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EXECUTIVE SUMMARY

This report summarises the Steep Slope Logging Conference that was held in Vancouver, Canada on Wednesday 2 March 2016, detailing subjects of relevance to the New Zealand logging industry. The report covers presentations by:

- Dale Ewers from Falcon Forestry Equipment Ltd, whose largest selling innovation has been the Falcon Forestry Claw grapple carriage.
- Ryan Potter, from Tolko Industries in Alberta, who spoke about the breakthroughs made in their forest operations using the ClimbMAX steep slope harvester.
- Eric Krume of Krume Logging & Excavation Ltd and manufacturing company, Summit Attachments and Machinery Ltd. in Kelso, Washington
- Chris Hancock from EMS, who detailed the engineering approach they adopted in designing the Tractionline traction-assist system.
- Iain May, from Rosewarne and May Ltd, who presented their remote-operated bulldozer (ROB) development.
- Mathieu Lavoie, representing HSM Forestry Equipment, based in Quebec, Canada.
- Major forestry equipment manufacturers on technical views on steep slope harvesting mechanisation developments.

INTRODUCTION

The Steep Slope Logging Conference was held in Vancouver B.C. on 2nd March 2016. It was advertised as an opportunity to “meet the world's leading steep slope innovators from New Zealand and North America at a logging conference devoted to the latest in winch-assist harvesting” (Innovatek, 2016). The conference was attended by 250 people, which was the maximum number that the venue could accommodate.

The conference was followed by a field trip on 3 March to visit two cable-assisted logging operations. The first was a Remote Operated Bulldozer (ROB) attached to a Tigercat feller buncher. The second operation featured a ClimbMAX Steep Slope Harvester.

After the Conference, Paul Milliken visited FP Innovations on 4 March to discuss recent developments at FFR and FP Innovations.

This report presents a summary of the conference proceedings, and material that was presented at the Steep Slope Logging conference. A section identifying the most relevant points for New Zealand is also presented.

SUMMARY OF CONFERENCE PROCEEDINGS

1. The Falcon Forestry story: Recent Advances and Future Plans

Dale Ewers, owner of Moutere Logging Ltd, DC Equipment Ltd and Falcon Forestry Equipment Ltd, presented a history of his three companies. The main points of the presentation covered four recent developments from DC Equipment Ltd consisting of: a smaller and lighter Falcon Forestry Claw grapple; a prototype accumulating arm for the Falcon Forestry Claw grapple; the DC Equipment Ltd winch-assist machine; and designs for new haulers.

Falcon Forestry Claw Grapple

The new smaller model Falcon Forestry Claw is pictured next to the original version in Figure 1. A comparison between the specifications of the two models is shown in Table 1.

Table 1: Comparison of the specifications for the two models of Falcon Forestry Claw

Parameter	Model 2150	Model 1250
Weight (kg)	2150	1250
Maximum payload (tonnes)	6	8
Grapple opening (metres)	1.8	2.0
Closing force (tonnes)	27	27
Closing time (seconds)	3.5	3.5

The new smaller model Falcon Forestry Claw is pictured next to the original version in Figure 1.



Figure 1: The new Falcon Forestry Claw 1250 (right) and the original 2150 model (left)

A prototype accumulating arm for the Falcon Forestry Claw is also in development, and is shown in Figure 2.



Figure 2: Prototype accumulating arm for the Falcon Forestry Claw

Winch-Assist Machine

DC Equipment Ltd has been developing and building a single drum winch-assist machine. Its features include:

- Twin hydraulic drives for the drum
- Single 1 $\frac{1}{8}$ inch (28 mm) winch rope
- Rear facing camera viewing the winch drum
- Automatic alarm on cab access of the winch machine
- Rope spool out limited to five rope wraps on the drum
- Automatic over-speed arrest
- Machine movement alarm
- Tension monitoring.

New Hauler Designs

DC Equipment Ltd has designed two pole yarders and two swing yarders. Drawings of one of the swing yarders are shown in Figure 3.

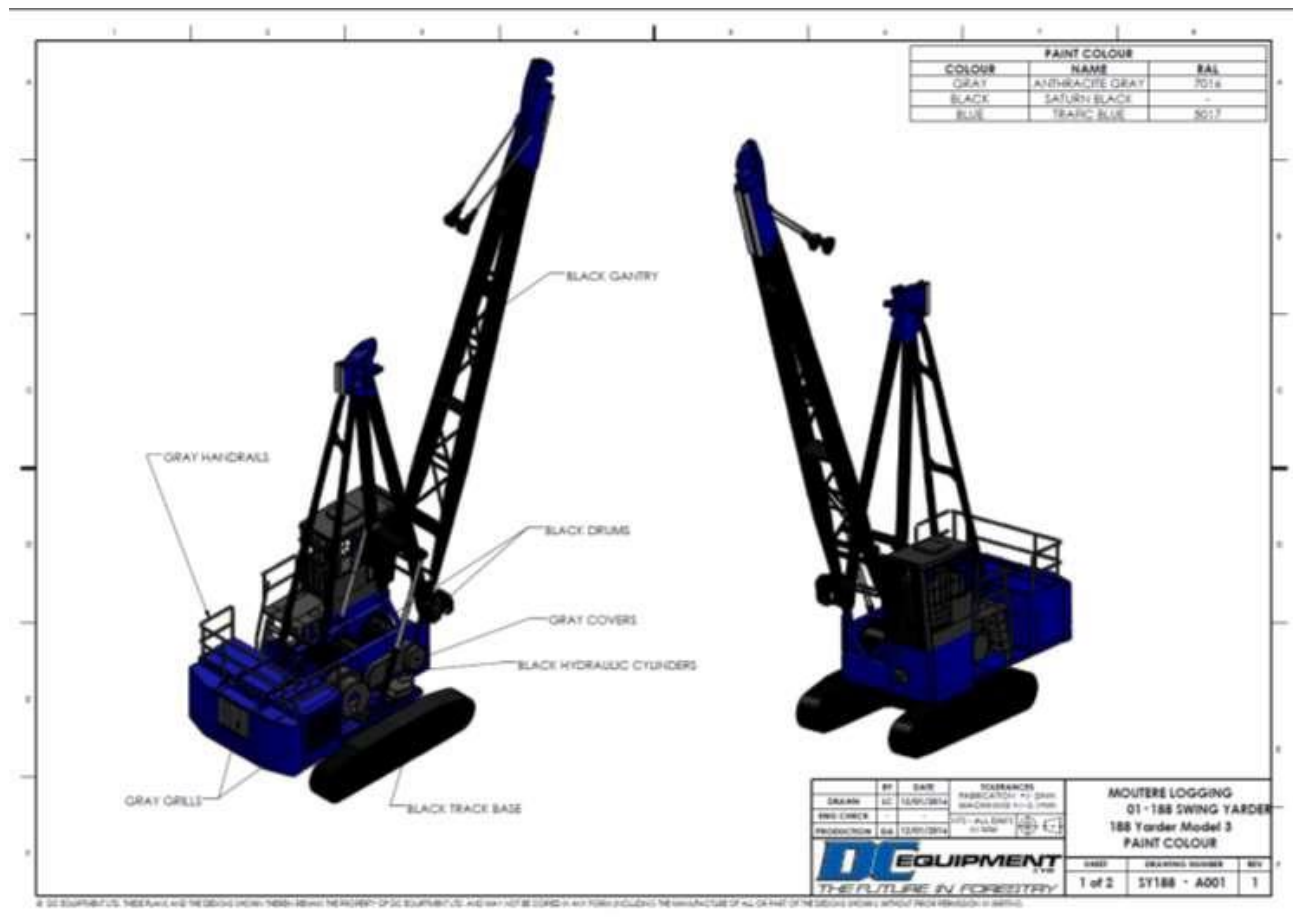


Figure 3: DC Equipment swing yarder design

For more information see DC Equipment's website: <http://dcequipment.co.nz/falcon-forestry-equipment-products.html>

2. The ClimbMAX Approach to Safe Steep Slope Harvesting

Ryan Potter works for Tolko Industries in Canada, a company which has been successfully using a ClimbMAX Steep Slope Harvester since September 2013 to replace manual falling on steep terrain. There are currently five ClimbMAX harvesters working around the world (three in New Zealand and two in Canada). Another four machines will be delivered to BC in 2016, and one more will be delivered to a customer in the US.

Tolko have operated the ClimbMAX harvester for 3600 hours with no incidents or near misses. The strengths of the ClimbMAX were described as:

- reducing the need for hand fallers
- elimination of yarding on some blocks
- improved grapple yarder productivity
- good stability and reach
- blade provides a back-up safety device
- one-machine operation
- good for medium/large trees.

Limitations of the ClimbMAX harvester were listed as:

- parts and service due to the distance between NZ and Canada
- performance on soft ground
- reduced efficiency with small piece size or rotten timber
- bedrock (due to low friction of track base)
- operator comfort on steep terrain.

For more information contact Paul Jensen at ClimbMAX Equipment Ltd, Phone +64 27 4943 644 or see the ClimbMAX website: <http://www.climbmax.co.nz/>



Figure 4: ClimbMAX Steep Slope Harvester

3. Building and Operating a Dual Purpose Steep Slope Machine

Based in Castle Rock, Washington, U.S.A., Eric Krume is the owner of Krume Logging & Excavation Ltd, and manufacturing company Summit Attachments and Machinery Ltd in Kelso, Washington. The first Summit steep slope winch-assist system had 400m of 1" rope (26mm) running off a 50-foot tower with a two-speed winch drum powered from a Kobelco SK350 hydraulic knuckleboom loader. The winch was operated from a wireless remote control with a wireless video of the landing operation.



Figure 5: Winch assist machine from Summit Equipment.

Summit Equipment sells a winch-assist system that can be fitted to a base machine such as a used feller buncher (Figure 5). It features a pivoting gantry which gives adequate fleeting distance for good cable spooling on the winch drum. Eric Krume presented an economic comparison between a winch-assisted feller buncher and manual fallers on steep terrain. The average unit cost to fell and bunch trees with a winch-assisted feller-buncher was \$200 per load, compared to an average felling cost of \$65 per load when using manual fallers. Despite the higher felling cost, Krume Logging experienced lower yarding costs overall when using the winch-assisted machine because bunching resulted in the yarder extracting 11 loads per day with bunched trees compared to 7 loads per day for manually felled trees.

For more information contact: Bruce Skurdahl or Eric Krume at Summit Attachment & Machinery Ltd, Phone: +1 503 806 9323, or email skurdahl6@frontier.com.

4. Development of the EMS tethered harvesting system

Tractionline is the latest innovation from Electrical & Machinery Services Ltd (E.M.S.) based in Rotorua. Chris Hancock of E.M.S. presented a description of the EMS Tractionline winch-assist system (Figure 6).

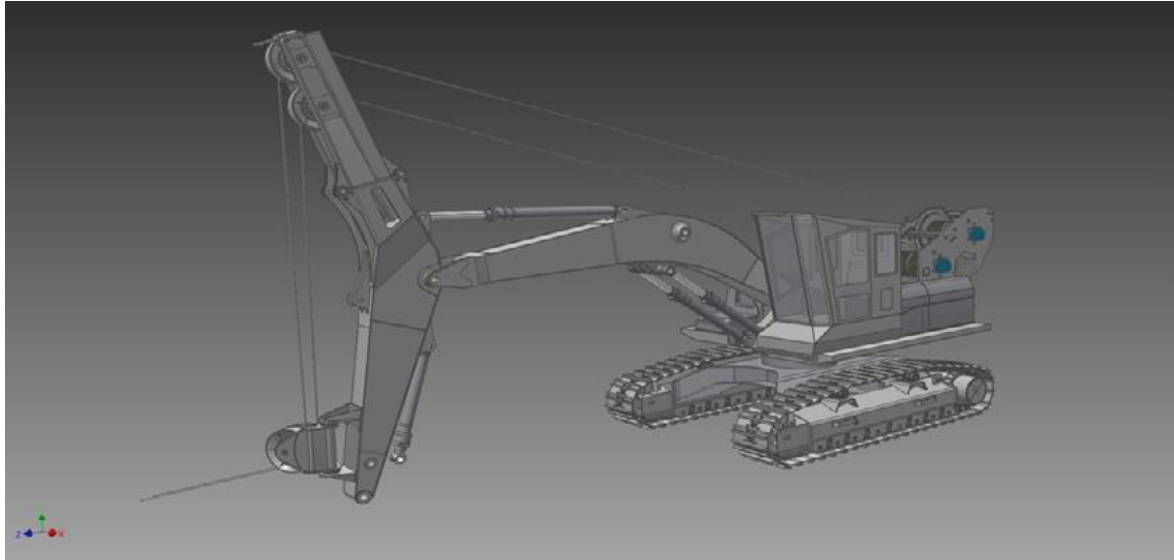


Figure 6: EMS Tractionline winch assist system

The main points of the presentation were:

- E.M.S. Tractionline uses a dual rope system with independent winches.
- Tractionline products are manufactured to AS1418-1 safety standard, which is the standard for cranes, hoists and winches, and demands a safety factor of 5:1 on all components.
- The system runs constant tension with back up and emergency brakes all controlled via wireless communication between the two machines.
- EMS have taken care to design attachment points to minimise stress hot spots on the cable-assisted machine. They have had the modifications certified by an engineer.
- A movement alarm will alert the operator if the anchor machine moves.
- A chain is used between the cable-assisted machine and the rope for additional durability.
- The sheaves are large enough to accommodate the chain, which means the cable-assisted machine receives traction assistance right up to the location of the anchor machine.

EMS have used a novel approach to prevent movement of the anchor machine that involves reversing the direction of the bucket as shown in Figure 7.



Figure 7: Reversed bucket on the anchor machine

In North America the Tractionline product is being represented by Technical Forest Solutions (T.F.S.) which is based in the Kelso in Washington State. T.F.S. have a full install and support service underway, and will service the Western U.S. and Canadian markets.



Figure 8: Tractionline in operation in New Zealand

For more information: see <http://emsnewzealand.co.nz/tractionline/>

5. A Contracting Approach to Mechanical Harvesting Systems on Slopes

Iain May of Rosewarne and May Ltd in Whangarei presented a summary of the Remote Operated Bulldozer (ROB) winch assist system (Figure 9) and their experiences and learnings.

Features of the ROB include:

- Hydrostatic drive with two independent winch drums and dual ropes
- Each rope has a 21-tonne safe working load
- Each winch drum has a spring-loaded fail-safe brake
- Tension monitors
- Instant shut down of the drums in the event of the ropes jumping off the winches.
- Electronic monitoring of water temperature, oil level and hydraulic level
- Rope capacity of 500 metres
- Multi-disk brake system.

B.C. logger Lyle Newton of Island Pacific Logging Ltd owns 3 ROB systems and is the North American distributor for the ROB system. Contact Information:

Email: kaelyn@islandpacificlogging.com or phone: +1 250 246 1414.

Contact information for New Zealand:

Email: admin@cableloggers.co.nz or phone +64 9 430 3450 or see <http://remotebulldozer.com/>.



Figure 9: Remote Operated Bulldozer (ROB) in New Zealand

6. Winch-assisted clam bunk harvesting/forwarding in B.C.

Mathieu Lavoie, of INOVForest Forestry Equipment Ltd, representing HSM, based in Quebec, Canada, presented early indications of costs and performance of HSM purpose-built forestry equipment in Canada. INOVForest is the North American vendor for HSM forestry machines. The HSM products are wheeled harvesters and forwarders that are designed for cut-to-length and full-length harvesting operations.

An HSM winch-assisted harvesting machine is shown in Figure 10. The machine includes an optional traction winch marketed as a Force Synchro Drive. The machine is designed to be used on slopes where it could remain stationary if the winch was not installed. Features include a levelling cab and rubber tyres for operator comfort and a squirt stick for additional reach.



Figure 10: HSM cable-assisted harvesting machine

For cut-to-length operations, the HSM forwarder provides a self-loading steep slope forwarder with optional traction-assist. Rough terrain can be accommodated with active pivot of both bogies as shown in Figure 11. In some cases, the combination of a cable-assisted harvester and a cable-assisted forwarder will negate the need for a hauler.

HSM also sells a clam bunk skidder with optional cable assistance for full tree length harvesting operations.



Figure 11: HSM forwarder

For more information contact Mathieu Lavoie, phone +1 819 277-0939 or email: lavoie@inovforest.com or visit the INOVForest website: <http://inovforest.com/>

7. Equipment Suppliers: Steep Slope Harvesting Developments

Caterpillar

Kolin Kirschenmann, Product Manager, Caterpillar Forest Products. The main points of Kolin's presentation were:

- Cat now offers factory solutions to facilitate steep terrain harvesting. These include:
 - extended roller frame for enhanced stability
 - a factory-certified hitch to provide an attachment point for cable assistance
 - an additional escape hatch through the front windscreen.
- Cat partnered with ARA to develop and deploy a teleoperated harvester to harvest a forest in the US with unexploded mines.

John Deere

Richard Lawler, Director of Engineering, Forestry Equipment for John Deere. Richard's presentation covered the following:

- John Deere offers a Haas winch to provide traction assistance for its machines
- John Deere has partnered with FP Innovations to model and measure static rollover threshold (SRT) for its machines in a variety of configurations with and without traction assistance. An example of an SRT locus is shown in Figure 12.

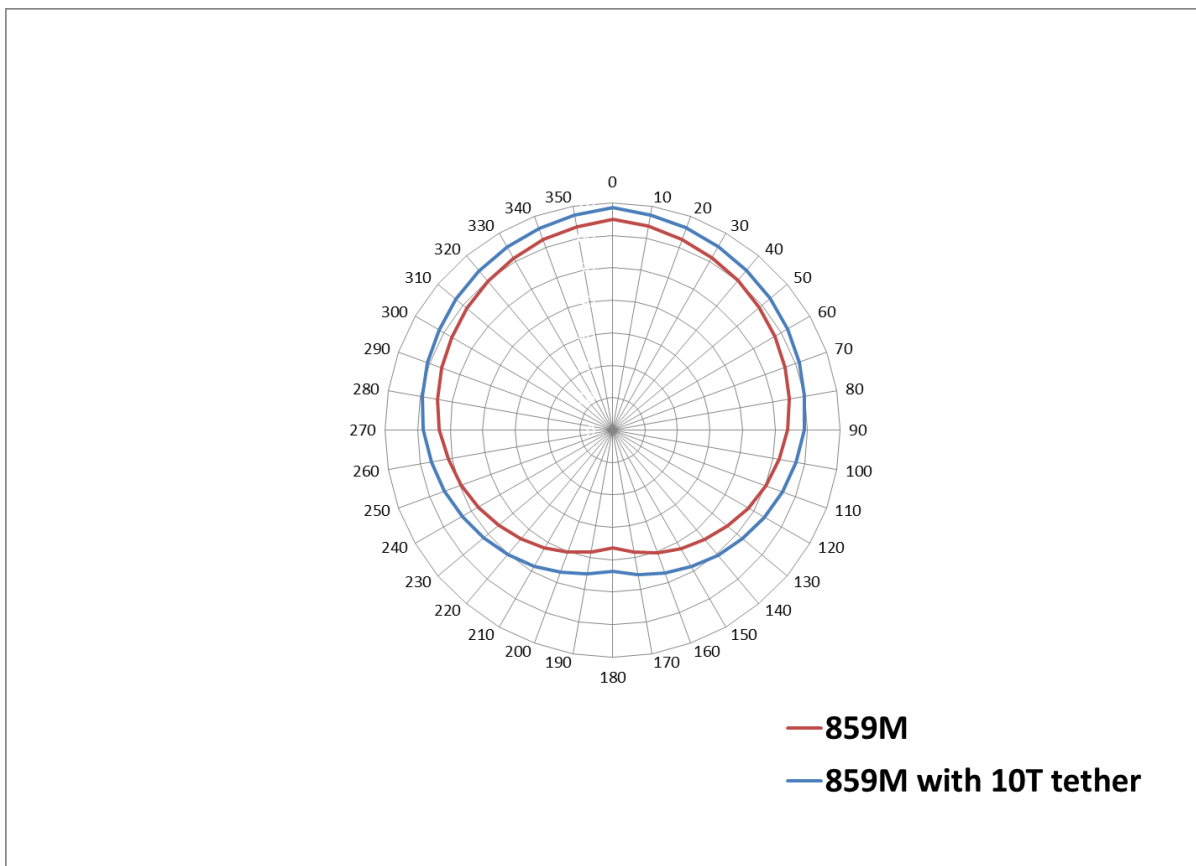


Figure 12: Static Rollover Threshold locus for John Deere 859 with and without a tether

- Traction models have also been developed to determine the effect of winch assistance on a variety of conditions and soil types
- TimberNavi is a customizable mapping solution similar to HarvestNav that is due to be released in April 2016. TimberNavi is a Geographic Information System (GIS) that uses Global Positioning System (GPS) so the machine operator can see his position on a computer display with other map information such as terrain information and harvesting areas. It will display real-time maps to the machine operator and it will be able to display pitch and roll information as part of its Vehicle Stability Sensor (VSS) system.
- For more information see <http://www.timberoffice.com/english/products/timbernavi/> or download from: https://www.deere.com/en_US/myjohndeere/timbernavi-home.page.

Tigercat

Gary MacDonald works in Product Support for Tigercat. Gary's presentation covered an overview of Tigercat's products and a number of new developments. Tigercat has a number of features that they advertise as assisting harvesting on steep terrain, including:

- Slope indicators in cab
- Factory non ratcheting seatbelt option
- Three escape routes
- Large cab to limit head contact
- Extra mounting holes to mount monitors
- "Plug and play" for manufacturer's electronics
- Patented weight shifting levelling system

Tigercat is working on the following to facilitate cable-assistance and steep-terrain operations:

- working with manufacturers and customers to make machines factory "assist ready" by offering a factory-designed hitch
- developing training programs for felling with new systems
- developing felling heads for the job under "one roof"
- investigating the advantages of rubber-tyred machines.

8. Key Risk Management Issues for Mechanised Harvesting Operations

Reynold Hert is CEO of BC Forest Safety Council. Reynold's presentation on key industry-identified risk management issues for mechanised harvesting operations covered the Coroner's Death Review Panel in 2009. This panel resulted in an interest in tethered falling.

Lost time, serious injury and fatality data show that hand falling is vastly more hazardous than mechanised falling in Canada.

The recommended hazard analysis and planning process was briefly described along with a description of the regulations for BC.

9. Practical Outcomes from FP Innovations' Steep Slope Initiative

Jim Hunt, Research Leader Harvesting Operations at FP Innovations presented an overview of FP Innovations' Steep Slope Initiative, and practical outcomes arising from this initiative. The Steep Slope Initiative is summarised in the road-map shown in Figure 13.

GOALS

- 1) Increased safety - reduce accidents by 50%
- 2) Increase margin - by \$5/m³
- 3) Access more fibre - 2 M m³

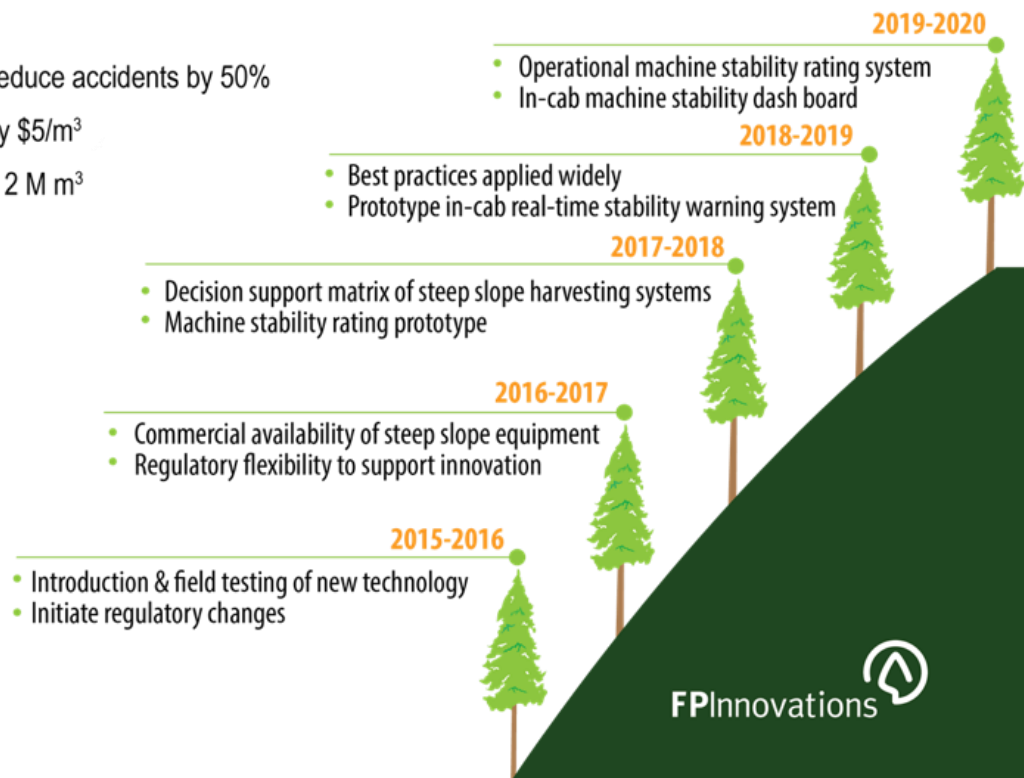


Figure 13: Roadmap for Steep Slope Initiative

Some recent results included:

- FP Innovations compared the productivity and associated yarding cost of hand-felled versus mechanically felled wood in steep terrain on Vancouver Island. The results were:
 - Hand falling resulted in 18 cubic metres felled per man hour compared with 48 cubic metres per man hour with a feller-buncher.
 - The yarding cost was \$22.78 per cubic metre for hand-felled stems compared with \$9.53 per cubic metre for mechanically felled and bunched stems.
- A heli-logging costing/planning tool has been developed.

For more information contact: Jim Hunt, Research Leader, FPInnovations, phone +1 604-222-5618 or email: james.hunt@fpinnovations.ca

FIELD TRIP

FP Innovations organised a field trip to visit two logging operations on Vancouver Island. The ROB machine was working with a levelling Tigercat feller buncher at the first site (Figure 14), and a ClimbMAX harvester was operating in the second block.

Selected comments from some of the logging contractors who visited the two machines were:

- The integrated winch on the ClimbMAX was regarded as favourable
- The dual rope system provided by the ROB was also regarded as favourable
- Several loggers stated their preference for wheeled feller-bunchers with band tracks fitted over the wheels. The reasons for this preference were operator comfort and better contact with the ground.
- A cable-assisted cut-to-length operation combined with a cable-assisted forwarder was proposed as an alternative to using a hauler with whole stems



Figure 14: ROB in action at the field trip in Richmond B.C.

DISCUSSIONS WITH MACHINERY MANUFACTURERS

After the conference the opportunity was taken for discussions with several machinery manufacturers in Vancouver.

- Dean Isley, Vice President of Risley Equipment Ltd.
Dean was interested in commercialising the FFR teleoperation control system in North America. Paul Milliken has emailed Dean to clarify the role of Risley Equipment and the type of agreement that they prefer. Further discussions will be held with FFR.
- Richard Lawler, Director, Engineering Forestry Equipment at John Deere.
Richard discussed some new developments at John Deere.
These included:
 - a binocular camera system for automatic obstacle detection and machine state estimation
 - ram position sensing.Richard Lawler offered to pay for travel costs for Paul Milliken to visit Iowa to discuss how the teleoperation system might integrate with the new developments.
- Rob Archibald, Project Engineer at Tigercat Inc.
Rob Archibald asked to be kept up to date with the development of the FFR teleoperation control system.
- After the conference, Paul Milliken visited FP Innovations. The following were the main points of the discussions:
 - Jim Hunt expressed his view that the FFR steep terrain harvesting programme has achieved a lot with a modest budget
 - The team at FP Innovations indicated that they would like to collaborate more with FFR. Although no immediate opportunities for collaboration were identified, FP Innovations is keen to work with FFR
 - FP Innovations worked with Kevin Lyons at UBC to develop a remote-controlled felling wedge. The felling wedge used a scissor jack concept which is a different concept to the design that is based on the Koller wedge. The results can be compared once the remote controlled Koller wedge has been field tested.

IMPLICATIONS FOR THE NEW ZEALAND FOREST INDUSTRY

The Steep Slope Logging conference provided attendees with information about recent innovations in steep-terrain harvesting in New Zealand. Therefore, most of the material that was presented would not have been new to a New Zealand audience.

The following points were identified as the most relevant information for FFR members:

- A new smaller, lighter Falcon Forestry Claw is now available from DC Equipment Ltd.
- Tolko purchased a ClimbMAX more than two years ago and it has been operating successfully in BC. There have been five more orders for ClimbMAX machines in North America.
- Summit Equipment Ltd in Washington, USA build and sell winch-assist machines that can be used with any feller buncher.
- HSM build tethered wheeled harvesters and forwarders. HSM machines have optional factory-fitted winches and have a number of features that make them well suited to operating on steep terrain.
- Caterpillar have developed a teleoperated feller buncher that has been operating on a site with unexploded bombs in the US.
- John Deere have been working on integrating additional sensor information into the next Model 909 feller buncher. These new developments should improve situational awareness and make the 909 easier to operate from the cab or via teleoperation
- Tigercat offer an optional hitch attachment to facilitate winch-assist systems.
- FP Innovations started a six-year Steep Slope Initiative in 2015. This initiative is likely to provide opportunities for collaboration with researchers in New Zealand. FP Innovations are very open to collaborating on future projects.

CONCLUSIONS

- The main focus of the Steep Slope Logging Conference was winch-assisted machines
- Two of the presentations by Paul Milliken and Kolin Kirschenmann covered remote-controlled and/or teleoperated feller bunchers
- Dean Isley of Risley Equipment indicated that they would be interested in commercialising the FFR teleoperation control system. Further discussions will be held between FFR and Risley Equipment Ltd
- Richard Lawler of John Deere described recent developments at John Deere that are likely to assist the FFR teleoperation project. Richard offered to support travel costs for a visit to John Deere's Iowa facility to discuss how FFR's teleoperation system may be integrated with some of the new subsystems that are being developed by John Deere.
- Although no immediate opportunities for collaboration were identified, FP Innovations are keen to collaborate with FFR in steep slope harvesting developments.

REFERENCES

Innovatek (2016) "Steep Slope Logging Conference", web page <http://steepslopelogging.events/> accessed on 12 March 2016.

ACKNOWLEDGEMENTS

The financial support of Innovatek Ltd in paying for travel expenses for Paul Milliken to attend the Steep Slope Logging Conference is acknowledged. Thanks also to FP Innovations for arranging a field trip on the day following the conference.