HARVESTING TECHNICAL NOTE

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The Koller K602H Yarding System

Summary

A Koller K602H cable yarder was trialed in Mangatu Forest near Gisborne during February 2015. The forest block comprised *Pinus nigra* (Corsican pine) at high stocking with trees of small piece size on moderately steep slopes. The yarder was observed working in a single span operation from a split-level roadside location and from a landing in a multi-span operation using intermediate supports. Limited production data were collected during the trial as the equipment was being commissioned and the operators were still being trained, but data collected were compared with those from a ten-day study of a Koller K602H yarder working in Chile. Costs of logging systems using the Koller yarder were estimated, and ranged from $35 per tonne for a single span operation to $48 per tonne using intermediate supports. It is proposed that the yarder could be competitive in New Zealand forest stands with average piece size of less than 1.6 tonnes, and in small landing and roadside operations.

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Introduction

The returns from steep country harvesting in many parts of New Zealand are marginal currently, due to flat or declining average log prices and rising costs. A small reduction in log prices, or a slight increase in operational costs, could render many forests uneconomic to harvest. More efficient ways to harvest New Zealand's steep country forests are needed to ensure economic viability.

Figure 1: Koller K602H yarder at Mangatu Forest

New technology that reduces the amount of capital investment or labour input required could reduce harvesting costs and negate potential cost increases.

A 2013 survey identified 305 haulers in New Zealand but found very few were in the smaller size range and none had the sophistication of the new yarder designs coming out of Europe[1]. The Koller K602H yarder, manufactured in Austria, is a small cable yarder by New Zealand standards. It is a trailer-mounted, three-drum yarder with an 11.5 m tower. The Koller has been designed for specific use with a standing skyline using a slack pulling carriage, either in single span or multi-span operations using intermediate supports.

The Koller yarder is remote-controlled, with automatic carriage return and the ability to transfer control of the winches between the landing and the break out site. This high level of automation and control means lower fuel use and a lower labour requirement. It is possible to operate the Koller yarder with a crew of four to five workers (tree faller, breaker-out, processor operator, a loader operator and a quality control/pre-rigger). The breaker-out operates the yarder from the break-out site and during inhaul transfers control to an operator on the landing.

In Europe, the Koller yarder would typically work with a combination processor/loader machine. The operator of the processor would also take control of the yarder and carriage during the log landing operation.

The capital cost of the yarder was NZ$500,000 to $650,000, depending on whether a haulback drum was installed and whether a drive axle was required for positioning the trailer. The cost includes wire rope, a Koller MSK3 motorised slack-pulling carriage, four radio-controlled chokers with remotes, and a maintenance kit.

Despite operating with fewer workers than are commonly used in New Zealand cable logging conditions, with lower capital and daily costs, the production capability of the Koller yarder is the key to reducing the overall cost of wood from stump to truck.

The first Koller yarder arrived in New Zealand in January 2015, and this presented an opportunity to demonstrate its production capability to the New Zealand logging industry. The yarder owner, Mr Christian Welte of Monte Farm and Forest Ltd, donated the use of the machine to FFR for the purposes of a production trial and field demonstration. Forest manager, Ernslaw One Ltd and its contractor Storm Logging Ltd, put the yarder to work in a Corsican pine block in Mangatu Forest near Gisborne (Figure 1).

This report summarises the technology features of the Koller yarder and results of a brief production study of the yarder operating in a single span setting, and over intermediate supports. Indicative costings are provided of possible operational scenarios where the Koller K602H yarder would be best used in New Zealand.

Features of the Koller K602H Yarder

The specifications of the Koller K602H yarder are given in Table 1. It is powered by a Deutz 6-cylinder engine delivering 147 kW power. Engine operation is controlled by an on-board computer system that continuously runs diagnostics on the engine. Yarder operation is monitored and controlled by the on-board computer system – the Koller MultiMatik. For example, if the oil level is low, the computer will stop the engine and not allow it to start again and the monitor will display the fault. The computer also minimises fuel consumption by optimising speed during acceleration and deceleration. The yarder design ensures every part of the yarder and carriage operation is synchronised. The hydraulic control system ensures that overloading is difficult and that the system is able to measure hydraulic pressure accurately and relate this to tension and safe working load restrictions of operating ropes.

Table 1. Koller K602H specifications[2].

Engine	6cyl Deutz 147 kW
Tower height	11.5 m
Linepull – mid drum	
Skyline	95 kN
Mainline	50 kN
Haulback	43 kN
Line capacity-	
Skyline	720 m/22 mm swaged
Mainline	730 m/12 mm swaged
Haulback	1350 m/1 2mm swaged
Strawline	1700 m/6 mm synthetic
Guyline	4x50 m 20 mm/ 2x15 m extensions
Brakes	
Skyline	Two hydraulically actuated spring-applied disc brakes
Mainline	Pneumatically actuated spring-applied band brake
Haulback	Hydraulically actuated spring-applied multi-disc brake
Operation	Koller MultiMatik radio control
Carriage	Koller MSK3 - 2 speed, 5.5 kW diesel powered slackpulling carriage (weight 690kg)
Weight	15.5 t (with powered axle)

The MultiMatik computer control panel (Figure 2) is used to set up background systems, including:

1. the starting point distance,
2. the skyline pre-tension,
3. the tension designated as overload where the system will lower the skyline automatically to restore the correct tension,

4. the tension in the synchronised mainline interlock with the tailrope and strawline,
5. the position of intermediate supports and the distance for automatic slowing of the carriage speed when it reaches the supports, and
6. the distance from the landing where the carriage automatically stops.

Figure 2: Koller MultiMatik control system.

The 'MultiMatik' remote control units (Figure 3) allow full control of the winches and carriage and have an operating range of 1.0 km. The two identical remote controls cannot be used at the same time. Control must be transferred from one controller to the other. A loud whistle sounds when this occurs.

Figure 3: Koller MultiMatik remote control unit.

The remote controls, which do not have the full function of the yarder control panel, offer the following functions:

1. single lever control of all main operating winches (excluding guylines),
2. engine on and off,
3. winch speed,
4. carriage control, including the clamps and line out speed,
5. control handover,
6. emergency stop,
7. emergency carriage clamp,
8. emergency drop of the skyline, and
9. adjustable overload shut-down.

The skyline drum (Figure 4) has a section for rope storage and a section for tension. No more than one layer is used on the tension side of the drum. This allows the system to monitor the diameter of the drum for hydraulic pressure readings and ultimately rope tension calculations. If the tension becomes too great, the skyline will automatically spool out slowly until the correct tension is achieved. In extreme cases, the skyline will fall slowly to the ground.

Figure 4: Skyline drum showing narrow tension section and spooling device.

Rope crushing is also reduced with only one wrap on the tension side of the drum. The recommended skyline size is 22 mm swaged, which has a safe working load of slightly less than 15 tonnes (at 3:1 safety factor). The skyline winch is capable of exerting 12 tonnes force in the tension section of the skyline drum.

The skyline drum has a mechanical spooler controlled by the yarder operator. This helps to get the skyline from the storage section to the tension section, and also helps to keep the rope straight on the drum.

The main rope winch has a mid-drum line pull of slightly less than 5 tonnes, which is equal to the safe working load of the recommended 12 mm power-swaged rope. Rope wear should be reduced as tensions are well within rope specifications. Both the main rope and tail rope winch drums have a simple mechanical brake system. This is a free spool brake system that is automatically applied when there is low tension on the ropes, which prevents problems associated with slack on the drum.

Dyneema synthetic rope was used for the strawline. The advantages of this light weight rope are that during setup, one person can easily pull the strawline and ensure that, as soon as the backline is reached, the strawline is ready to connect to the tail rope. The Dyneema synthetic rope was very easy to splice. A join is less than 1.0 metre long and takes just a few minutes to splice. The automatic outfeed on the strawline drum was controlled by the tension on the strawline. As the strawline was pulled by the breaker-out, the drum sensed how far to let the rope out, and as soon as the weight came off, the drum would apply the brakes, limiting any chance of “over-wind”.

The tower (Figure 5) is constructed from box section steel and looks light when compared to North American yarders. However, the tower is of appropriate strength given the safety mechanisms in place to control rope tensions and to limit any possibility of overload. The tower telescopes to reach its full height of 11.5m. It is lifted with a cable and a small winch on the side of the tower and locked in place when fully extended with locking dogs. The skyline sheave has a guide to ensure the skyline could never fall off the sheave.

Two stabiliser feet, one either end of the machine, take almost all the weight off the trailer undercarriage once the tower is up This reduces wear and tear on the undercarriage.

Figure 5: Top of the Koller tower showing rope guides on the guyline and skyline sheaves.

The tower is rigged vertical (not leaning) and has four rear facing guys. This contrasts with North American yarders that use leaning poles when the guys are rear facing. It was noted that when the tailrope was not in use this was rigged as a snap guy in the front. The European guying style of wrapping the guy around the stump more than once was also used, a practice not often seen in New Zealand but common throughout Europe. The guyline winches are controlled by a separate remote that allows the operator to guide the guys safely back onto the drum during retrieval. The guyline tower sheaves all had guides to ensure the guyline could never fall off the edge of a sheave.

System Design

The Koller is designed for standing skyline operations with a slackpulling carriage such as

the Koller MSK3 (Figure 6) either over single spans or, more commonly in Europe, over intermediate supports.

Figure 6: MSK3 Motorised slackpulling carriage.

Use of intermediate supports provides lift to the loads, ensures improved ground clearance where deflection is poor and results in less site disturbance by eliminating stem dragging (ground hauling). Intermediate supports are important to the operation as these smaller yarders would not pull the payload they can without them, given that the mainline has only 5.0 tonnes of line pull at mid-drum.

Intermediate supports do take some time and skill to prepare and rig, and skilled workers are required to install them. A standard work sequence included the following steps:

1. The yarder operator programmed the yarder to slow the carriage outhaul speed for each intermediate support used.
2. Carriage outhaul (travel empty) – the yarder operator at the landing selected the auto return button on the remote once the carriage cleared the edge of the landing control. The carriage outhaul then occurred automatically.
3. Once the carriage reached the breakout site, the breaker-out controlled the carriage position on the skyline and applied the skyline clamp (Figure 7). This also released the mainline clamp and the carriage began to pull slack from the yarder mainline drum. The mainline drum sensed the load and fed out mainline at the same speed.

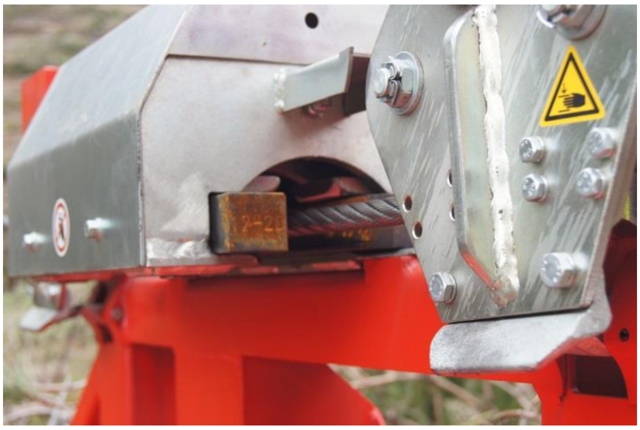

Figure 7: Skyline clamp on MSK3 carriage – a mechanical over centre type mechanism.

4. The breaker-outs attached the desired number of trees by strops and walked out to a safe position.
5. The breaker-out then controlled the yarder to break out the load of trees. In Europe, the safe retreat distance can be close to the trees as the breaker-out has full control of the yarder and the yarder lacks the power required to rotate trees out of a stuck position.
6. The mainline clamp was activated and the skyline clamp released once the trees were at the carriage and inhaul began. The breaker-out pressed the "auto return" button once the load was clear. The yarder automatically brought the carriage and load to the edge of the landing, stopping automatically to wait for the operator at the landing to complete the inhaul under manual control. Control of the yarder and carriage is passed back and forth between the breaker-out and the operator on the landing.
7. When the carriage reached the drop zone, the carriage skyline clamp was activated, the mainline clamp released, and the trees lowered to the ground. There, the chokers were released and pulled back up to the carriage ready for outhaul to begin again.

Study Method

Stand Description

The trial stand (Harvest area 37/1) was *Pinus nigra* (Corsican pine) planted in 1963. Mean values from a 2003 silvicultural assessment showed a stocking of 829 stems/ha and a mean piece size of 0.7 m^3/tree. A recent estimated average conversion factor was 0.84 m^3/tonne (Tim Petro, pers. comm.).

The estimated piece size (excluding broken pieces) was 0.68 m^3/tree during the trial of the single span operation and 0.74 m^3/tree for the multi-span operation using intermediate supports. The contractor, Storm Logging Ltd, had felled all the trees for the trial, cleared the chute, and supervised the breaking-out operations during the trial.

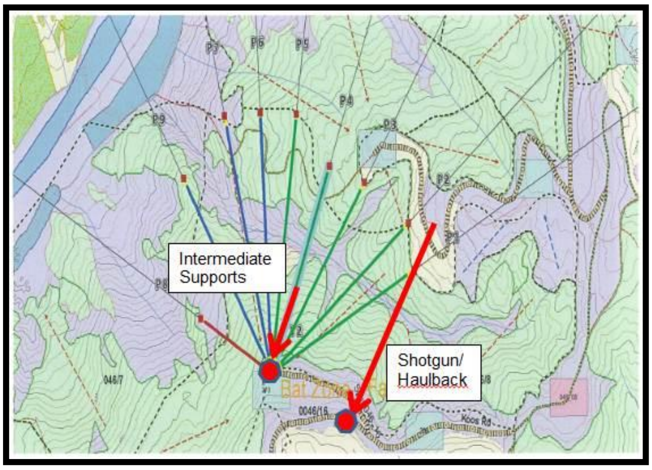

Figure 8. Location of two trial haul lines.

The yarder was set up in two settings (Figure 8). The first was a single span operation using both shotgun and slackline systems where the yarder was positioned on the road approximately 8 m above a lower road (as shown in Figure 1). The second setting was a slackline system using intermediate supports (Figure 9) extracting to a separate landing.

Koller Forsttechnik GmbH of Austria had sent a technician to New Zealand to commission the yarder and train an operator and a breaker-out in the use of the Koller MultMatik remote control system. The training took place immediately prior to the trial, so the operators were still learning the system while data were being collected.

Figure 9. Intermediate support (No.1).

Production data were recorded for one day each for the single span and multi-span configurations.

Results

Production estimates from Mangatu trial

Establishing intermediate supports

Notching stumps and topping and rigging the intermediate supports (Figure 10) took three workers approximately 8.5 hours in total (or 25.5 worker-hours). The tree climber was experienced in rigging intermediate supports. Take-down time was not recorded. Topping the intermediate supports took two workers about 45 minutes per tree.

Figure 10. Intermediate support tree (No.2) rigging detail.

A comparison was made between the trial set up times and intermediate support installation times from some European operations[3]. The European set up data included take-down times. It was reported that the average set up time for 155 corridors was 18 worker-hours per corridor or six hours for a three-man crew. Average take down time was eight worker hours. Intermediate support trees were not topped. Support trees consisted of two intermediate supports and a rigged tail tree.

The predicted installation time for the trial data for two intermediate supports, uphill extraction, a skyline corridor length of 120 m and an average of 2.7 workers was approximately nine hours or 24 worker-hours.

Walk in/Walk out

The breaker-out has control over the yarder/carriage close to the breakout area with the Koller MSK3 carriage system. The final position of the carriage prior to breakout was controlled from a safe distance. Walk in to this point by the breaker-outs took place during carriage out haul and did not interrupt the productive cycle. When the carriage was stationary, the mainline was fed out, and the chokers were lowered.

Single span operation

The breaker-outs walked out to a marked safe retreat position some 40 m away once the trees were hooked up. This complied with the default process noted in the Approved Code of Practice for Safety and Health in Forest Operations (ACOP)[4] and was also agreed in the daily “tailgate” safety meeting. The mean walk-out time was 0.69 min. Only then was the yarder/carriage moved by remote control to a suitable position and the mainline hauled in. Time study data were collected from the far face of the haul line of the U-shaped profile setting.

Observation of logging operations in Europe, where breaker outs have remote control of the yarder/carriage, suggests that safe retreat distance protocols involve shorter distances than those established for New Zealand (Hill, pers.com). Each breakout event is unique and the safe zone for mainline inhaul varies with terrain and obstacles.

Intermediate Support or Multi-span operation

The safe retreat position for intermediate support operation was in standing trees nearby. Breaker out procedure was similar to that for haulback operation.

Remote control

Remote control of the carriage by the breaker-out gives the controller the ability to avoid snagging a drag on break out. Control of the carriage by the breaker-out enabled the use of European safety protocols regarding safe retreat distance. In European thinning operations, breakout often takes place near standing trees and into a corridor. In clearfelling, it was reported by the Koller technician, trees are often felled directly downhill, minimising the need to turn the tree on approach to the skyline.

Production Data

Production data obtained for the two different settings are given in Table 2.

Table 2: Koller trial results from Mangatu Forest

	Single span	Multi-span
Productive hours (hr/day)	7.4	7.4
Average haul distance (m)	217	50
Average tree volume (m^3)	0.68	0.74
Average trees/haul	2.7	1.5
Average haul volume (m^3)	1.84	1.11
Average cycle time (min)	7.24	4.8
Average volume/day (m^3)	112.9	102.7

European operations often use labour productivity as a key comparative measure of operational efficiency. In the trial, labour productivity for the single span operation was estimated to be 28.2 tonnes/man-day and the multi-span operation was 25.7 tonnes/man-day (assuming a four-man crew in each case). As a comparison, typical New Zealand cable logging operations have manpower productivity of between 20-24 tonnes/man-day [5].

Ergonomics

Rigging weight is reduced owing to lighter main rope (12 mm) and lighter radio-controlled chokers than are commonly used in New Zealand. The Ludwig chokers[2] used weighed 1.6 kg each (used with 12 mm rope) compared with the 3.1 kg New Zealand-built Fortronics brand chokers (used with 19 mm rope). Noise levels from the yarder engine are lower than other larger haulers and consequently did not exceed the level requiring hearing protection to be worn.

Applications to New Zealand

There is definitely a place for high-technology yarders such as the Koller K602 in New Zealand. However, the standard harvesting system of cutting a large number of assorted logs on large forest landings is likely to hamper the introduction of these lower producing yarders due to the additional equipment required to move, sort and stack logs at the landing.

A single Koller yarder system could be cost competitive where the Koller yarder is matched with only one additional machine (a combination processor/loader) and operated with four workers (Table 3).

Given the limited production data in this trial, in the example of a single span operation, daily production of 120 to 140 tonnes per day would be achievable, resulting in a unit production cost between $35 and $41 per tonne. In a multi-span situation daily production between 100 to 120 tonnes per day could be expected and the unit rate would more likely be between $41 and $48 per tonne.

Table 3: Single Koller yarder operation with a combination processor and loader

One Koller 602H System	No	Hours	$/Day
MACHINERY			
Koller 602H	1	8	915
Cat 330 Excavator	0	0	0
Processor/Loader Combo	1	10	1,754
PERSONNEL			
Machine Operators	1	10	317
Logmaker/QC	1	8	316
Fallers	1	8	316
Breaker Outs	1	8	316
ADDITIONAL EXPENSES			
Vehicles, Training, Management			621
SUB-TOTAL			4,439
Profit allowance on non-staff items	15%		493
TOTAL DAILY RATE REQUIRED			4,932
Indicative Production			130
Indicative Rate			37.94

A motor manual operation (Table 4) may offer some advantage if one excavator could perform all the functions on the landing area, including clearing the chute, laying out, sorting, stacking and loading trucks. The cost of this option is estimated at $37 per tonne.

Table 4: Single Koller yarder with manual processing

One Koller 602H System	No	Hours	$/Day
MACHINERY			
Koller 602H	1	8	915
Cat 330 Excavator	1	8	1,060
Processor/Loader Combo	0	0	0
PERSONNEL			
Machine Operators	1	10	317
Logmaker/QC	2	8	631
Fallers	1	8	316
Breaker Outs	1	8	316
ADDITIONAL EXPENSES			
Vehicles, Training, Management			662
SUB-TOTAL			4,073
Profit allowance on non-staff items	15%		395
TOTAL DAILY RATE REQUIRED			4,468
Indicative Production			120
Indicative Rate			37.23

Another option could be a multi-yarder operation with one quick coupling processor head moved between yarders on a trailer rather than moving the processor and base. A two-yarder operation (Table 5) would likely produce 220 to 240 tonnes per day, corresponding to a unit rate of $32 to $33 per tonne and offering advantages over a single yarder operation.

Table 5: A two-yarder operation with a shared processor

Two Koller 602H System	No	Hours	$/Day
MACHINERY			
Koller 602H	2	8	1,830
Cat 330 Excavator	1	8	778
Processor Transporter	1	8	240
Processor/Loader Combo	1	10	1,754
PERSONNEL			
Machine Operators	2	10	629
Logmaker/QC	1	8	286
Fallers	1	8	286
Breaker Outs	2	8	572
ADDITIONAL EXPENSES			
Vehicles, Training, Management			703
SUB-TOTAL			6,906
Profit allowance on non-staff items	15%		796
TOTAL DAILY RATE REQUIRED			7,702
Indicative Production			240
Indicative Rate			32.09

Two key elements would be needed for such an operation: a quick coupling mechanism to allow the processing head to be quickly detached and transported between yarder operations, and efficient truck scheduling to avoid landing interference delays.

Comparison with other NZ operations

These cost estimates compare closely with the long run average logging rate for tower yarders from the FFR harvesting benchmarking database [5] of $33.80 per tonne for a 4-5 machine operation with 9 workers (averaging 204 tonnes/day in 2.0 tonne piece size).

Multi-span systems using a standing skyline with intermediate supports are also likely to become more common in New Zealand in the future as they can reduce the environmental impact of logging in low deflection situations (Figure 11). Most of the conventional haulers in New Zealand are capable of running standing skyline configurations. However, the lighter European equipment does make setting up multi-span systems a little less arduous.

Figure 11: Soil disturbance resulting from poor deflection

Comparison with Chilean Koller K602H Trial

The reported productivity of a ten-day trial of a Koller K602H working in radiata pine in Chile (personal communication, Koller GMBH) in a multi-span configuration was 133 tonnes per day (Table 6).

Table 6: Chilean Koller K602H trial results

Productive hours worked (hr/day)	7.4
Maximum haul distance (m)	240
Average tree volume (m^3)	1.0
Average trees/haul	2.46
Average haul volume (m^3)	2.46
Average cycle time (min)	8.3
Average fuel use (litres/hr)	6.1
Average volume/day (m^3)	133

Additionally, it was reported that each new corridor over intermediate supports took one day to set up. Due to differences in extracted piece size, haul size and haul distance, a direct comparison between the New Zealand and Chilean operations is not advisable, but results are indicative of the range of daily production common in these operations.

Conclusions

Given the constraints generated from trying to carry out a production study at the same time as the equipment was being commissioned and the operators were still being trained, limited production data were collected during the trial.

Despite these constraints, production estimates indicated that a two-yarder Koller system comprising four workers in each operation and a shared processor (using a quick coupler attachment) could provide unit rates comparable to current New Zealand operations but would rely on efficient use of the machine and well scheduled truck arrival times.

Use of a Koller yarder in New Zealand conditions would probably be limited to harvest areas with an average piece size of less than 1.6 tonnes. The Koller is also suited to operation at roadside or on small landings in conjunction with a processor and loader.

Once the machine is fully commissioned and operators are experienced a further estimate of productivity should be completed to investigate the potential of the Koller yarder system working in typical New Zealand radiata pine plantations.

Acknowledgements

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References

1. Visser, R., Spinelli, R., and Stampfer, K., New developments in European yarder technology. Harvesting Technical Note HTN04-01, Future Forests Research Ltd: Rotorua, N.Z. (2011).
2. Koller (2014): Koller yarder technologies. Koller Forsttechnik GmbH, Kufstein, Austria, retrieved November 6, 2014, from http://www.kollergmbh.com/index.php/service/prospekte
3. Stampfer, K., Visser, R., and Kanzian, C., Cable corridor installation times for European yarders. International Journal of Forest Engineering, 17 (2), 71-77, 2006.
4. MBIE (2012): Approved code of practice for safety and health in forest operations. Ministry of Business, Innovation and Employment, Wellington, New Zealand, (2012).
5. Visser, R., Harvesting cost and productivity benchmarking: 2013 update. Harvesting Technical Note HTN06-06, Future Forests Research Ltd: Rotorua, New Zealand. (2014).