 1991.

Spencer Hill

Key roles relating to the Programme:

- Harvesting Project Leader contracted to Forest Growers Research Ltd, 2017-present
- Director and owner, Logpro Ltd
- Harvesting Team Leader, Scion (NZ Forest Research Institute)
- Forest Engineering Manager, PF Olsen Ltd.

5.3 Letters of support from Consortium forestry organisations

FOREST OWNERS ASSOCIATION

26 July 2017

Keith Raymond
Harvesting Programme Leader
Forest Growers Research Ltd
PO Box 1127
Rotorua 3040

SUPPORT FOR THE PGP FOREST AUTOMATION PROJECT

This letter is to highlight the Forest Owners Association (FOA) support of the Forest Growers Research proposal for the forest work in the modern age proposed programme of work.

FOA is strongly supportive of the project and the proposed complete redesign of the harvesting process for a number of reasons.

The forestry sector needs to improve our engineering and environmental practices. There have been a number of regrettable lapses in roading and landing engineering works over the past few years, and the sector as a whole needs to look at how to improve in this area. Delivering the project's aim to reduce the negative environmental effects (of harvest in particular) would be very valuable to the sector and the immediate community. The programme would enhance our environmental credentials, FSC and PEFC certification, and would reduce the impact on downstream landowners.

In addition, the goals of reducing soil movement, reducing the use of chemical fumigants, reducing log waste, managing residue better, and transport load reduction, will all contribute hugely to the forestry sector's strategic and environmental goals. Our aims are to reduce environmental impacts while increasing productivity and profitability, and the proposed project fits well with our core focus. A number of our foci for the next five years are aligned with these goals.

Our desire is to induce step change in the sector, driving innovation, efficiency and improvements. As such, we strongly support and endorse this programme of work.

Yours sincerely,

David Rhodes
CE, Forest Owners Association

Level 9, 93 The Terrace, PO Box 10-986
Wellington 6143, New Zealand
Tel: +64 4 4734769
www.nzfoa.org.nz

FOREST OWNERS ASSOCIATION

NEW ZEALAND FARM FORESTRY ASSOCIATION

28 July 2017

Keith Raymond
Harvesting Programme Leader
Forest Growers Research Ltd
PO Box 1127
Rotorua 3040

SUPPORT FOR THE PGP FOREST AUTOMATION PROJECT

The aim of this letter is to give support to the Forest Growers Research project and endorse the objectives of reducing; soil disturbance, use of chemical fumigants, log making waste, and log truck numbers on our roads.

There are many apparent benefits for small scale foresters that will result from this project and the Small and Medium Enterprises Committee (SME) has no doubt it is worthy of PGP Investment funding.

Many small scale forest growers when harvesting, face problems of lack of scale that can add substantial costs to the process and in some cases make harvesting marginally economic. This is sometimes compounded by a lack of skilled log makers which results in wasteful log grading. This project with its aim to reduce the amount of machinery on site and removing the log making to a fully automated site using advanced scanning technology has the potential to greatly improve returns for small growers.

The environmental returns from reducing the size of skid sites would be considerable as compaction, removal of soil, and contamination with bark and waste wood make these areas much less productive in future rotations. Centralising debarking and log grading would make utilisation of bark and residue wood for biofuel a much simpler and more viable proposition. The current non-use of lower value parts of the harvested trees that are left on site and can create problems downstream in flood events is an ongoing issue for tree growers.

A disproportionate number of serious harm accidents occur when harvesting smaller wood lots. This proposed automated process would greatly reduce risk of injury as would having a highly skilled and mechanised harvesting workforce which is also an outcome of this project. Small scale forest growers are particularly vulnerable to inefficiencies and increased costs at harvesting, so welcome the thrust of this project to reduce costs while improving productivity and protection of the environment. We therefore are strong supporters of the project and look forward to its realisation.

Yours sincerely.

Neil Cullen
Chair, Small and Medium Enterprise Committee (a joint FOA/FFA Committee).

Level 9, 93 The Terrace, PO Box 10-986
Wellington 6143, New Zealand
Tel: +64 4 4734769
www.nzfoa.org.nz

PF Olsen Ltd
PO Box 1127 | Rotorua 3040 | New Zealand
P: 64 7 921 1010 | F: 64 7 921 1020 | E: peter.clark@pfolsen.com
www.pfolsen.com

8 December 2017

By Email
russell.dale@fgr.co.nz

Mr Russell Dale
Manager, Forest Growers Research Ltd
P.O. Box 1127
ROTORUA 3040

Dear Russell

PGP Automation Project

First established in 1971, PF Olsen Ltd is the is the leading independent provider of professional forestry services in New Zealand, delivering a wide range of services to a diverse range of clients including TIMOs, farmers, forest investors, Maori groups, and government agencies. We manage significant plantation forest estates, and many woodlots and forests across New Zealand, and we annually harvest and market over 4 million cubic metres of logs.

PF Olsen Ltd is one of the forest management companies that has formed a Consortium to address key issues of labour shortages and rising costs, and improving long term sustainability and safety across the entire value chain. We have had a leading role with Forest Growers Research Ltd over the last three years in the development of the proposed PGP programme "Automated Forestry Value Chains" to develop automated harvesting and centralised log sorting and HPMV log transport operations. We are keen for Forest Growers Research Ltd to drive this programme to achieve the stated outcomes.

We are particularly interested in participating in the development of the following outputs of the programme:

- semi-automated log processor-debarker for in-forest debarking
- log sensing and processor head-based log tagging technology
- 'smart' yarder grapple & semi-autonomous hauler control system
- robotic log sorting facility with automated truck loading gantry

These engineered products will allow positive change to occur across the forestry value chain and, on successful completion of this development programme we will look to implement such a log sorting hub in the King Country region of the North Island, and potentially elsewhere.

We recognise the benefits of teleoperation, automation and robotics across the forest value chain in terms of reducing cost and addressing labour shortages in the industry.

Yours sincerely,

PF OLSEN LTD

Peter Clark
Chief Executive Officer

8 September 2017

Mr Russell Dale
Manager, Forest Growers Research Ltd
P.O. Box 1127
Rotorua 3040

Dear Sir

Rayonier Matariki Forests is the third largest forestry company in New Zealand with approximately 130,000 hectares of plantations across the country. Matariki Forests is managed by Rayonier New Zealand, a subsidiary of Rayonier Inc. A brochure with more information on our operations is attached with this letter.

Rayonier Matariki Forests is one of the forest management companies that has formed a Consortium to address key issues of labour shortages and rising costs, and improving long term sustainability and safety across the entire forestry value chain.

We have had discussions with Forest Growers Research Ltd regarding the proposed PGP programme "Automated Forestry Value Chains" and we are keen for Forest Growers Research Ltd to drive this programme to achieve the stated outcomes.

We are interested in participating in the development of all the following projects:

- semi-automated log processor-debarker for in-forest debarking;
- log sensing and processor head-based log tagging technology;
- automated residue management system;
- large capacity truck loading grapples and automated truck loading gantry;
- automatic log load securing system;
- 'smart' yarder grapple & semi-autonomous hauler control system;
- robotic log sorting facility (log deck plus scanner);
- automated felling robot to second (or 'beta') prototype;

and we recognise the benefits of teleoperation, automation and robotics across the forest value chain in terms of reducing cost and addressing labour shortages in the industry.

We look forward to the outputs of this programme as these will allow positive change to occur across the forestry value chain. On proven success, we would look to implement these developments across our contractor workforce to capture the benefits.

Yours sincerely
RAYONIER | MATARIKI FORESTS

Brendan Slui
Operations Director

Level 5, 32-34 Mahuhu Crescent, Auckland CBD, 1010, New Zealand. PO Box 9283, Newmarket, Auckland 1149, New Zealand.
T +64 9 302 2988 F +64 9 377 0249 W www.matarikiforests.co.nz

Forest Enterprises
Creating wealth. Naturally.

5 Papawai Place, Masterton 5810
PO Box 128, Masterton 5840
New Zealand
Office +64 6 370 6360
Fax +64 6 370 6369
www.forestenterprises.co.nz

Mr Russell Dale
Manager
Forest Growers Research Ltd
PO Box 1127
ROTORUA 3040

13 March 2017

Dear Sir,

PGP Proposal

Forest Enterprises Ltd is New Zealand's leading direct forestry investment company. Currently we have just over 21,000 hectares in 75 different forests under management with more than 6,400 investors. We have demonstrated over the past 30 years continued innovation to ensure we create the best value for our investors. We are now harvesting forests that were established early in the company's beginnings thus completing the investment cycle for our early clients. Harvesting focus is on sustainability through such key drivers as minimising costs, maximising value (best markets), staying safe and protecting the soil for future forests.

We have had discussions with Forest Growers Research Ltd regarding the new PGP Proposal on Automated Forestry Value Chains and note that the programme they have discussed with us is what the industry needs to make another step change in reducing costs, improving value, making the industry safer and protecting our environment. We are in full support of this programme and we can see how our investor clients will benefit. We look forward to the outputs of this programme and in particular, automated log sorting, processors with the capability to debark and faster truck loading equipment. These engineered products will allow positive change to occur in the supply chain and as such we would implement some of these immediately on their proven success.

Yours sincerely,

Bert Hughes

Bert Hughes
Forestry Director
DDI +64 6 370 6361
Mob. +64 27 441 0535
bhughes@forestenterprises.co.nz

FOMS YOUR PARTNERS IN FORESTRY

Mr Russell Dale

Manager, Forest Growers Research Ltd

P.O. Box 1127

Rotorua 3040

Dear Sir

Forest Owner Marketing Services Ltd (FOMS) is one of the largest independent log procurement and harvesting and marketing service providers in New Zealand, providing professional, skilled and reliable forest harvesting and marketing services to private forest owners across the North Island. We focus on providing the best net return possible to our clients through value maximisation and cost minimisation and above all else we are committed to improved Health and Safety performance and industry incident reduction.

FOMS has had preliminary discussions with Forest Growers Research Ltd during 2016 and we are very interested in participating in the proposed PGP programme "Automated Forestry Value Chains" to develop in-forest transport, automated log sorting, and HPMV log transport operations in the southern North Island (SNI) region. FOMS currently employs over 40 harvesting crews throughout the North Island. FOMS also has a close working relationship with Central Logistics Services who are a large SNI log cartage contractor with access to transport hubs in Masterton, Wanganui and Karioi. On successful completion of this development programme we will look to implement automated harvesting systems across all our harvesting and transport operations.

Yours sincerely

FOMS LIMITED

Dan Gaddum,

Managing Director

Agri-Business Centre
8 Weld Street Feilding 4702
PO Box 96 Feilding 4740

P 06 323 5621
F 06 323 5372
www.foms.co.nz

WOOD MARKETING
SERVICES LIMITED

12 Western Road
PO Box 293
Ngongotaha
Rotorua 3041
Telephone
64 7 357 4649

Mr Russell Dale
Manager, Forest Growers Research Ltd
P.O. Box 1127
Rotorua 3040
7 March 2017

Dear Russell,

Wood Marketing Services Ltd was established in 2005, and provide personalised harvesting and marketing services to forest and woodlot owners in the Waikato and Bay of Plenty. Since 2005 the business has rapidly expanded to become one of the larger private suppliers of forest harvesting and marketing services in the North Island. This success is a direct result of strong client and industry relationships. WMS has a solid team of staff and contractors and prides its self on continuous improvement to ensure client returns are maximised. Currently WMS is putting a lot of effort into contractor improvement to ensure the best logging rates are achieved while staying safe and environmentally sound, results of this work are returned to the client in improved net stumpages.

WMS have had discussions with Forest Growers Research Ltd regarding the new PGP Proposal on Automated Forestry Value Chains. The programme is focussed on the main issues impacting better returns for forest owners. We are in full support of this programme and we can see how our clients will benefit. We look forward to the outputs of this programme and in particular, automated log sorting, processors that can debark and faster truck loading equipment which gives greater access to HPMV log transport. These engineered products will allow good change to occur in the supply chain and as such we would implement these products immediately on their success.

Yours faithfully

Duncan Mills
Wood Marketing Services Ltd
027 2855598
duncan@woodmarketingservices.co.nz

5.4 Letters of intent from Consortium manufacturing partners

HEAD OFFICE - 150 VIEW ROAD, ROTORUA, NEW ZEALAND
TELEPHONE (07) 348 -7746
FACSIMILE (07) 347-1687

14 February 2017

Mr Russell Dale
Manager, Forest Growers Research Ltd
P.O. Box 1127
Rotorua 3040

Dear Russell

The Patchell Group is involved in the heavy transport and trailer design and manufacture sector. We have held the number one status over the last 5 years for highest number of trailer builds/registrations in New Zealand. The forestry sector is a significant component of our business, with the design and build of logging transport equipment. Our involvement in forestry sector stems back to 1972, when the company was created, where bush canopies for bull dozers plus coupling systems for buckets on wheel loaders were developed and built.

Included in our umbrella of products is our Container Transport Equipment (Swinglift and Skeletal trailers) and Stainless Tanker product.

We have strong ties with Logging Cartage Operators right through to Wharf Logistic Companies (Off Road wharf log trailers) so have significant knowledge of the logging sector requirements.

Our company has approx. 210 staff, all based in New Zealand, and includes a Design Team with Certified Engineers. (13 in Design team).

The Patchell Group has had preliminary discussions with Forest Growers Research Ltd regarding the proposed PGP programme "Automated Forestry Value Chains" to develop in-forest debarking, automated log sorting, and HPMV log transport operations and we are very interested in participating in this proposed PGP programme.

We are particularly interested in participating in the development of

- Large capacity loading system for faster loading and reduced truck delays
- Improved log truck load securing system
- New configurations to increase the use of HPMV

PATCHELL
Group of Companies

We have already optimised equipment under HPMV and VDAM so interested in how this could be extended further.

Opportunities to commercialise products resulting from this programme will be closely scrutinised and explored.

Please feel free to contact me directly if you need any further information.

Yours sincerely

Brent Whibley
General Manager
Patchell Group

O: 07 348 7746
M: 027 416 9420
E: brentwhibley@patchell.co.nz

Letter of Intent regarding collaboration on the PGP Programme "Forestry Work in the Modern Age"

The Parties

Patchell Industries Ltd

and

Forest Growers Research Ltd (FGR)

Project Description

This records the intention of both parties to work together to design, develop, manufacture and take to the market the following Products:

1. *Semi-automated truck loading gantry. Features of this system include design of a truck loading solution with pre-loading of sorted logs, and semi-automated loading of HPMV truck and trailer units to reduce truck loading delays.*
2. *Automated log load securing system. Features of this system include automatic load tensioning to ensure safe transport of debarked logs. It is envisaged as an 'after-market' retrofit for all brands of truck and trailer and does not require purchase of a new vehicle. This development may be integrated with other developments of automatic tensioning systems.*

The parties will work with participants of the PGP programme (which may include Applied Teleoperation Ltd, Log Truck Safety Council, other developers of automatic tensioning systems, various forest owners and forest management companies and harvesting and log transport contractors) to design and evaluate the Products. For each Product development project this will involve the following:

Activities

1. Business case for development (Work plan and budget formulation)
2. Literature search of existing technologies and regulations
3. Concept feasibility
4. Obtaining provisional patent (if appropriate)
5. Design parameters
6. Detailed design and simulation
7. Alpha prototype development
8. Field testing
9. Beta prototype development
10. Full patent protection (if appropriate)
11. Commercialisation (including field demonstration to the forest industry)

Indicative Contributions of the Parties

Assuming estimated design and development budgets of:

- Approximately $1,050,000 for the first ('alpha') prototype of the semi-automated truck loading gantry; and
- A maximum of two subsequent ('beta') prototypes of the semi-automated truck loading gantry with an estimated development budget of approximately $650,000 each
- Approximately $400,000 for the first ('alpha') prototype of the automated log load securing system; and

- A maximum of six subsequent ('beta') prototypes of the automated log load securing system with an estimated development budget of approximately $20,000 each:

    (i) Resources from Patchell Industries Ltd:
    In-kind contribution of time and resources for design, development and testing to the value of approximately 1 full-time equivalent (FTE) design engineer for each Product (approximately $370,000 in total) plus technical support to the value of approximately 0.25 FTE for each Product (approximately $90,000 in total).

    (ii) Resources from the PGP programme
    - Direct costs of development (materials and build cost) of the first ('alpha') prototype of the semi-automated truck loading gantry of approximately $865,000, plus estimated direct development costs (materials and build cost) of two 'beta' prototypes of the semi-automated truck loading gantry of approximately $650,000 per unit.
    - Direct costs of development (materials and build cost) of the first ('alpha') prototype of the automated log load securing system of approximately $215,000, plus estimated direct development costs (materials and build cost) of six 'beta' prototypes of the automated log load securing system of approximately $20,000 per unit.

Intellectual Property Management

The parties will work together to achieve the MPI requirements regarding Intellectual Property (IP) management, specifically that:

1. Where Patchell Industries Ltd is engaged to perform part of the Programme and brings Existing IP to the Programme, the Existing IP shall be clearly defined and set out in an agreement and FGR shall negotiate terms and conditions with Patchell Industries Ltd for the use of the Existing IP.
2. New IP arising from the programme investment is defined broadly and includes any new designs, drawings, algorithms and inventions, arising after programme commencement, through meeting the milestones and delivering the objectives of the programme.
3. New IP will be owned by FGR and FGR will invest in protecting the new IP.
4. FGR holds the new IP exclusively for 5 years following the start of commercialisation, and will use its best endeavours to commercialise the IP. FGR will licence the New IP to Patchell Industries Ltd on an exclusive basis (to manufacture and market on behalf of FGR) until the exclusive period finishes. After this point the IP licence will be converted to a non-exclusive licence for New Zealand.
5. After 5 years following the start of the commercialisation MPI will have the right to promote the IP and FGR must assist MPI, and FGR must seek to licence to third parties the New IP non-exclusively in New Zealand.
6. Any subsequent licence by FGR to third parties must be on reasonable commercial terms, and Patchell Industries Ltd will share in the licensing fees with FGR on terms to be agreed.
7. Patchell Industries Ltd owns all IP developed subsequent to conclusion of any product development contract with FGR. Any IP developed by Patchell Industries Ltd subsequent to the development contract could only be included in a license by FGR to other third parties on the agreement of Patchell Industries Ltd.

Process for formalising agreement between the Parties

Consequent to the development of a business case for investment by each party and approval of such by the Boards of both parties, Patchell Industries Ltd will sign an agreement with FGR to design, develop, manufacture, evaluate and sell the Products.

In entering this contract the parties expect:

(i) FGR to undertake the following:

- Coordinate and lead PGP programme, facilitate development of innovative solutions, field test and evaluate the Products, and demonstrate to industry
- Provide support to the Product Development team leader at Patchell Industries Ltd, coordination with forestry company/contractor(s) to trial and evaluate the Products, and organise field demonstration of the Products to the forest industry.
- Source cash resources for materials and build of one Alpha prototype of the semi-automated truck loading gantry of approximately $865,000 (co-funded by FGR, MPI and the first purchaser of the Product).
- Source cash resources for materials and build of one Alpha prototype of the automated log load securing system of approximately $215,000 (co-funded by FGR, MPI and the first purchaser of the Product).
- Source cash resources for materials and build cost of two Beta prototypes of the semi-automated truck loading gantry of approximately $650,000 per unit (co-funded by FGR, MPI and the first purchasers of these Products)
- Source cash resources for materials and build cost of up to 6 Beta prototypes of the automated log load securing system of approximately $20,000 per unit (co-funded by FGR, MPI and the first purchasers of these Products).

(ii) Patchell Industries Ltd to undertake the following:

- Provide a staff member in the role of Product Development Team Leader
- Contribute in-kind resources (approx. 1 FTE design time for each Product, plus manufacturing facilities and expertise)
- Design the Products
- Manufacture, workshop test, install the Products in the first sort yards and on first purchasers' truck/trailer units, and commission the Products
- Contribute in-kind resources (approx. 0.5 FTE marketing expertise, networks, channels to market, after-sales product support)
- Record accurately and report all in-kind contributions to FGR every 3 months during the development projects
- Actively market and sell the Products in New Zealand

Signed as a non-binding letter of intent:

Brent Wrigley
General Manager
Patchell Industries Ltd

23 August 2018
Date

and

Russell Dale
Chief Executive
Forest Growers Research Ltd

23 August 2018
Date

MTEL
MURAL TOWN ENGINEERING

21 February 2017

Mr Russell Dale
Manager, Forest Growers Research Ltd
P.O. Box 1127
Rotorua 3040

Dear Sir

Mural Town Engineering Ltd (MTEL) is a New Zealand company that designs, manufactures, services and sells equipment to the forestry industry worldwide. Our products include a full range of attachments such as lightweight heavy duty grapples, saw boxes, rotators, forestry booms, and levelling platforms including the innovative All Terrain Platform. Our philosophy is to create equipment that is not only unique in the way that it works in the field but is also very reliable so that it never lets you down. Our extensive hands-on experience in the forestry environment, combined with the exceptional skills of our personnel, ensures that our equipment will always perform successfully while operating in the field.

Mural Town Engineering Ltd (MTEL) has had preliminary discussions with Forest Growers Research Ltd regarding the proposed PGP programme "Automated Forestry Value Chains" to develop in-forest debarking, automated log sorting, and residue management system. We are very interested in participating in this proposed PGP programme.

We are particularly interested in participating in the development of the robotic tree-to-tree thinning machine and the automated wood residue management system.

The Robotic tree-to-tree thinning machine is a very complex project to bring it practical implementation and uptake by harvesting contractors. We do however recognise the benefits of this system but it will require a total rebuild of the initial prototype, something we are unsure could be done without significant funding from PGP.

We are also involved in the early development of a new concept for a wood residue management system. Our company is developing a new technology to push this through to commercialisation where others cannot succeed to the same level. We have invested, and will continue to invest, a significant amount of our own resources into this project. I understand that this investment qualifies as in-kind contribution as a co-investment in the proposed PGP programme. The problem we see with a product solution is that, while it will be a very quick and cost effective solution to the problem of accumulated forest residues, it will still be a net cost to the forest owner. As part of this programme, we will work to find innovative solutions to this problem.

On successful completion of this development programme we look to successfully commercialise the wood residue management system.

Yours sincerely

Don Rust

Director

Mural Town Engineering Ltd

Letter of Intent regarding collaboration on the PGP Programme "Forestry Work in the Modern Age"

The Parties

Mural Town Engineering Ltd

and

Forest Growers Research Ltd (FGR)

Project Description

This records the intention of both parties to work together to design, develop, manufacture and take to the market the following Product:

Automated log residue chipper attachment. Features of this system include: automatic comminution of solid wood residues by grinding/mulching/chipping to reduce the build-up of log residues arising from the log manufacturing process. The device is envisaged as an 'after-market' retrofit for all models of loader/grapple processor and does not require purchase of a new base machine. The log residue chipper attachment will feature auto stop once material has been comminuted and will have to be compatible with an automatic quick coupler to enable rapid switching between the loading grapple/grapple processor. This development may also be integrated with development of debarking of tree stems prior to log manufacturing so that a merchantable chip product can be produced.

The parties will work with participants of the PGP programme (which may include manufacturers of grapple processors such as Southstar Equipment Ltd, Waratah NZ Ltd, and Satco Ltd, and Doherty Engineered Attachments Ltd for the quick coupler development, various forest owners and forest management companies and harvesting contractors) to design and evaluate the Product. This will involve the following:

Activities

1. Business case for development (Work plan and budget formulation)
2. Literature search of existing technologies and regulations
3. Concept feasibility
4. Obtaining provisional patent (if appropriate)
5. Design parameters
6. Detailed design and simulation
7. Alpha prototype development
8. Field testing
9. Beta prototype development
10. Full patent protection (if appropriate)
11. Commercialisation (including field demonstration to the forest industry)

Indicative Contributions of the Parties

Assuming estimated design and development budget of:

- Approximately $265,000 for the first ('alpha') prototype of the Product; and
- a maximum of six subsequent ('beta') prototypes of the Product with an estimated development budget of approximately $200,000 each:

(i) **Resources from Mural Town Engineering Ltd:**
Commercialisation and technical support for the Product (including field demonstration to the forest industry) of approximately 0.25 FTE (as judged by MTEL to be provided as/when appropriate).

(ii) **Resources from the PGP programme:**
Direct costs of development (design, materials and build cost, development and testing) of the first ('alpha') prototype of approximately $265,000 plus estimated direct development costs (materials and build cost) of 'beta' prototypes (to a maximum of 6 units) of approximately $200,000 per unit.

Intellectual Property Management

The parties will work together to achieve the MPI requirements regarding Intellectual Property (IP) management, specifically that:

1. Where Mural Town Engineering Ltd is engaged to perform part of the Programme and brings Existing IP to the Programme, the Existing IP shall be clearly defined and set out in an agreement and FGR shall negotiate terms and conditions with Mural Town Engineering Ltd for the use of the Existing IP.
2. New IP arising from the programme investment is defined broadly and includes any new designs, drawings, algorithms and inventions, arising after programme commencement, through meeting the milestones and delivering the objectives of the programme.
3. New IP will be owned by FGR and FGR will invest in protecting the new IP.
4. FGR holds the new IP exclusively for 5 years following the start of commercialisation, and will use its best endeavours to commercialise the IP. FGR will licence the New IP to Mural Town Engineering Ltd on an exclusive basis (to manufacture and market on behalf of FGR) until the exclusive period finishes. After this point the IP licence will be converted to a non-exclusive licence for New Zealand.
5. After 5 years following the start of the commercialisation MPI will have the right to promote the IP and FGR must assist MPI, and FGR must seek to licence to third parties the New IP non-exclusively in New Zealand.

Process for formalising agreement between the Parties

Consequent to the development of a business case for investment by each party and approval of such by the Boards of both parties, Mural Town Engineering Ltd will sign an agreement with FGR to design, develop, manufacture, evaluate and sell the Product.

In entering this contract the parties expect:

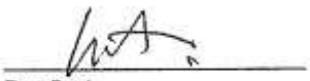
(i) **FGR to undertake the following:**

- Coordinate and lead PGP programme, facilitate development of innovative solutions, and, in conjunction with Mural Town Engineering Ltd, field test and evaluate products.
- Provide support to the Product Development team leader at Mural Town Engineering Ltd, coordination with forestry company/contractor(s) to trial and evaluate the Product, and organise field demonstration of the Product to the forest industry.
- Source cash resources for design, materials and build cost of one Alpha prototype of approximately $265,000 (co-funded by FGR, MPI and the first purchaser of the Product).
- Source cash resources for materials and build cost of up to 6 Beta prototypes of approximately $200,000 per unit (co-funded by FGR, MPI and the first purchasers of these Products).

(ii) Mural Town Engineering Ltd to undertake the following:

- Provide a staff member in the role of Product Development Team Leader
- Design, manufacture and workshop test the Product
- Install on first purchasers' base machines, and commission the Product on each base machine
- Provide after-sales product support, marketing expertise, networks, channels to market etc. (approx. 0.25 FTE)
- In conjunction with FGR, field test and evaluate products, and demonstrate to industry
- Record accurately and report any in-kind contributions to FGR every 3 months during the development project
- Actively market and sell the Product in New Zealand

Signed as a non-binding letter of intent:



Don Rust
General Manager
Mural Town Engineering Ltd

20 August 2018
Date

and

Russell Dale
Chief Executive
Forest Growers Research Ltd

21 August 2018
Date

9th January 2018

Mr Russell Dale
Manager, Forest Growers Research Ltd
P.O. Box 1127
Rotorua 3040

Pocket Solutions Ltd
71-73 Port Road
P O Box 44-070
Lower Hutt
New Zealand
Ph:+64 4 920 6580
Fx:+64 4 5696 452

Dear Sir

Pocket Solutions Ltd is a New Zealand-based technology development company that is a leader in developing streamlined information systems through the innovative application of mobile technology for all businesses throughout New Zealand and overseas.

Pocket Solutions provides a wide range of services including:

- Software design and development
- System integration
- Hardware supply/procurement and servicing
- Wireless WiFi Infrastructure design and installation
- Supply of custom barcode labels and RFID tags
- Supply of RFID scanners and portals
- RFID software processes as required
- System hosting

Pocket Solutions Ltd has had discussions with Forest Growers Research Ltd regarding the proposed PGP programme "Automated Forestry Value Chains" to develop in-forest log processing and sort yard technologies.

We are very interested in participating in this proposed PGP programme and we are a potential commercial partner in the further development of log tagging and tag reading technologies. These technologies will be designed to enable individual log identification (LogID) and recording of key product information for log customers such as source, time of manufacture, supplier(s), log grade and length, SED, LED, cubic volume, JAS volume etc. This will provide traceability of log products and enable replacement of current log weighing and manual export log scaling processes, and improve the value of log products to wood processing customers.

Pocket Solutions Ltd has expressed interest in participating in this PGP programme to support company growth through further development of our range of mobile technology. On successful completion of this development programme we look to commercialise the LogID system and support uptake of this new technology across the New Zealand forest industry.

Yours sincerely

Stuart Oehlrich

Director
Pocket Solutions Limited

Letter of Intent regarding collaboration on the PGP Programme "Forestry Work in the Modern Age"

The Parties

Pocket Solutions Ltd

and

Forest Growers Research Ltd (FGR)

Project Description

This records the intention of both parties to work together to design, develop, manufacture and take to the market the following Product:

Automated log tagging and tag reading system. Features of this system include: design of log tag solution to hold or reference all required log information, automatic attachment of log tags to logs using a grapple processor, design and development of tag reading technology to maximise readability of tags in operational harvesting conditions. This development will have to be integrated with development of a grapple processor to enable log tagging during the log manufacturing process.

The parties will work with participants of the PGP programme (which may include manufacturers of grapple processors such as Southstar Equipment Ltd, Waratah, Satco Ltd or Engineering Services Rotorua Ltd, GS1, various forest owners and forest management companies and harvesting and log transport contractors) to design and evaluate the Product. This will involve the following:

Activities

1. Business case for development (Work plan and budget formulation)
2. Literature search of existing technologies and regulations
3. Concept feasibility
4. Obtaining provisional patent (if appropriate)
5. Design parameters
6. Detailed design and simulation
7. Alpha prototype development
8. Field testing
9. Beta prototype development
10. Full patent protection (if appropriate)
11. Commercialisation (including field demonstration to the forest industry)

Indicative Contributions of the Parties

Assuming estimated development budget of:

- Approximately $765,000 for the first ('alpha') prototype of the Product; and
- a maximum of six subsequent ('beta') prototypes of the Product with an estimated development budget of approximately $120,000 each:

(i) **Resources from Pocket Solutions Ltd:**
In-kind contribution of time and resources for design, development and testing of the Product to the value of approximately $330,000 in total, including technical support of the Product.

(ii) **Resources from the PGP programme:**
Direct costs of development (materials and build cost) of the first ('alpha') prototype of approximately $435,000 plus estimated development costs (materials and build cost) of 'beta' prototypes (to a maximum of 6 units) of approximately $120,000 per unit.

Intellectual Property Management

The parties will work together to achieve the MPI requirements regarding Intellectual Property (IP) management, specifically that:

1. Where Pocket Solutions Ltd is engaged to perform part of the Programme and brings Existing IP to the Programme, the Existing IP shall be clearly defined and set out in an agreement and FGR shall negotiate terms and conditions with Pocket Solutions Ltd for the use of the Existing IP.
2. New IP arising from the programme investment is defined broadly and includes any new designs, drawings, algorithms and inventions, arising after programme commencement, through meeting the milestones and delivering the objectives of the programme.
3. New IP will be owned by FGR and FGR will invest in protecting the new IP.
4. FGR holds the new IP exclusively for 5 years following the start of commercialisation, and will use its best endeavours to commercialise the IP. FGR will licence the New IP to Pocket Solutions Ltd on an exclusive basis (to manufacture and market on behalf of FGR) until the exclusive period finishes. After this point the IP licence will be converted to a non-exclusive licence for New Zealand.
5. After 5 years following the start of the commercialisation MPI will have the right to promote the IP and FGR must assist MPI, and FGR must seek to licence to third parties the New IP non-exclusively in New Zealand.
6. Any subsequent licence by FGR to third parties must be on reasonable commercial terms, and Pocket Solutions Ltd will share in the licensing fees with FGR on terms to be agreed.
7. Pocket Solutions Ltd owns all IP developed subsequent to conclusion of any product development contract with FGR. Any IP developed by Pocket Solutions Ltd subsequent to the development contract could only be included in a license by FGR to other third parties on the agreement of Pocket Solutions Ltd.

Process for formalising agreement between the Parties

Consequent to the development of a business case for investment by each party and approval of such by the Boards of both parties, Pocket Solutions Ltd will sign an agreement with FGR to design, develop, manufacture, evaluate and sell the Product.

In entering this contract the parties expect:

(i) **FGR to undertake the following:**

- Coordinate and lead PGP programme, facilitate development of innovative solutions, field test and evaluate products, and demonstrate to industry
- Provide support to the Product Development team leader at Pocket Solutions Ltd, coordination with forestry company/contractor(s) to trial and evaluate the Product, and organise field demonstration of the Product to the forest industry.
- Source cash resources for materials and build of one Alpha prototype of approximately $435,000 (co-funded by FGR, MPI and the first purchaser of the Product).
- Source cash resources for materials and build cost of up to 6 Beta prototypes of approximately $120,000 per unit (co-funded by FGR, MPI and the first purchasers of these Products).

(ii) **Pocket Solutions Ltd to undertake the following:**

- Provide a staff member in the role of Product Development Team Leader
- Contribute in-kind resources of approximately $330,000 in total (design time, development, testing and after-sales product support)
- Design the Product
- Build, workshop test, install on first purchasers' grapple processors, and commission the Product on each grapple processor
- Record accurately and report all in-kind contributions to FGR every 3 months during the development project
- Actively market and sell the product in New Zealand

Signed as a non-binding letter of intent:

Stuart Oehlrich
Director
Pocket Solutions Ltd

4th September 2018
Date

and

Russell Dale
Chief Executive
Forest Growers Research Ltd

5th September 2018
Date

Letter of Intent regarding collaboration on the PGP Programme "Forestry Work in the Modern Age"

The Parties

Engineering Services Rotorua Limited

and

Forest Growers Research Ltd (FGR)

Project Description

This document records the intention of both parties to work together to design, develop, manufacture and take to the market the following Product:

Large capacity loading grapple. Features of this Product include: design and development of a log grapple suitable for loading trucks and trailers with multiple mixed length and mixed grade logs. The log grapple will have a large loading capacity to enable loading a truck or trailer in as few grabs as possible. The log grapple development will have to be compatible with an automatic quick coupler to enable rapid switching between the log grapple and a grapple processor attachment to reduce truck loading delays.

The parties will work with participants of the PGP programme (which may include manufacturers of other grapple processors such as Southstar Equipment Ltd, Waratah NZ Ltd, Satco Ltd, and Doherty Engineered Attachments Ltd for the quick coupler development, various forest owners and forest management companies and harvesting and log transport contractors) to design and evaluate the Product. This will involve the following:

Activities

1. Business case for development (Work plan and budget formulation)
2. Literature search of existing technologies and regulations
3. Concept feasibility
4. Obtaining provisional patent (if appropriate)
5. Design parameters
6. Detailed design and simulation
7. Alpha prototype development
8. Field testing
9. Beta prototype development
10. Full patent protection (if appropriate)
11. Commercialisation (including field demonstration to the forest industry)

Indicative Contributions of the Parties

Assuming estimated development budget of:

- Approximately $140,000 for the first ('alpha') prototype of the Product; and
- a maximum of six subsequent ('beta') prototypes of the Product with an estimated development budget of approximately $70,000 each:

(i) **Resources from Engineering Services Rotorua Limited:**
In-kind contribution of time and resources for design, development and testing of the Product to the value of approximately 0.25 full-time equivalent (FTE) design engineer

(approximately $45,000) plus technical support of the Product to the value of approximately 0.25 FTE (approximately $45,000).

(ii) **Resources from the PGP programme:**
Direct costs of development (materials and build cost) of the first ('alpha') prototype of approximately $95,000 plus estimated development costs (materials and build cost) of 'beta' prototypes (to a maximum of 6 units) of approximately $70,000 per unit.

Intellectual Property Management

The parties will work together to achieve the MPI requirements regarding Intellectual Property (IP) management, specifically that:

1. Where Engineering Services Rotorua Limited is engaged to perform part of the Programme and brings Existing IP to the Programme, the Existing IP shall be clearly defined and set out in an agreement and FGR shall negotiate terms and conditions with Engineering Services Rotorua Limited for the use of the Existing IP.
2. New IP arising from the programme investment is defined broadly and includes any new designs, drawings, algorithms and inventions, arising after programme commencement, through meeting the milestones and delivering the objectives of the programme.
3. New IP will be owned by FGR and FGR will invest in protecting the new IP.
4. FGR holds the new IP exclusively for 5 years following the start of commercialisation, and will use its best endeavours to commercialise the IP. FGR will licence the New IP to Engineering Services Rotorua Limited on an exclusive basis (to manufacture and market on behalf of FGR) until the exclusive period finishes. After this point the IP licence will be converted to a non-exclusive licence for New Zealand.
5. After 5 years following the start of the commercialisation MPI will have the right to promote the IP and FGR must assist MPI, and FGR must seek to licence to third parties the New IP non-exclusively in New Zealand.
6. Any subsequent licence by FGR to third parties must be on reasonable commercial terms, and Engineering Services Rotorua Limited will share in the licensing fees with FGR on terms to be agreed.
7. Engineering Services Rotorua Limited owns all IP developed subsequent to conclusion of any product development contract with FGR. Any IP developed by Engineering Services Rotorua Limited subsequent to the development contract could only be included in a license by FGR to other third parties on the agreement of Engineering Services Rotorua Limited.

Process for formalising agreement between the Parties

Consequent to the development of a business case for investment by each party and approval of such by the Boards of both parties, Engineering Services Rotorua Limited will sign an agreement with FGR to design, develop, manufacture, evaluate and sell the Product.

In entering this contract the parties expect:

(i) **FGR to undertake the following:**
- Coordinate and lead PGP programme, facilitate development of innovative solutions, field test and evaluate products, and demonstrate to industry
- Provide support to the Product Development Team Leader at Engineering Services Rotorua Limited, coordination with forestry company/contractor(s) to trial and evaluate the Product, and organise field demonstration of the Product to the forest industry.
- Source cash resources for materials and build of one Alpha prototype of approximately $95,000 (co-funded by FGR, MPI and the first purchaser of the Product).

- Source cash resources for materials and build cost of up to 6 Beta prototypes of approximately $70,000 per unit (co-funded by FGR, MPI and the first purchasers of these Products).

(ii) **Engineering Services Rotorua Limited to undertake the following:**

- Provide a staff member in the role of Product Development Team Leader
- Contribute in-kind resources (approx. 0.25 FTE) for design time, manufacturing facilities and expertise
- Design the Product
- Manufacture, workshop test, install on first purchasers' loaders, and commission the Product on each loader
- Contribute in-kind resources (approx. 0.25 FTE marketing expertise, networks, channels to market, after-sales product support)
- Record accurately and report all in-kind contributions to FGR every 3 months during the development project
- Actively market and sell the Product in New Zealand

Signed as a non-binding letter of intent:

David Cox — 7-9-2018
Date

David Cox
Managing Director
Engineering Services Rotorua Limited

and

12/9/18
Date

Russell Dale
Chief Executive
Forest Growers Research Ltd

APPLIED TELEOPERATION LTD

paul@appliedteleoperation.co.nz
www.appliedteleoperation.co.nz
021 210 3350
17 Windsor Street
Rotorua 3015
New Zealand

29 June 2017

Mr Russell Dale
Manager, Forest Growers Research Ltd
P.O. Box 1127
Rotorua 3040

Dear Sir,

Applied Teleoperation Limited has had preliminary discussions with Forest Growers Research Limited regarding the proposed PGP programme "Automated Forestry Value Chains" and we are very interested in participating in this programme.

We are particularly interested in participating in the development of the semi-autonomous hauler control system and any other areas where teleoperation or vision systems may be applied.

Although Applied Teleoperation Limited is a newly formed company, we believe our expertise in control systems, teleoperation and vision systems will enable us to successfully develop a safe and productive semi-autonomous control system for grapple yarding. Moreover, we believe this type of product will fit well with our existing business of vision systems and teleoperation systems. Therefore, we believe that, once development has been completed, Applied Teleoperation Limited will be in a good position to take the resulting product or products to market.

Yours sincerely

P Milliken

Paul Milliken
(Director of Applied Teleoperation Limited)

AWDON TECHNOLOGIES

46Lloyd George Road, Gisborne, 4010, New Zealand
Ph +64 6 8675498 Fax +64 6 867 5816
Mobile: 0274466440
Website: www.awdon.co.nz

20-2-17

Mr Russell Dale
Manager, Forest Growers Research Ltd
P.O. Box 1127
Rotorua 3040

Dear Sir
Awdon Technologies is a forestry technology company specialising in mechatronic solutions development and delivery. These technologies include;

1. Ruggedised Handheld Computers – Interpine Forestry
2. ICO Stem Optimisation - Forestry Corporation
3. Remote Electronic Logstocks – Forestry Corporation
4. Timbertech Handheld Stem Optimisation - IFR
5. Optimiser Carriage and Software – Forestry Tasmania
6. Buckmaker Stem Processing – Pan Pac
7. Full Stem Optimisation Plant - Wenita Forestry
8. 3PY Stem Processing – Pan Pac

Currently Awdon is building a 3400m3 daily output, log merchandiser for Hikurangi Forest Farms in Gisborne.

Awdon has had preliminary discussions with Forest Growers Research Ltd regarding the proposed PGP programme "Automated Forestry Value Chains" to develop in-forest debarking, automated log sorting, and HPMV log transport operations. Awdon is very interested in participating in this proposed PGP programme.

Awdon wants to participate in the development and commercialisation of technologies as outlined in the programme as it is obvious to Awdon management there are inefficiencies along the value chain that desperately need improving.

Awdon understands the benefits of in-forest debarking, automated log sorting, and HPMV log transport operations and recognises these will help catalyse multiple further improvements.
As important, safety risk and environmental performance in the industry need a step change solution. This will integrate with the proposed solutions.

The sorting facility is a good fit with Awdon expertise and on successful completion of this project Awdon will be determined to commercialise the technology. This technology will also be useful overseas, particularly in Chile.

In terms of co-funding Awdon would provide an agreed amount of design time.

Don Scott has a proven track record of completing mechatronic development commercialisation with multiple successful projects.

Yours sincerely

Don Scott
Managing Director
Awdon Technologies

LINCOLN AGRITECH LTD

20 November 2017

Mr Russell Dale
Manager, Forest Growers Research Ltd
P.O. Box 1127
Rotorua 3040

Dear Sir

Lincoln Agritech Ltd is a New Zealand-based technology development company that is a leader in developing sensing and scanning technologies for the New Zealand agricultural and other sectors and for international sales.

The Table below lists some example activities and outcomes that are relevant to the proposed PGP Programme.

Activity	Track Record
Vision systems using electromagnetic waves that penetrate biomass and materials with low permittivity.	Grape Yield Analyser- able to measure bunches of grapes behind foliage & vines.
	Snow Depth Analyser- able to measure depth of snow above an ice sheet.
Cutting-edge microwave sensing technologies that provide high resolution images at deep penetration depth.	Bessel beam- able to measure condition score (thickness of fat layer) on the flank of a lamb thorough wool, skin etc. So - high resolution measurement at deep penetration depths.
	Microwave lens technique – able to measure material properties (e.g. of an apple) at 10mmx10mmx10mm cube spatial resolution, > 50mm from the surface.
Measurement of material properties using Time Domain Reflectometry (TDR) & Time Domain Reflectometry Imaging (TDRi)	Aquaflex- Developed by Lincoln Agritech and a leading soil moisture measuring product for ~ 20 years.
	TDRi – analysis of defects in sawn logs by making images of the TDR response across the surface. This technique has also been used to detect hign moisture content areas in the subsurface of roads

The first 2 examples (Vision systems) generally use mature science and demonstrate our ability to apply it to real world problems. The next 2 examples (Cutting-edge microwave sensing technologies) are at the research frontier of electromagnetic sensing and aim to overcome a current limitation where it is not possible to have deep penetration depth and high spatial resolution. The Aquaflex product is an example of a product that has been commercialised and is still a market leader after 20 years. Finally, the TDRi projects are natural extensions of the TDR technology but where the transmission lines can be placed adjacent to the object being measured (as opposed to within it) and thereby provide additional, useful information.

Over the past two months Lincoln Agritech Ltd has had discussions with Forest Growers Research Ltd regarding the proposed PGP programme "Automated Forestry Value Chains" to develop improved log extraction, log processing technologies.

We are very interested in participating in this proposed PGP programme and we are a potential research and development partner in the further development of a 'smart' yarder grapple and hauler control system using new

sensing and scanning technologies. This technology will be designed to enable improved tree stem identification which could potentially be integrated with an improved hauler control system for automated grapple yarder extraction.

Lincoln Agritech Ltd has expressed interest in participating in this programme to support company growth through further development of sensing and scanning technologies in the primary sector. On successful completion of this development programme we look to collaborate with the commercial partner in this project and assist them to commercialise this technology and support uptake of this new technology across the New Zealand forest industry.

Yours sincerely

Dr Clive Marsh
Principal Scientist
LINCOLN AGRITECH LTD