HARVESTING TECHNICAL NOTE

HTN05-10
2013

Innovative Yarding Systems – Analysis of Ideas

Summary

Earlier work in this project comprised workshops involving harvesting staff and contractors from FFR member companies to generate concepts for an innovative steep country harvesting system. An expert panel was convened to discuss and analyse the concepts to shortlist the best options according to set criteria. As a result of this initial work, eight innovative yarding concepts were selected for further analysis. This report summarises the analysis of economic viability of each concept in terms of productivity and cost. The result of the analysis showed three ideas from the original eight would likely lead to a reduction in the cost of harvesting compared to current systems. The expert panel selected the idea that best met the objective of achieving a 30% increase in productivity and had the best chance of success. The option chosen will be subject to further engineering feasibility analysis prior to design and development of a small scale prototype model.

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Introduction

The objective of the FFR project Innovative Yarding System is to investigate development of an alternative new extraction system which can reduce extraction costs and achieve productivity gains of 30% over current steep country extraction systems.

An earlier report described the process of concept generation as a result of a series of four workshops run in 2012 to generate innovative ideas for steep country harvesting (Hill and Parker, 2013).

An expert panel was convened to discuss in detail the merits of the 18 innovative yarding ideas arising from the workshops. The criteria used to define an innovative yarding system were that the concept had to be a yarding system (not another type of harvesting system), and it had to be achievable and new to New Zealand.

As a result of the initial expert panel analysis, eight innovative yarding concepts were shortlisted for further analysis according to set criteria. These criteria were that the concept was not part of an existing FFR project, that it had wide application and was considered to be achievable in terms of cost and timeframe. Agreement was reached on how each concept might work in reality and whether the idea would deliver the goal of a 30% increase in productivity or a similar reduction in cost.

An example of one of the concepts shortlisted for further analysis is shown in Figure 1. This is the "Spider Camera" type concept as used in sports stadiums. Four independent winches are anchored at corner points of a harvesting setting and instead of a camera, a motorised grapple is suspended via a main rope to each winch. In this way the grapple can move to any part of the setting to extract in any direction depending on which combination of winch drums is activated for inhaul.

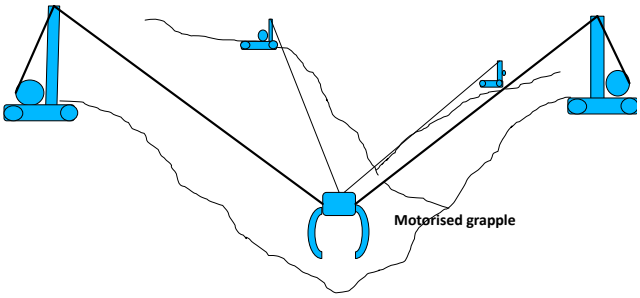

Figure 1: Concept of "Spider-Cam" yarder setup

This report summarises the method used to undertake broad level feasibility analysis of the eight shortlisted ideas in order to identify the best ideas that were not only technically feasible but also economically viable.

Method

Each member of the expert panel ranked each of the eight shortlisted ideas from 1 to 8 in order of priority, 1 being the most preferred concept. This resulted in a ranking, based on the panel's perception of likelihood of success (Table 1).

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Table 1. Final ranking of the best 8 ideas

Ranking	Idea
1	Full automation of hauler controls. The breaker-out has full control of the hauler from the break-out site to make the operation safer. Possibly hydraulic to provided better information on rope tensions etc. Includes automation of return function (e.g. UBC 044 automated Swing Yarder).
2	Lowering a clambunk skidder capable of felling (e.g. Highlander) down the hill. Fell trees and place in clambunk and when clambunk is full the clambunk is pulled back up the hill with approx. 10 trees (20 tonne).
3	Convert a swing yarder into a guyless machine (such as a Harvestline type yarder) by taking off the boom and gantry and replacing it with a digger boom and arm with tower addition. No guylines (faster shifting) but retaining fast line speed.
4	A "Spider Camera" type yarding set up for hauling trees. Four independent drums anchored at corner points of a setting joined to a carriage that can move over any part of the setting depending on which combination of winch drums was activated.
5	Cable ways to access difficult blocks rather than building roading system. Logs removed from block along cable way to where trucks can access. Intermediate supports could be mobile tractor units.
6	"Draw Well" cable system where two carriages/grapple carriages run on two skylines. One carriage is coming in while the other is returning. Excavators feed the grapples. Yarder has 4 drums: 2 skylines, main rope and tail rope.
7	"Ground Arch" system. Single main and haulback (Highlead type) system. Two grapple arches run over the ground. When one grapple arch is coming in the other is returning. This system would operate like the "Draw Well" system without the need for skyline support. The system has two mobile back anchors with the possibility of the back anchors running Dutchman sheaves to tension the rope.
8	"Continuous Loop" cable system similar to a chair lift setup (horizontal large sheaves) with 4 grapples spaced evenly on the continuous loop mounted on a setup similar to the connection used on the chairlift. A rope tensioning device either with a Dutchman type block or a third mobile back tower. A rope storage (rewind) mechanism would need careful design.

The final eight ideas were then taken to analysis stage involving broad level technical and economic feasibility of each idea in terms of productivity and cost.

A Microsoft Excel spreadsheet model was developed to analyse the different yarding system concepts. An estimate of how much each machine system would cost to build was made and then an estimate of the running cost per day was calculated. The costing for each system was calculated the same way to provide an operating cost per day of the harvesting system that was comparable.

Cycle times and productivity estimates were used to calculate the cost per unit so a comparison could be made between systems. Standard cable harvesting systems were also developed as the bench mark for comparison purposes (Prebble, 1989a, 1989b, 1989c, 1989d).

Due to expected high cost, Concept 4 was modified in the analysis from four winches to two single drums mounted on excavator type bases (possibly a new base machine such as the Awdon Hill Country Harvester development). A grapple is suspended by a main line to each base machine. One excavator acts as a tailhold (which includes a recovery winch similar to those used by snow groomers) and is controlled by the main machine (at the landing). An electrical six-axis control system manages the positioning of the motorised grapple rather than controlling individual winch drums.

Concept 5 was not not analysed further as it was not considered to be a harvesting system but rather a roading system.

Results

All systems included a processor for log merchandising even though in some circumstances motor manual merchandising would have been more cost effective. This was done to meet the vision of the PGP Harvesting programme 'no hand on the chainsaw'. All systems included a two-stage skidder.

The cost of developing each machine system was estimated based on other developments, not actual harvesting unit rates, as these would vary from block to block and region by region. An example of one system costing, for Concept 2, the clambunk skidder lowered down the hill, is shown in Table 2.

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Table 2: Example system costing: Concept 2

Job Costing Summary
Highlander Skidder lowered down hill

				$/Hr	$/Day	$/Year
MACHINERY		Units	Hours			
	24 Tonne Excavator	1	8	**99.89**	**799.09**	**191,782**
	Log Processor	1	8	**173.06**	**1,384.44**	**318,422**
	Caterpillar 525 Grapple Skidder	1	8	**110.11**	**880.87**	**202,601**
	4x4 Double Cab Work Ute	3	2	**117.06**	**234.12**	**56,189**
	Highlander	1	8	**157.75**	**1,261.99**	**277,637**
	D8 Tractor Lowering Clambunk	1	8	**93.80**	**750.38**	**165,084**
PERSONNEL						
	Operation Foreman/Owner	1	8	**35.00**	**280.00**	**74,200**
	Machine Operators	4	8	**25.00**	**800.00**	**212,000**
	Skid/Xcut, etc	3	8	**25.00**	**600.00**	**159,000**
CONTRACTOR OHEADS						
	Contractor Management	$7.70		**4.81**	**38.50**	**10,203**
	Camp Facility per person	$0.00		**0.00**	**0.00**	**-**
BUSINESS OVERHEADS						
	Based on Annual Figure	$12.00		**12.00**	**96.00**	**25,440**
OPERATING SUPPLIES						
	Tools, Equipment, etc ($/Man/Day)	$7.21		**7.21**	**57.68**	**15,285**
Basic Unit Total				**860.68**	**7,183.08**	**1,707,843**
ADD: Allowance for Profit		10.00%		**86.07**	**718.31**	**170,784**
ADD: Additional Costs						
	Management Company Fees	-		**0.00**	**0.00**	**0**
TOTAL DAILY RATE REQUIRED				**946.7**	**7,901.4**	**1,878,627**

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Table 3: Comparison of Harvesting Systems Productivity and Cost

Comparison of Harvesting Systems											
Elements	Current Grapple Swing Yarder Operation	Current Swing Yarder MSP Operation	Current Standard Tower Operation	1 - Full Automated Hauler controlled by Breaker-outs	2 - Lower a Clambunk Skidder down the hill	3 - Convert Swing Yarder to Harvestline (no guys)	4 - Two Single Drum Hauler Grapple Operation - Spider Cam	5 - Cableway to Access Blocks in Replacement for Roads	6 - Draw-well Two Skyline Operation	7 - Continuous Loop Grapple Hauler Operation	8 - Hi-lead with ground arch yarding system
Piece Size	2	2	2	2	2	2	2		2	2	2
Minutes per Day	480	480	480	480	480	480	480		480	480	480
Haul Distance	280	280	280	280	280	280	280		280	280	280
Out Haul	30	30	30	30	150	30	30		0	0	150
Position Grapple	10				20	10	5		40	160	20
Position butt rigging		20	20	20							
Grapple	30	0			0	25	20		40	160	0
Load Clambunk					300						240
Hook-on		220	220	200							
In Haul	75	90	90	90	450	75	90		200	180	300
Drop Load	5	10	10	10	30	10	10		20	160	30
Un-hook		40	40	40						160	
Lift Ropes	5	5	20	20	20	5	5		20	0	20
Cycle Time	2.58	6.92	7.17	6.83	16.17	2.58	2.67		5.33	13.67	12.67
Contingincy 10%	0.26	0.69	0.72	0.68	1.62	0.26	0.27		0.53	1.37	1.27
Time Per Cycle	2.84	7.61	7.88	7.52	17.78	2.84	2.93		5.87	15.03	13.93
Move backline minutes per day	20	20	30	30	0	20	20		20	20	0
Reposition Hauler minutes per day	30	10	10	10	5	5	5		15	15	5
Rig up minutes per day	10	10	15	15	5	5	5		30	30	5
Rig down minutes per day	10	10	15	15	5	5	10		20	20	5
Mechanical Delay minutes per day	10	10	10	10	10	10	5		5	5	20
Operational Delay minutes per day	20	20	20	20	20	20	10		20	20	10
Cycles per day	134	53	48	51	24	146	145		63	25	31
Tonnes per cycle	2.00	4.60	4.60	4.60	10.00	2.00	2.00		4.00	12.00	8.00
Trees per cycle	1	2.3	2.3	2.3	5	1	1		2	6	4
Production per Day	267	242	222	233	245	292	290		252	295	250
Day Cost of Operation	7,803	7,654	7,754	7,799	7,901	7,982	8,065		7,590	11,662	6,983
Unit Rate	29.17	31.65	34.97	33.54	32.30	27.33	27.83		30.09	39.49	27.96

Table 3 shows the estimates of cycle time elements and daily production for each machine system. This was combined with the daily cost estimates to result in unit rates for each system. A comparison of potential unit rates arising from each of the systems analysed was then made against standard cable harvesting system estimates as the bench mark.

Discussion

From the analysis of standard cable harvesting systems it is clear that grapple systems are the most cost effective method of harvest, but traditionally they are used over short haul distances only. As haul distance increases, grapple harvesting costs approach that of more conventional systems if payload is limited to one tree per haul.

Of the innovative yarding system concepts analysed, Concept 3 "converting a swing yarder into a Harvestline type machine" was the most cost effective. This was due to its quicker set up time and move time, although the slewing/swing time would likely be slower. The problem with this option is that altering a swing yarder would require approval of the manufacturer, and it is unlikely that this approval would be given for such a major design change.

The second most cost effective idea was Concept 4, the two single drum machines with a grapple suspended between them in a configuration similar to the "Spider Camera" system now common at major sporting events. While the original concept was for multiple winches for greater control and accessibility, for cost reasons the analysis was undertaken on a dual yarder system. Given the control systems have already been proven it was considered that this idea has great potential to succeed.

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The highlead "Ground Arch" system (Concept 8) was determined to be not particularly innovative, but easy to implement, as the ground arches are available in Europe. As this is a much simpler system than the clambunk system there was a cost advantage, however the ground arch would require loading and for this analysis a ClimbMAX feller buncher was added to the original costing for this function, reducing this option in the final ranking.

The third idea that showed potential was Concept 6, the 'Draw Well' yarding system with two skylines where one grapple is coming in with logs as the other grapple is returning to the break out zone. The draw well idea would be relatively easy to build, however putting this system into practice would be moderately difficult given the main and tail rope would be shared between the two skylines and therefore rigging up and rigging down as well as shifting would be difficult to coordinate. The system would also require clamping carriages that would allow the main and tail rope to pass through the carriage to allow for changing haul distance. Hauler controls would also have to be sophisticated or automated for ease of operation.

The "Continuous Loop" yarding concept, similar to that of a ski field chair lift demonstrated problems with rope tensioning, increasing and decreasing the haul distance, and rigging up and rigging down the system. A system would also need to be designed to lower grapples or chokers to the ground.

The idea of lowering a clambunk skidder (Highlander) down a hill by a rope secured to a machine on the skid would be relatively easy to put into practice, but accumulating a load on steep country would be difficult. It is likely that some alterations to the clambunk skidder would be necessary for operation on steep country. The analysis showed that moving to such a system was unlikely to have a cost advantage.

Table 4 outlines the final ranking of new ideas based on analysis and discussion of the expert panel. An indication of how difficult the idea would be to implement operationally is also provided.

Conclusion

The development of 18 innovative yarding concepts from the industry workshops was a good result. The process of ranking and analysis of ideas using an expert panel also worked very well. After analysis, the three systems that showed good potential to provide an innovative approach to harvesting and best meet the project objectives were:

1. Converting a swing yarder to a Harvestline type machine with no guylines to enable rapid shifting. While this showed good potential it is very unlikely that approval would be given by the manufacturer to convert a swing yarder to a Harvestline type machine and therefore this option was determined very difficult and therefore a low likelihood of success.

Table 4: Final ranking of ideas after analysis

Idea	Rank	Ease of Implementation
3 - Convert Swing Yarder to Harvestline (no guys)	1	Very Difficult
4 - Two Single Drum Haulers with Grapple – "Spider Cam"	2	Moderate
6 – "Draw Well" Two Skyline Operation	3	Difficult
7 - Continuous Loop Grapple Hauler Operation	4	Very Difficult
1 - Full Automated Hauler controlled by Breaker-outs	5	Moderate
2 - Lower a Clambunk Skidder down the Hill	6	Easy Moderate
8 - Hi-lead with ground arch yarding system	7	Easy
5 - Cableway to Access Blocks in Replacement for Roads	Not Analysed	

2. Two single drum excavator-based yarders linked together in an adaptation of the "Spidercam" system showed great potential. The control system incorporating a six-axis electric controller that has already been developed for use in sports stadiums. It was proposed that further engineering analysis be undertaken and based on this to open discussions with the manufacturers of the "Spidercam" system. This option is taking an already proven idea from a different industry (television) and applying it to the logging industry; hence this option was determined to be of only moderate difficulty and therefore had good potential for success.

3. A "Draw Well" system whereby one grapple is coming in with a load while the other grapple is

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returning to the field also showed potential, but requiring a suitable location to use this concept would probably limit its potential and therefore this option was deemed difficult and a low likelihood of success.

Recommendation

It was recommended by the expert panel that Concept 2 (the dual yarder modified "Spidercam" system) be selected for further analysis of its engineering feasibility, as this option had the greatest likelihood of success given its proven technology.

The next step in the project is for the expert panel to undertake further feasibility analysis prior to design and development of a small scale working model (alpha prototype).

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