Meeting notes

Workshop on robotic forestry systems

(Park Royal, Melbourne Airport, December 4th, 2017)

The workshop was convened by Forest and Wood Products Australia Limited (FWPA) to discuss the current state of robotic systems in the forest sector and identify what activities, if any, should be undertaken in Australia (and possibly collaboratively with NZ).

A list of attendees at the workshop is shown in appendix 1.

Prior to the workshop, Professor Rien Visser from the School of Forestry, University of Canterbury, was commissioned to undertake an international scan of the current state of robotic systems in the forestry sector. Professor Visser's report was circulated to participants prior to the workshop and a copy is available here.

To help stimulate discussion and scene setting, two presentations given to the workshop:

- Dickson Leow, Principal Technology Leader, Australian and NZ Driverless Vehicle Initiative (ADVI) – click here to view Dickson's presentation
- Professor Rien Visser, School of Forestry, University of Canterbury – click here to view Rien's presentation

Both presentations were very well received by the participants and generated a large amount of questions.

Participant's were then requested to write down what questions were in their mind about the role and possible introduction of robotic systems into the Australian and NZ forest sectors. A full list of participant questions grouped in various categories is shown in Appendix 2

Following lunch, the participants were asked to work in small groups to address two questions:

- Should the Australian forest sector invest in research and extension related to robotic forestry systems?
- If so, what should be the focus of investment?

Across the four subgroups, there was a very high level of agreement about the need to invest in research related robotic systems, but unsurprisingly, there was a wide range of

views about the priorities and level of investment required – subgroup reports are shown in appendix 3.

Overall, the groups agreed that investment in automation will deliver value through labour cost savings and improved safety, and will help address the potential skills shortage. There is also a view that the investment would help the sector to be viewed as innovative and technologically sophisticated. One group summarised the benefits into the following three categories:

- **Social** - the industry has an ageing workforce and it will be important to introduce new technologies that attract a new generation of workers.
- **OH&S** - there were 987 injured in harvesting operations in NZ over the last 5 years. The sooner we get people out of the way of trees and equipment the better.
- **Environmental** – potential for reduced compaction and ability to spot koalas etc using image sensing

Given the complexity of the topic area, the groups identified a number of pathways or focal areas for the Australian (and NZ) sector. There was a general view that any move forward in this space should include the equipment manufacturers and not to start from scratch – work with other researchers and players to leverage in forestry specific elements, including international activities.

It was generally agreed that the sector should focus on its own areas of specialised interest as silviculture (e.g., planting, pruning) and harvesting operations, especially in log forwarding. One group presented this as the following priority matrix:

	Near term	Longer term
External to sector	Transport → Planting → Remote sensing →	
Internal to sector	Silviculture →	Harvesting → forwarding →

It was generally agreed that any research investment would require further consultation with the broader industry and the challenge to get decision makers to think beyond the current day operational issues.

It was suggested that an industry paper that sets the vision for the industry in what robotic technology can deliver is needed to generate excitement in and around the industry. There is opportunity to get some quick wins (i.e., low hanging fruit) to build confidence and goodwill and generate further investment.

One group suggested a bimodal approach to implementation

- **Mode 1**: Advance with "low hanging fruit" in order to demonstrate what is possible and get the industry thinking about the potential. For example, autonomous forwarding could be a reality within the next 12-18 months.
- **Mode 2**: Start to invest in the research necessary to break through impediments to the longer term goal of autonomous harvesting. For example, visualisation of trees (either in real time, or from point cloud data) will be critical and this research should be prioritised.

With respect to Mode 1, the group also recognised that the early movers will probably make a loss because the autonomous equipment is not as productive as existing systems. Therefore, there might be a case for the broader industry contributing to operational trials or appropriate business model(s) for deploying new capital intensive new technology.

CONCLUSION AND NEXT STEPS:

There is a general view by participants that the development and deployment of robotic forestry systems is inevitable but there has been insufficient discussion within the broader sector about the implications and the pathway to adoption. However, there was strong agreement that any activity in the space should be collaborative, and include equipment vendors and international players.

FWPA, in conjunction with AFORA and NZ researchers, will aim to raise awareness of the opportunities of this technology and identify mechanisms to pilot the technology in limited circumstances.

In addition, the business case for more transformation research will be developed for consideration by potential investors.

Appendix 1 - List of attendees

Attendee	Organisation
Ricky Leeson	Leesons contracting
Liqiong Song	PF Olsen
Russell Dale	NZ Forest Growers Trust
Ian Hinton	Timberlands NZ
Jim O'Hehir	Forestry SA
Vilius Gendvilas	UTAS
John Comiskey	HQ Plantations
Rowan Eyre	Midway
Mark Wells	GTFP
Andrew Jacobs	Forico
Anne Partridge	HVP
Belinda Lengenberg	Hyne
Keith Lamb	Forico
Jodie Mason	FWPA
Mick Theobald	Onefortyone
Ayden Piri	Caterpillar
Richard Parker	Scion
Nick Roberts	Forestry Corp
Mike Sutton	Forestry Corp
Brenton Yon	Komatsu Forest
John Tredinnick	FPC
Martin Strandgard	USC
Christ Lafferty	FWPA
Ric Sinclair	FWPA

Apologies:

Mitch Bryson	University of Sydney
Nathan Trushell	Vicforests

Appendix 2 – Research questions identified by workshop participants

Collaboration and focus

How best to collaborate with other industries to ensure specific forestry needs are allowed for in automation?

What can the ANZ forest sector contribute to the R&D and implementation of the vision?

- When do we dip in?
- Concentrate effort?

What driverless vehicle technology or closer associated technology could be applied to existing log trucks to allow them to operate more safely now?

Do we have a model to copy in terms of collaborations amongst manufacturers?

How do we as an industry promote targeted research and development of 'best' options and priorities?

Nothing particularly unique to forestry – problems are at least known or describable – how to move forward?

What is the enabling technology required to move this forward into forest sector?

Social

Social impact if we replace workers with robots?

How to engage with workforce? Wharf operations have been successfully automated but train systems/networks have not – why?

Having driverless trucks is great, but how do we resolve the issue of other road users in a private forest, both invited and uninvited?

How can we have robots in the forest and still maintain jobs for the displaced workers (who don't want to be robot technicians)?

What level of social acceptance is there for autonomous forestry machines in rural Australia?

What is the social benefit and cost of removing people form boring/hazardous work by replacement with automation?

Communication technology/infrastructure

What communication platforms/standards are required for cloud processing and what is the current coverage of this standard in Australia?

To what degree will 3D perception tasks in harvesting operation depend on real-time cloud-based computing resources in the 'outside world'? What are the implications for operations with low communications infrastructure?

What is the pathway to improving communications black spots throughout Australia? Is this a cross-industry initiative?

Technology requires in-forest communication infrastructure – how do we extend this infrastructure to remote locations or are there other alternatives?

Equipment manufacturers/economics?

Is there one company prepared to trial an autonomous forwarder (ie accept lower productivity higher cost for a period of time)? Would an equipment manufacturer assist in this trial?

What equipment manufacturer is developing remote control as an option for their harvester/forwarder?

The value proposition for machinery manufacturers in 'automating forestry' and how does it compare relative to other industries?

How can we fast track the development of technologies to visualise trees in the forest and make decisions?

Specific applications of technology

Wood quality testing using autonomous machines – making decisions in processing on forest site based on wood quality, by setting sensors on harvesting head?

Robotic applications in testing wood quality in laboratory environment – any latest developments in that area?

Is it possible to use the harvesters, drones or other machines to collect accurate field information and automate map production?

Are there real life examples of autonomous vehicles in log yards (e.g. unloading trucks, logs to log yard, logs to log deck)?

Technology

What are the other "low hanging fruit" in the area of automating forest machine activities?

What is the potential to create an automated (operator controlled) planting device avoiding multiple passes across the cut over?

What is the difference Internet of Things and Robots?

Autonomous tree felling – how can the computer anticipate directional falling considering tree size, shape of crown, branching, etc?

Steep slope harvesting with autonomous machines – how would the computer deal with loss of traction?

What are the potential gains to other aspects of forestry operations (outside of harvesting) by using sophisticated real-time sensing of trees during harvesting?

Can we fly a drone under canopy to undertake pre-harvest surveys in hardwood forests?

How do we bridge the gap in productivity between operator and robot?

How to accelerate automation of forwarder tasks? What are the phases and who are the partners?

A productivity drop of 40% is unacceptable but to do nothing is equally unacceptable. What is the basis of the 40% drop and how can it be resolved?

The plantation may be sold and managed by different companies and different companies have different data formats, standards – is it possible to have a centralised data centre to share all the plantation information (e.g., forestry open data platform)?

To use the cloud, we need strong data communication capability and much of NZ/Aust forest is in remote areas with poor data capability. How and who is working on this? Also the need for back up systems if one were to fail?

How does this technology improve outcomes in relation to forest optimisation (right product to the right customer)?

What developments are needed to develop assisted (not autonomous) planting systems?

Can we use higher level GIS systems and spatial info to aid automation in forestry? What are the current constraints?

What other technologies should/could be used to speed up the required artificial intelligence? Can data for learning be gathered? If so, what does that look like?

Can visual recognition systems identify form (sweep, branching) to augment harvest operator decision making?

Could small autonomous drones be used to map the area ahead of an autonomous harvester to improve its recognition of trees and planning its progress through the stand?

How will cloud-based AI systems work in communication/connectivity constrained forest environments?

Could the layout of a plantation (row/tree spacing, etc) be modified to improve autonomous machine operation without compromising other objectives?

How to improve tree selection when thinning to maximise occupancy and quality metrics?

What can we learn from existing visualisation processes (eg, in agriculture)? What are the R&D needs for this?

How can we fast track the development of technologies to visualise trees in the forest and make decisions?

Can AI assist quality decisions in cut-to-length (eg, branch size, wobble, sweep)?

Can we use satellite based remote sensors to determine stand nutrient status (N,P,K, Boron) in radiata plantations?

Approx 2 hours to retrofit a current machine to remote control but how much $$$?

What is the next stage to develop visual recognition of koalas in trees (plantations and native forests)?

How do we map out a “critical path” to go to autonomy?

What are the actual challenges associated with 3D real time perception for tree selection in autonomous harvesting operations? What makes this different to related applications and is this 20 years away?

Terrain management – autonomous harvesting – dealing with constant changes in ground conditions (ie, following heavy rain)?

Ground condition assessment/environmental issues such as rare flora/fauna – is the technology feasible with remotely operated machines or will operators be required to assess as per usual?

Boom tip control – is this still operation within safety confines of machines? Some machines (harvesters) will have restricted movement whilst boom is operating

Capacity and Skills

What needs to be done to ensure access to forest related R&D capacity in this space?

How to identify and work with technology and engineering companies to drive forest sector change?

As a global industry what are the opportunities to effectively collaborate between companies, countries and researchers?

How to build sufficient capacity?

Where will the skills come from?

What should be done now to recruit skills and capacity?

Issues

Could the technology be delivered by lots of small cheap robots vs a small number of expensive ones?

Where and how to establish trials?

How to deal with equipment breakdowns?

Use of augmented reality to train operators?

Loss of productivity in unattended machines – with increasing scale and volume demands of large mills. Does this mean more machines required to maintain overall productivity and at what cost?

Engagement with governments to make sure the legislative and regulatory changes required can be supported by adopting this technology?

Any stats on logging injury rates?

How would the industry be perceived by the community?

Funding models – how much and who pays

Contractors risk averse – what are the rewards or offsets for early adopters/pilots?

Can we use private funding and recover costs from future sales?

Is there a role for public or collective funding?

Relatively small demand for these forest specific systems compared to commercial and personal transportation – impact on costs per unit model

Appendix 3 – Subgroup summaries

Group 1 (spokesperson Keith Lamb)

The FWPA Risser report was recognised as a good summary of the current status and prospects for autonomous technology and robotics in and around the forestry and agricultural sector. While there was strong overall support and enthusiasm for investing into this new area, it is challenging to form a judgement as to when and how to engage. The discussion focussed on where the sector should position itself – bleeding edge, early adopter or follower? The case for being seen as an innovative and technologically sophisticated sector was balance against the notion that robotics and autonomous technology will continue to be developed (evolve into new applications) whether the sector invests or not, so why not wait and adopt the technology off-the shelf rather than commit scarce R&D funds into uncertain applications?

This in turn lead to the following key points:

1. The charter of FWPA or AFORA should be expanded to include a scanning role to keep the sector appraised of developments in other sectors and the potential application for forestry
2. The sector needed to consider what the appropriate business model(s) would be for (developing and) operationalising what is likely to be capital intensive new technology
3. The group concluded that if the sector was to invest into forestry applications, it should be as some sort of consortium with other R&D providers/forestry countries, and should focus more on internal applications that are unique to forestry, and/or could be more easily solved. For example, it made more sense to focus forestry R&D funding on silvicultural applications (pruning and thinning), compared to transport which has a wider cross-sectoral approach (see figure below). Harvesting and forwarding is a key internal area of interest, but would likely benefit from adoption of applications from other sectors such as spatial orientation, lifting and loading in a relatively uncontrolled forest environment.

	Near term	Longer term
External	Transport →	
	Planting →	
	Remote sensing →	
Internal		Harvesting →
		forwarding →
	Silviculture →	

Group 2 (Spokesperson: John Tredinnick)

Question 1:

- The group believed that it was urgent to begin the work towards autonomous harvesting. The journey towards this goal is likely to provide efficiencies. For example semi-autonomous harvesting where the operator is assisted by digital technology that identifies crop/ habitat trees would still be a step forward.
- It is also "semi-urgent" from a social, OHS, and environmental perspective.
    - Social - the industry has an ageing workforce and it will be important to introduce new technologies that attract a new generation of workers.
    - OH&S - there were 987 injured in harvesting operations in NZ over the last 5 years. The sooner we get people out of the way of trees and equipment the better.
    - Environmental – potential for reduced compaction and ability to spot koalas etc using image sensing

Question 2:

The group suggested a bimodal approach to implementation

- Mode 1: Advance with "low hanging fruit" in order to demonstrate what is possible and get the industry thinking about the potential. For example autonomous forwarding could be a reality within the next 12-18 months.
- Mode 2: Start to invest in the research necessary to break through impediments to the longer term goal of autonomous harvesting. For example, visualisation of trees (either in real time, or from point cloud data) will be critical and this research should be prioritised.

With respect to Mode 1, the group also recognised that the early movers will probably make a loss because the autonomous forwarders are not currently as productive as existing gear. Therefore, there might be a case for the broader industry contributing to operational trials.

It's a small industry and a collective approach will be necessary that involves companies (growers and equipment suppliers) to work together. It may also be important to work jointly across countries.

Group 3 (Spokesperson: Jodie Mason)

There is a generally agreed expectation that Investment in automation will deliver value through labour cost savings and improved safety. But analysis required on where to focus: e.g. Keith's matrix of whether to lead or follow in investment and uptake of automation technology (e.g. transport – follow; harvesting in the middle-ground).

Investing in automation will deliver incremental value along the way. e.g. mechanising planting is a step along the way to automating the planting process. There may be ways to overcome the need for visual recognition technology e.g. by spot cultivating in the same pass as, or close behind planting.

An industry paper that sets the vision for the industry in what robotic technology can deliver, is needed to generate excitement in and around the industry. There is opportunity to get some quick wins/ low hanging fruit to build confidence and goodwill and generate further investment. There is potential for the generation of public goodwill and increase new interest in working in the industry through publicising the industry's focus on the use of technology.

Group 4 (Spokesperson: Chris Lafferty)

Activity in this space was seen as critical – if they don't do something proactively now – current industry players are doomed.

Funding levels – at the moment labour adds $5 per cubic meter to harvest and haul costs so any savings in this area would be significant

Further exacerbated by current labour shortages and an ageing workforce particularly in the forestry space.

Any move forward in this space should include the OEM (equipment manufacturers) sector as well

On road transport systems (square boxes from mill to distribution centre) – will be delivered by other parts of the sector (Toll, Linfox etc) – need to have engagement with these developments but managed by others

Don't start from scratch, work with other researchers and players to leverage in forestry specific elements.

Important to identify and develop future skill sets in this space.

Any ideas to research further in this area would require further consultation with the broader industry. As a part off that consultation it would be important to get them to think beyond the current day operational issues. Look towards strategic needs and how they will ultimately impact their operational roles in the future.

Look at activities of international forestry groups as well as national logistics groups from other sectors.

Needs around automated extraction, in field loading and unloading as low hanging fruit, also issues around data communication needs, plus issues around roading design and layout. Bigger BHAG would be autonomous harvesting.

If sector chose to pursue a CRC – potential around 10c per cubic metre annual input from forest growers, plus contributions from OEM sector – would be enough to attract Commonwealth interest.