# HARVESTING TECHNICAL NOTE

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# Measuring the utilisation of winch-assist machines

## Summary

The introduction of winch-assist for felling machines over the last decade to support felling and shovel logging has allowed ground-based harvesting machinery to work safely on significantly steeper slopes than unsupported machines. This has promoted increased mechanisation of tree felling in cable operations, reduced the reliance on motor-manual felling and opened up opportunities for grapples to replace choker-setters during the extraction phase. However, winch-assist units incur a significant capital cost, and increasing the machine utilisation is a typical way of reducing operating costs by spreading fixed costs over more working hours. As winch-assist is only used to support felling machinery when required, it was expected that machine utilisation would be highly variable, and lower than that of machinery used full-time. This report presents the findings of two studies to evaluate the utilisation of winch-assist machines. The first study was a survey of existing machinery and their operating hours. Utilisation of the 12 machines surveyed averaged 45% of scheduled time, ranging from a low of less than 20% up to 80%. The second study gathered more detailed information on delays through the use of GPS navigation devices on two machines operated by a contractor in Hawkes Bay.

**Hunter Harrill, Ben Reriti & Rien Visser,**
**University of Canterbury, School of Forestry**

## INTRODUCTION

Forest harvesting machinery incurs high capital cost, and one key metric for minimising the ownership cost component is ensuring a high level of utilisation. However, harvesting systems are complex, and individual machines can often be delayed by repair and maintenance demands (mechanical delays) or by simply awaiting a task that is being constrained upstream or downstream of the machine in the system (operational delays). Machine utilisation data drives management decisions such as machine costing (Miyata & Steinhilb, 1980), productivity target calculations, and in distinguishing between machine alternatives (Spinelli & Visser, 2007). Utilisation data is also useful for forest managers and loggers for operational planning and identifying system productivity improvements.

Most productivity studies of harvesting systems or machinery report utilisation rates, and over time a lot of information has been collected for common equipment including cable yarders, skidders, grapple harvesters and loaders. However, for relatively new systems such as winch-assist machinery there is almost no information. Only one study has been published, where a 71% utilisation rate of a Falcon winch-assist machine in British Columbia, Canada was reported. It was suggested anecdotally that utilisation rate could range from 40 to 70% (Amishev & Dyson, 2018).

Traditional methods for establishing utilisation usually consist of on-site observation or recording of machine activity for a given period of time, also known as time and motion study, or work study.

While this method is accurate, it is also both labour intensive and time consuming, and as such these studies are typically constrained to just a few days of data collection. For studying felling systems, the ability of the observer to be in an optimal position is also often compromised by the requirement to be a safe distance from operational equipment.

Winch-assist systems are not new to the forest industry (Visser and Stampfer, 2015), and in New Zealand they have become increasingly common over the past five years in an effort to increase the range of ground-based harvesting systems (Visser, Raymond, & Harrill, 2014). This has resulted in an increase in mechanisation in harvesting operations in a bid to reduce serious harm incidents which often involve personnel on the ground, such as manual tree fallers.

Winch-assist machines are often not required all day, every day. They are used only to support the movement of machines up or down slopes that exceed the ability of the felling machine to


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traverse safely or efficiently or without excessive ground disturbance.

The Operations Manager at Pan Pac Forest Products Ltd, Damon Wise, noted that in his experience winch-assist machines often were unused for periods of 3 to 4 days at a time. It was highlighted that there is no current data regarding the utilisation of winch-assist machines in New Zealand, nor is there any information on the factors which influence the utilisation of these systems.

## OBJECTIVES

The purpose of this project was to provide an indicative range of utilisation rates of winch-assist machinery using two methods: a survey of machine owners, and the use of Global Positioning System (GPS) navigation devices on-board forestry machines that would allow such data to be captured in more detail and automatically. The long-term data obtained from the survey of contractors was compared with detailed short-term data obtained from the GPS study. For the detailed study, factors that influenced utilisation rate were also investigated.

## METHODS

### Utilisation Rate

Utilisation rate (UR%) is the ratio of productive machine hours (PMH) to scheduled machine hours (SMH) expressed as a percentage:

$$\text{Equation 1: } UR\ \% = \left(\frac{PMH}{SMH}\right) * 100$$

To determine UR% for winch-assisted machines PMH must be recorded. PMH is defined as any time the machine is carrying out its primary task; all other time is assigned to various categories of delay. The method for collecting long-term PMH was through a machine survey, and assumptions need to be made about the SMH worked. Short-term PMH and SMH data was collected from the machine on-board computer using an integrated GPS.

### Machine Survey

A survey of contractors owning and operating winch-assist machines in New Zealand, and manufacturers who produce machines, was conducted. Only 12 responses were received, whereby it was noted that only about half of the contractors contacted were able to provide machine hours and months owned.

The machine type, the hours on the machine and the purchase date were recorded for each machine. From the information provided the average monthly use (in hours) was calculated and used as an estimate of PMH. In order to convert machine clock hours into an estimate of utilisation, it was assumed that each month comprised 180 SMH based on the measured average of 9 SMH per day from the FGR benchmarking database (Visser, 2017).

### GPS Study

Installing GPS navigation devices on forestry equipment presented some challenges. Firstly, to determine if forest canopy cover affected location data capture, and secondly wiring the units so that they were able to capture the necessary information to accurately derive utilisation of a winch-assist machine.

Navman GPS units are typically used for fleet management purposes (e.g. logging trucks), and have the ability to capture a wide range of data. Navman GPS navigation devices were installed in a Tractionline winch-assist machine and a Caterpillar 552 felling machine in December 2017 (Figure 1).


**Figure 1: Navman GPS unit mounted on the CAT 552 felling machine.**



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The CAT 552 is a purpose built felling machine for use on steep slopes, and the Tractionline is manufactured by Electrical & Machinery Services Ltd (EMS) in Rotorua, NZ.

After the Navman GPS units were installed data was captured from both machines for a period of 5 months from January 2018 until the end of May 2018. The units captured machine On/Off data and distinguished machine movements and identified when and where the machines were moved. Location information as well as machine status was updated at one-minute intervals when the machine was turned on (Figure 2).


**Figure 2: Navman user interface showing felling machine movements for one day's work.**

The Navman interface also allowed the user to see live updates of where a machine was operating, and how long it had been "On" or "Idle", as well as determining whether the machines were working together or not – a key step in diagnosing why a machine was not working when it was expected to be. For the purpose of calculating UR% for the winch-assist machine, "On" hours were used as an estimate of PMH; SMH for each day were provided by the logging crew and forest manager.

## GPS Study Sites & Systems Description

The two machines studied during this project were a Tractionline winch-assist and Caterpillar 552 felling machine (Figure 3) owned and operated by D G Glenn Logging Ltd (DGL) in Napier.

DGL manages approximately 18 crews in the Hawkes Bay region. This mechanised felling system was often rotated between a number of DGL crews as required. During the study period the felling system was operated at four different sites across the region, all of which were forests owned by Pan Pac Forest Products Ltd, or woodlots acquired by the company.


**Figure 3: Tractionline winch-assist and CAT 552 felling machine.**

The four study sites covered a range of operating conditions. Maximum slope and felling distance data were recorded on-site both during and after harvesting had occurred (Table 1).

**Table 1: Summary of study site characteristics for felling system.**

| | Max Slope (degrees) | Max dist. felling machine from winch (m) |
|---|---|---|
| Site 1 | 48 | 130 |
| Site 2 | 44 | 180 |
| Site 3 | 37 | 160 |
| Site 4 | 30 | 88 |

The Cat 552 feller buncher was shovel logging and bunching at Site One (Figure 4).


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**Figure 4: CAT 552 Felling machine shovelling/bunching at Site One.**

Site Three comprised a difficult woodlot setting that contained a large amount of wind-throw (Figure 5).

**Figure 5: Site Three, a woodlot harvest setting that contained a large portion of wind-throw.**

## RESULTS

### Machine Survey

Twelve machines covering the four main New Zealand manufacturers spanning from Northland to Southland were surveyed over a five month period. The productive hours per month that winch-assist machines were used varied from 31 to 150 (Figure 6).

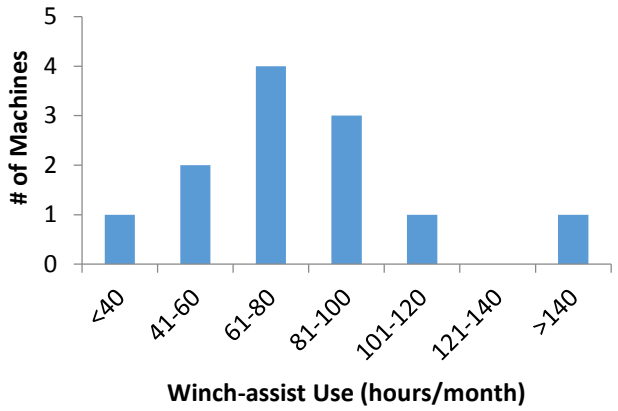


**Figure 6: Monthly hours of use for 12 surveyed winch-assist machines.**

One system reported an average of 31 hours per month, which equated to 17% utilisation. At the other extreme, one system reported 150 hours per month, which equated to 83% utilisation. The mean (average) utilisation calculated was 45%.The median, or most common response (4 of the 12 machines), was between 60 and 80 hours per month, which equated to machine utilisation of 33-44%.

### GPS Study

In total the GPS units showed that the CAT 552 felling machine worked for 113 days (794 hours), and the Tractionline winch-assist worked for 80 days (455 hours) during the 5-month study period. Average daily operating hours for the winch-assist were directly affected by felling machine use. The average “On” time for the 80 days the two machines were together was 5.68 hours per day. The average “On” time as a proportion of the 113 days the felling machine worked was only 4.0 hours per day.

Two values of utilisation have been derived for the winch-assist machine, the first based on only the time the two machines were working together. The second value is the total winch-assist hours worked as a proportion of total felling machine time (Figure 7).


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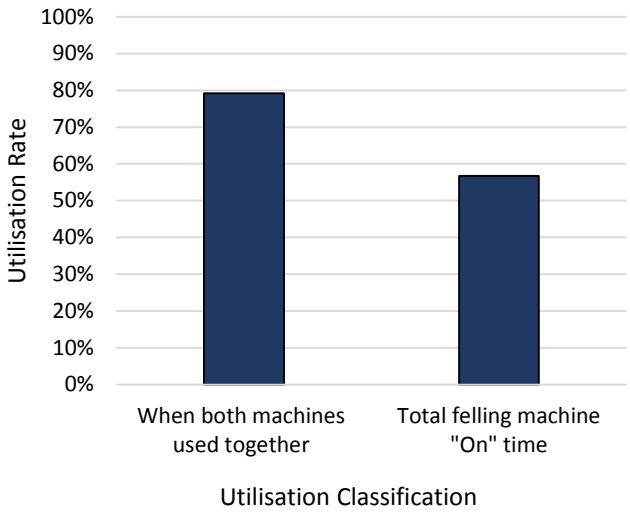


**Figure 7: Average winch-assist utilisation rates for the 5-month study period.**

The average utilisation rate of the winch-assist machine when working with the feller buncher was 81% (5.68 hours out of 7.02 feller buncher hours per day). The utilisation rate calculated as the total winch-assist hours as a proportion of total felling machine time (455/794 hours) dropped to 57%. While the 'productive' machine utilisation of the winch-assist on the days it was working was quite high (81%), the 33 days when the winch-assist machine was not used reduced its 'effective' machine utilisation to only 57%.

The major contributing factor in the difference in these utilisation rates was that the felling machine was often required on ground-based settings where winch-assist was not required. As the contractor did not have any other felling machines available to work with the winch-assist, the machine was simply not used until the feller machine returned to the cable harvest setting.

## Delay Study

Machine "On" and "Off" hours were used as the primary data to derive utilisation rate. However, just because the machine was "On" did not mean that it was necessarily being productive. While the GPS unit could identify when the machine was not working (i.e. a delay had occurred), it could not distinguish the reason for the delay. Therefore, hours "On" indicated by the GPS unit was considered to be an imperfect estimate of PMH.

For this reason a 3-day delay study was conducted to determine how well the GPS measured delays and to gain an understanding of what affected the utilisation rate of the winch-assist machine.

For this delay study, the utilisation rate of the Tractionline winch-assist machine on Day 1 was 60%, when it was used for a full day's work. On Days 2 and 3 the winch-assist was used only for a portion of each day and the delay time did not account for when the felling machine was still operational and the winch-assist was not. For days when the two machines were working together only, the utilisation rates were 80% and 68% respectively. Overall the utilisation rate for the three-day study period was 73%.

Results from the delay study carried out in the field were also compared to the GPS data captured on the same days, with the aim of determining how accurately the GPS units captured delays, compared to what was observed (Table 2).

**Table 2: Comparison between GPS and actual delay data.**

| | Total GPS Delay (min) | Total Measured Delay (min) | Δ (min) |
|---|---|---|---|
| Day 1 | 224 | 214 | -10 |
| Day 2 | 40 | 48 | - 8 |
| Day 3 | 43 | 53 | +10 |
| Total | 307 | 315 | -8 |

The results difference varied by up to ±10 min on any given day, but overall for the 3 days the difference was only - 8 min, or 3% of GPS delay time. Given these results, use of the GPS was considered to be a relatively accurate method of recording delays.

The GPS units captured all major (>10 min) delay events during the 3-day study period. Variation between observed and GPS data was due to short personal and operational delays that were


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not captured by the GPS units, but were observed during the study period. The GPS units were wired to the hydraulic lock-out on excavators which determine machine "On" and "Off", therefore during these short delays observed it could be assumed that the operator had not engaged the hydraulic lock-out, which is a plausible assumption as the operator remained in the machine during each of the recorded delays.

Overall the delay result was satisfactory (± 10 minutes per day), the difference between GPS delay to measured delay recorded for the full day the winch-assist was used being only 4%. For the two half days that the winch-assist was used, only 48-53 minutes of delays were recorded each day. The difference between that recorded and observed was -8 to +10 min, but as a percentage of recorded GPS delay that equated to 20-23% difference. As a result it is recommended that the GPS system should not be considered accurate for short recording periods of less than one full day.

Figure 8 shows that the majority of delays during the three-day study were operational, and fell into one of five different categories. The majority of the delays were associated with moving or re-positioning the winch-assist machine.

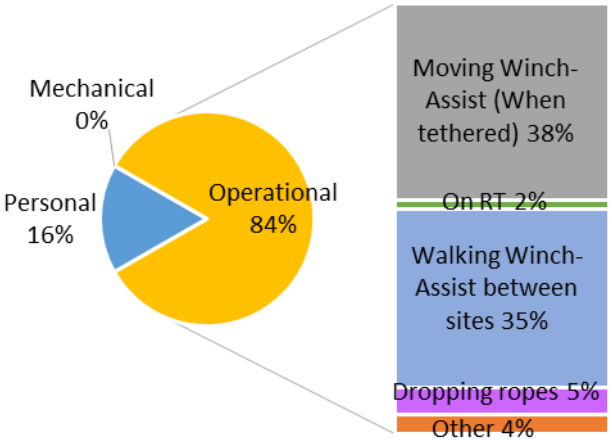


**Figure 8: Types of delays observed during the three day delay study.**

## DISCUSSION

This was the first time GPS software had been used to estimate the utilisation of winch-assist machines in New Zealand. Whilst the reporting software is available, data must be manually checked against machine activity to determine whether the two machines are working together, and also the cause of machine delays.

This project has helped to refine the use of the GPS method for Teletrac Navman, and once the user becomes familiar with the reporting software and identifies exactly what they want the units to capture and measure, the use of fleet management GPS units to estimate machine utilisation should increase.

Data collection from the Navman GPS units was found to be a straightforward process. Analysing and comparing recorded data and in-field observations however was more complex. Navman provided a number of user interfaces that summarised all data collected. Working with Navman allowed users to tailor the reporting software to portray the data in an informative and easy to interpret graphic. This interface is still under development as the units are currently in a trial phase, therefore the full capability of the user interface was not used to its full potential during the data collection and analysis for this study. However, Navman does have the potential to provide a straight forward "click and collect" interface, based on the user's specific requirements.

In any study there are usually data outliers. It has been assumed that "On" time for any day that totalled one hour or less was disregarded, as this corresponded to a winch-assist machine being moved or relocated and not actually working with the felling machine. When cases such as this occurred, each was checked against the Navman user interface and GPS data to confirm this assumption.

Pan Pac Forest Products Ltd had an expectation that utilisation for the winch-assist machine would be at least 75%. While the 'productive' utilisation rate of 80% met the company's expectations, it


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did not include the time that the winch-assist was not used when the felling machine was. Therefore, the true utilisation rate of 57% (≈ 5.7 hours per day for 16 days per month, or 91 hrs/month) was the 'effective' utilisation rate as this value represented the proportion of time that the winch-assist could have been used, but was not.

Using the felling machine on other jobs not requiring the winch-assist, and the limited opportunity for keeping these two machines working together all the time were two factors that influenced the utilisation rate. The full cost of the winch-assist machine would have to be apportioned across the two harvest areas felled with the CAT 552.

The study also showed that delays were mainly attributed to the operational setup of the machine (moving the winch-assist while tethered to the felling machine and moving the winch-assist between sites).

## CONCLUSION

These findings demonstrated that Navman GPS units can accurately estimate the utilisation rate of a Tractionline winch-assist machine, with an average variation of 3% between field measurements and data captured by the GPS units.

Utilisation for the Tractionline winch-assist machine was calculated to be 57% over a period of five months, which included all of the days that it was not used. This was higher than the mean machine utilisation of 12 winch-assist machines captured in the survey of owners (45%).

## ACKNOWLEDGEMENTS

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