Technological Developments in Cable Logging

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Abstract
Cable logging systems have been a common method of extracting timber on steep and difficult terrain in many regions of the world for over a century. The pace of development and integration with new technologies provides opportunities for improved productivity and safety and has gained momentum in recent years. These developments include: hybrid electric engines offering fuel savings and reduced noise levels; automated controls which speed up processes and free up operators for other tasks; carriages with integrated GPS and camera systems; new rigging configuration concepts; new types of wire rope, and choker-setter tracking systems for safety. Geographic Information Systems (GIS) and the use of LiDAR are finding new uses in not only planning for cable logging systems but also for gathering data including productivity monitoring and benchmarking. Increased computing power has allowed technology to become faster, smaller and more robust. Coupled with new software applications and increased network coverage, some regions are capable of monitoring operations in real-time and are able to have a faster feedback loop aiding in the planning and decision making process. This paper describes some of these technological developments that are being researched and trialled in New Zealand. Conclusions are drawn about what the future of cable logging operations may hold after the current technological step change has occurred.

Key Words
Harvesting, Yarding, Planning, Equipment, Software, Productivity, Economics

Introduction
Cable logging systems have been a common method of extracting timber on steep and difficult terrain for over a century. During this time the proportion of steep and difficult terrain harvested requiring cable logging methods has increased; in some nations these areas now represent the majority of annual harvest volume. In some regions the transition has been gradual and even predicted, while others have been more sudden (Carson 1983). Cable logging is inherently expensive because it is deployed on difficult sites and the complexity of a yarding system requires larger investments to achieve a lower production target compared to ground-based systems (Spinelli et al. 2016). Costs include the capital investment in machinery (fixed costs), the variable operating and repair costs and the cost of labor.

For cable logging, approximately half of the costs are related to the yader extraction and therefore production is of paramount importance (Murphy 1979). Cost-effectively harvesting timber on steep terrain requires not only the need for improved operational efficiency to remain competitive in an international market, but also to overcome challenges of safety and environmental performance (Raymond 2012).

For many years mechanization has been the most preferred and successful way of achieving operational efficiency in timber harvesting (Sundberg & Silversides 1987). Sometimes a step change in the harvesting process was driven by periods of low, or no, profitability. This is referred to by Samset (1985) as the “law of discontinuous evolution,” (Figure 1). The law can be observed in several different stages: Stage one is “price pressure” where increasing costs erode profitability.

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Stage two is when new developments emerge and are trialled. Stage three is when the successful new developments are introduced, which exhibit a sharp learning curve. Stage four is when the new developments are stabilized and become widely used.

![Figure 1: Stages of discontinuous evolution for harvesting systems (Samset 1985).](image)

The last few decades have seen considerable changes to logging practices in places like the Pacific Northwest (PNW) and New Zealand. The demise of many yarder manufacturers in the 90’s has led to an aging fleet in conjunction with increased costs of labor and environmental compliance, exacerbated by greater proportions of harvests on steep and difficult terrain consisting of smaller second growth or plantation forests. This has created significant economic pressures on cable yarding practices and some regions are probably experiencing the first stage of discontinuous evolution. Samset (1985) suggested that nominal costs of logging operations will always increase over time; however, the only way to decrease the operational costs is to introduce new organization of the work (planning), methods (techniques) or by introducing new equipment.

In New Zealand there are clear signs that a step change in cable logging is already underway. This presentation and accompanying paper aims to describe some of the technology that is being researched, trialled and introduced to the forest industry with potential applications overseas.

**GIS Tool and Cable Logging Planning**

Cable Harvest Planning System (CHPS) is a payload analysis software program much like Logger PC and SkylineXL, only fully integrated with the ArcGIS environment as an add-in program (www.cableharvesting.com). The program allows the harvest planner to select landing locations and then automates the calculation on physical feasibility with regard to both corridor distance and payload limits for various skyline systems and rigging configurations (Figure 2).
Deflection App – A Tool for Measuring Deflection in the field

While the analysis software calculates payloads, in order to ensure that the planned payloads are feasible, the machinery needs to be set up according to what was designed, especially in regards to deflection. Sessions (1976) described how to measure skyline deflection in the field, but few loggers used these methods as they required some mathematical calculations along with measurements of distances and angles using tools such as an inclinometer. With many loggers now having access to smart phones that are capable of measuring angles, one recent development is a deflection measuring app. This App provides users with step by step process for measuring deflection (from either the landing or tailhold position) using the phones inclinometer in conjunction with a laser range finder to measure distances (Figure 3).

Drones to aid set-up

Typically, initial skyline set-up and line shifts result in considerable non-productive delays (Olund 2001). One way of reducing the time and man-power required for setups is using new drone technology to fly a light weight synthetic straw line across the spans (Figure 4). The process which
normally requires multiple workers and several hours of strenuous work can now be completed in a half hour with minimal effort (Winmill 2015).

![Remote Control of Mobile Tailholds and Carriages](image1)

**Figure 4:** Eight rotor remote controlled helicopter used for running straw line in yarder setup process.

**Remote Control of Mobile Tailholds and Carriages**

Mobile tailholds (i.e. using a machine as an anchor) have been a favorable way to reduce the time associated with line shifts. However, the practice still requires someone to move the anchor machine. A recent research project has installed a remote control system into a Volvo EC290 excavator, where with the aid of cameras mounted in the cab, the yarder operator can reposition the anchor machine on their own (Raymond 2016).

A system that reduces the need for line shifts is the “twin winch tail hold carriage,” and a prototype of this carriage has been developed by Awdon Technologies Ltd (Figure 5). The skyline would shackle to this carriage and radio control of the carriage would pull the skyline towards one of two anchor points at the back end of a cable span, perpendicular to the skyline (Scott & Hill 2015).

![New cabs and control systems for older yarders](image2)

**Figure 5:** Twin winch tail hold carriage prototype developed by Awdon Technologies Ltd.

**New cabs and control systems for older yarders**

New yarders incorporate features designed to optimize both the system controls as well as the ergonomics to reduce operator fatigue. Cabs and systems are now increasingly being retrofitted to older machines with features such as adjustable seats with electronic controls simplified to two joy-sticks. Most utilise Programmable Logic Controllers (PLC) for electric over air or electric over
hydraulic controls, which can be programmed to optimise the winch performance by selecting a rigging configuration or mode (e.g. grapple, carriage or scab); (Visser et al 2013). Other features offered by these new computer-operated control systems are; simplicity of operation including more precise control of machine functions, audible alarms and indicators for distance and tension, ease of maintenance with machine diagnostics displayed on a screen in the cab and troubleshooting using a visual test points function (Figure 6). The computer controlled systems also provide the opportunity for autonomous control of certain processes (e.g. carriage outhaul) which have become standard for many of the European manufacturers.

![Modern cab with simple joystick controls and PLC system](image)

**Figure 6: Modern cab with simple joystick controls and PLC system (courtesy of Brightwater Engineering Ltd.).**

**Camera Systems**
Camera systems are also finding their place in yarding operations, for example in grapple yarding where a spotter is normally required. Cameras can be set up in the harvest area and relay a video feed to a screen in the cab of the yarder that can be remotely panned and zoomed ([www.cutoversystems.com](http://www.cutoversystems.com)). Cameras have also been integrated into new motorised grapple carriages designed for tower yarders, or mounted externally onto other carriages like swing yarder grapples (Figure 7). These carriage camera systems can also include infrared mode for low light conditions, GPS tracking, provide distance and altitude information and can transmit up to 900 meters ([www.dcforestryequipment.com](http://www.dcforestryequipment.com)).

![Integrated and externally mounted camera systems](image)

**Figure 7: Integrated and externally mounted camera systems (courtesy of DC Equipment Ltd.).**
Tension Monitoring App

Tension monitors are widely regarded as a useful production and safety tool. Usage allows accurate moderation of cycle volumes resulting in less rope failures and extended rope life. Tension monitoring also allows cycle volumes to be modified to suit the lift capacities of a site. However, most tension monitors only have a digital numeric display and the information is lost (i.e. cannot be recalled) after it has been displayed. A new type of display and data management system for tension monitors has been developed into a Tension Monitoring App. The App displays tension in a live streaming graph much like a heart rate monitor. Users can scroll backwards in time or zoom in or out to view different peaks and time frames. Additionally, there are color coded zones displayed on the graph that relate to the selected rope’s safe working load, endurance, and elastic limit; at any point in time a routine can summarize the operating time spent in each of these zones (Figure 8). In addition to monitoring and improving safe operating practices, the App should also be useful in helping to train new machine operators, to assess the effect of different operating techniques on overall tension loading and behavior, document rope wear and service life and should complement other software that provides feedback to operators.

![Tension Monitoring App](image)

*Figure 8: Tension monitoring app under development by University of Canterbury, showing two hours of continuous tension data (left) and summary of operating times in different loading zones (right).*

Another example of feedback software is the ACDAT (active data) system, an on board data storage computer system produced by Active Equipment, which is standard with the company’s new yarders or can be retrofitted into older machines (www.activeequipment.co.nz). This system is a one screen, multiple application computer which has four key functions: GPS tracking of choker-setters, live time tension display, modelling of the terrain and operations data recording. This information is stored by day and over a month of data is retained on the computer. Information categories include; skyline tension, mainline length, skyline length and engine voltage to name a few. The option for the yarder operator to manually enter haul statistics also exists.

For the choker-setter tracking system, the choker-setters wear a special GPS unit that are synced each morning with the yarder. The system creates a virtual skyline corridor between the tail-hold and the yarder around which a safety corridor is set. The corridor width can be changed as desired, but generally is set at the safe retreat distance. The yarder operator can track the location of the choker-setters on a screen at all times without needing a clear line of sight. As a secondary warning system when the choker-setters are inside the pre-set corridor, a flashing warning is present on the operators ACDAT screen (Figure 9). This means that any miscommunication regarding location of choker-setters is avoided and accidents are less likely to occur.
Hybrid Yarders
One development that has not yet reached New Zealand, but creates a larger amount of excitement, are the new hybrid yarders. In 2015 Koller released a prototype of a diesel electric hybrid machine (K507H-e) which is said to use 70% less fuel than a diesel yarder of the same size and output (Figure 10). In addition to fuel efficiency (multiple weeks between refuelling) and long service intervals (2000 hour service intervals requiring only 5 litres of oil and standard filters), the electric winches offer smooth variable continuous power to the drums (i.e. highest torque at lowest speed), and the pulling force remains constant over the full range of the drum layers. Operating the electric winches will also be easier to configure for either automated or remote control operation. Koller and several other European manufacturers have also produced electric slack pulling carriages where a battery is used to operate the skyline and mainline clamps and drive the slack-pulling system. An alternator (or similar device) is driven by the carriage sheaves as it moves along the skyline to charge the battery.

Figure 10: Koller 507H-e hybrid electric yarder (left) and ESK 2.0 electric slack pulling carriage (right).
Modern engine configurations also offer decreases in decibel emissions compared with older machines, which can create a safer work place due to reduce fatigue and better situational awareness. A study by Campbell (2016) compared decibel emissions from three different yarders, a Thunderbird TSY 255, a new Active 70 (produced in New Zealand) and a new Koller 602h; and at a distance of 10 meters from the machine the average decibels were 92, 80 and 65, respectively.

**Conclusion**

There are a number of new developments in cable logging technology, a few of which are presented in this paper. Clearly, a step change is already underway and improvements to cable yarding will come from not only new machines and the features they offer, but improved planning and successful implementation of new techniques. In order to fully realize the potential of these developments practitioners should be proactive with their involvement in trialling, learning and stabilising these new technologies.

**References**


