Tethered Machine Serious Harm 2016
New Zealand

MAXIMISING INCIDENT LEARNING OPPORTUNITIES

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1.0 PROJECT BACKGROUND

Simple cause and effect incident analyses do not address, understand or explain the dynamic interactions that persist in the complex systems our industry faces each day. The intent of an incident investigation is to prevent reoccurrence and to protect our people from further injury. To effectively prevent future adverse events, we have to be able to learn from the context of each incident.

During 2016, FISC commissioned Scion to undertake a Pilot Project to demonstrate the applicability and practicality of a new approach to adverse event investigation in New Zealand forestry incidents. The Learning Review is a comprehensive, applicable methodology based on dynamic inquiry rather than categorical assessment. Phase II of the work began in January 2017 and includes the completion of five case study Learning Reviews of recent incidents in the forest industry, as well as building capacity within industry to undertake the approach.

Error and uncertainty are unavoidable in the highly complex and dynamic environment in which the forest industry operates. Thus we must assume incidents will happen and direct our resources towards reducing the magnitude of adverse events. The Learning Review has been designed to maximise incident learning opportunities. We can use the process to learn ways to reduce the prevalence of contextual pressures, to allow error to exist without consequence, and to recover and adapt when the unexpected is bound to occur.

Maximising Incident Learning Opportunities Incident 4
Tethered Machine Serious Harm

The catalysing incident for the Learning Review occurred in June, 2016. It was determined that the incident aligned with the defined Selection Criteria, specifically:

i. The incident occurred well within the previous 12-month time period.
ii. The incident fits all 'Access', 'Information', 'Severity', 'Geographic Range', 'Operational Scope' requirements as well as learning value capacity, legal risk issues and uniqueness.
iii. The incident is relevant to the FISC Critical Risk Area of man versus machine.

PHASE 1
Information collection

Inquiry, identification of performance influencing factors, information collection and synthesis to create a complex narrative.

PHASE 2
Analysis and sensemaking

Use of focus groups and Subject Matter Experts to develop learnings and recommendations

PHASE 3
Application and adoption

Learning Review learning opportunities are evaluated and adopted by industry

Figure 1. Incident Scene http://www.newshub.co.nz/home/new-zealand/2016/06/man-injured-in-methven-logging-accident.html (retrieved 2 December 2017)

NOTE: There are numerous different tethered system setup types that utilise a diverse range of controls, displays, braking systems, and ropes. To limit the scope of the review to a manageable degree, where possible this report refers to the bulldozer anchor setup present in the incident. Any reference to other tethered systems will be identified in the text.

Blue is Focus Group comments and perceptions

It was thought that the bulldozer was anchored in a good position on flat ground with the blade buried in behind a large stump.

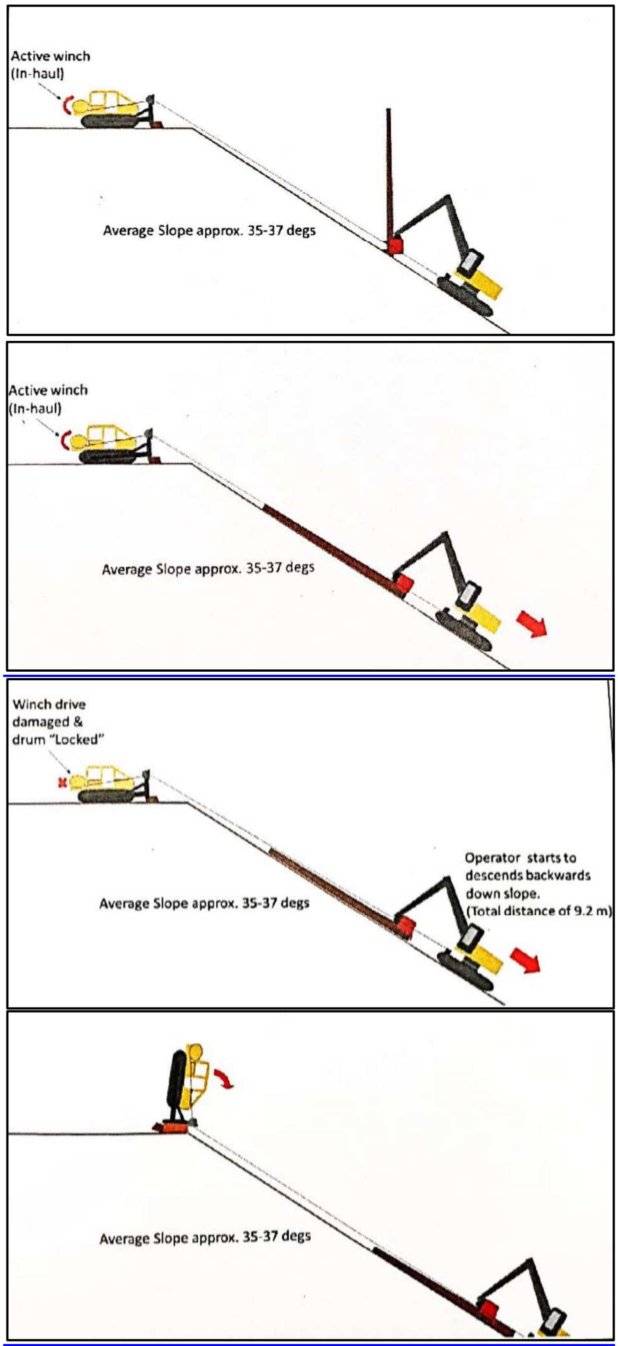

Figure 2. Incident Diagram.

The incident occurred on a 35- to 37-degree slope (that was up to 38 degrees in some places). The terrain was shingly underfoot.

The blade of the bulldozer anchor was buried behind a large stump, positioned facing downhill on flat ground. The bulldozer anchor machine weighed 33 tonnes, and the felling machine weighed 42 tonnes.

The feller buncher had been shifting the wood to the bottom of the slope for approximately an hour. The grapple skidder was dragging the bunched wood to the skid site landing terrace 200 metres away.

The teeth of one of the cogs in the winch known as the 'ball gear' had shorn off causing a mechanical failure that seised the winch dislodging the anchor bulldozer when the felling machine moved.

The felling machine continued to manoeuver nine metres down the slope on inhaul setting '2'. In a total of six seconds, the bulldozer anchor stood up on its end (Figure 2).

Looking up from the landing, the crew members noticed the bulldozer coming down from its anchored position. The bulldozer fell end over end descending 68 metres before glancing off the boom of the felling machine which halted its momentum. The operator dived out of the cab approximately at the same time the bulldozer hit the felling head boom sustaining serious injuries.

Tethered Operations in New Zealand

In New Zealand, harvesting on steep terrain is a challenge in terms of economic and environmental viability, as well as safety performance. Motor-manual felling with a chainsaw on steep terrain is the highest risk New Zealand forestry workers face, with many forestry companies encouraging their contractors to adopt tethered harvesting systems that work in mountainous environments (Visser, Raymond & Harrill, 2014). Slope is not the only influencing factor affecting safe operations or system productivity on steep topography (Strandgard, Alam & Mitchell, 2014). Soil bearing capacity, the vehicle-terrain interface and operator skill also have an influence (Heinimann 1999).

Across New Zealand, winch-assisted harvest systems can successfully log steep slopes, effectively compensating for certain conditions to assure the stability of the harvesting machine.

In steep slope harvesting, the real safety concern is the risk of machine roll-over. Forestry machines working on steep inclines will typically lose traction before rolling over (Visser, 2013). The loss of traction results in an uncontrolled gain in momentum and if followed by hitting an object, such as a stump, or a change in terrain slope, can readily result in a roll-over (Visser & Stampfer, 2015). Furthermore, Visser and Berkett (2015) have found that ground irregularity and stumps can have more impact on the position of the harvesting machine than the underlying gradient of the hill.

A cable connected to the machine can help maintain traction, thus extending the operating range to diverse slope gradients. A common misconception with tethered steep slope feller bunchers is that they are suspended and may fall over or slide uncontrollably without the winch rope holding them in position. The winch rope is actually designed for traction assistance and does not hold the machine on the hillside (Evanson, Amishev, Parker & Harrill, 2013).

In a two-part tethered harvesting system, a bulldozer or excavator powers a mounted winch. In addition to better mobility, this configuration removes the weight and power requirements from the machine on the slope (Visser & Stampfer, 2015). In an excavator setup, the tracks are pointed downhill with the bucket scoop dug in and embedded in the ground in front. The winch rope is fed along the boom so that when the rope is tensioned and pulling it forces the bucket into the ground creating a low centre of gravity that aids stability. In comparison, a bulldozer anchor feeds the rope through a pulley mounted on the blade. Therefore the angle of pull is substantially different between the two anchor points. The bulldozers blade is buried in behind a stump parked on flat ground. This means that an excavator is more convenient to move after each run because a stump is not required. Once the anchor is in position a 'pull test' is carried out. The pull test is always conducted on the straight run. The ground is tested for its water content daily as it is challenging to forecast conditions based on weather.

It was a commonly held opinion that the operator only trusts himself to set it up.

Typically, the feller buncher operator is responsible for setting up the mobile anchor at the beginning of each run. The winch is started remotely from the feller buncher. The operator can monitor the oil pressure, engine temperature, and select pull pressure setting. On the digger setups, it is possible to view a backward facing camera mounted on the anchor machine from a dashboard in the feller buncher. Depending on the type of tethered system, there are a number on sensors on the mobile anchor machine including (but not limited to) overheat sensor, hydraulic sensor, fuel sensor (cut out), movement monitor, and e-stop sensor (on both the inside and the outside of the machine on the digger setup). Typically, there is an over-speed sensor integrated into the winch drum. When an over-speed alarm occurs, it initiates braking within the winch automatically slowing it down to prevent shock-loading. The operator must either flick a toggle switch or hold a button on a touchscreen to turn the brake off. One sensor common to most systems is known as a 'movement monitor' or 'breakaway monitor', which is attached to the anchor machine and secured in the dirt behind. If this monitor is pulled out during the pull test, then a crew member is sent to check. If the door opens on the anchor machine, an alert will sound in the feller buncher. Should the door alert or the movement monitor sound, then all movement in the harvesting machine must cease. The incident system did not have a movement monitor installed.

The primary concern of the operator is the feller buncher rolling, not the anchor machine becoming dislocated.

The winch system functions like a fishing reel, enabling the maintained tension/pressure of the rope for the entire run. In the incident setup, there were three settings of wind-in pressure – '3' is the highest pull pressure (21 tonnes) and '1' is the lowest. When operating, the wrong power setting can put undue pressure on the winch gears. Revs are essentially equivalent to power. Pull pressure on the incident system was set through a torque converter with a 21-tonne maximum. The winch brakes will come on if the feller buncher is moving too fast (the rope is spooling too fast) like it is falling. The over speed sensor picks this up. There is a safe working load maximum instituted during operations of 23 tonnes. If the winch stops for any reason, it is common practice for harvesting machines to remain in position until identifying the cause.

The operators maintained that they do not go over this intentionally when working.

Depending on the system, the felling head is operated using a joystick with buttons on the side to open and close the grapple, initiate the saw and release the log. The joystick also controls the inward/outward and up/down motion of the boom. Foot pedals drive the felling machine itself. The winch power setting displays differ across machine setups. Some machines have a touchscreen, some machines have control buttons mounted on one of the joysticks, and some even have the winch settings integrated into the foot pedals. Operators agree that it takes time to become accustomed to the control setup, but after a few months it becomes second nature. All tethered systems will monitor the tension of the ropes. Most operations will fix the tension monitoring device to the winch. However, some contractors attach the device near the drawbar of the felling machine to obtain live weights as they are working.

The work method of the operator is to fell mostly downhill in the steeper sections, and across slope in other areas. After felling several trees, the machine is manoeuvred downhill to enable slewing/bunching/shoveling using gravity (Evanson, Amishev, Parker & Harrill, 2013). The harvesting machine begins felling the trees at the top of the run, working its way down the slope in a relatively straight line. The felled trees are shovelled to the side. The length of time it takes to complete a run varies depending on face length and terrain. At the end of a run, the operator will engage the winch to winds on steadily. If the harvested slope is below the landing, then the operator will bring the wood down with him to the skid site. At the top of the run, the operator may shift the anchor machine and head down again to bring up more felled wood.

The situated landing (skid) can be above or below the slope. Depending on the terrain, the harvesting machine will bunch the wood so it is accessible to a skidder. One of the primary goals of the felling machine operator is to manoeuvre the trees into a more manageable spot. The skidder then drags them to the landing for processing. Ideally, this will occur when the harvesting machine is at least one or two runs ahead if the landing is downhill so no machinery is directly under the felling operations.

Focus groups were assembled to map/understand the connections between pieces of information gathered in Phase 1 Data Collection and Synthesis. The focus groups considered the key actions/decisions identified in the incident and standard operating procedures, regulatory requirements and organisational policies. Events are a function of systems interactions, decisions, assumptions and conditions exclusively related to the operation and environment. The following analysis will illustrate the conditions which influence tethered operations, and meaningful recommendations will be produced.

Work Processes

'Out of Lead'

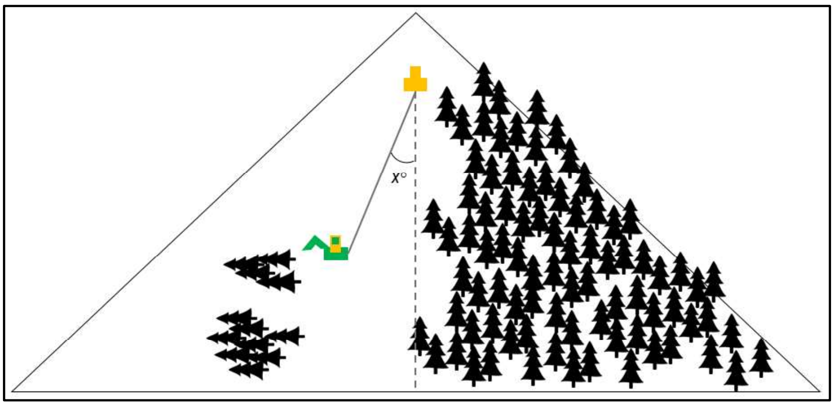

Figure 3. Feller Buncher working 'out of lead'

Out of lead" is demonstrated in Figure 3. It is when the harvesting machine moves out of the straight up and down run line at an angle to widen the area of trees felled. The bigger the angle directly from the anchor (*x* in Figure 3) the more the risk of anchor machine rollover is increased (however, this does vary across machine setups and is dependent on terrain type/gradient). In such cases, the operator can counterweight using the boom. Sometimes it is even possible to use the felling head to pick up a root-ball or grip a tree to maintain stability. If the operator feels the rope pulling, he will adjust the setting to reduce the tension. Binding, using trees for sideways movement, adds the ability for further angled movement.

Binding

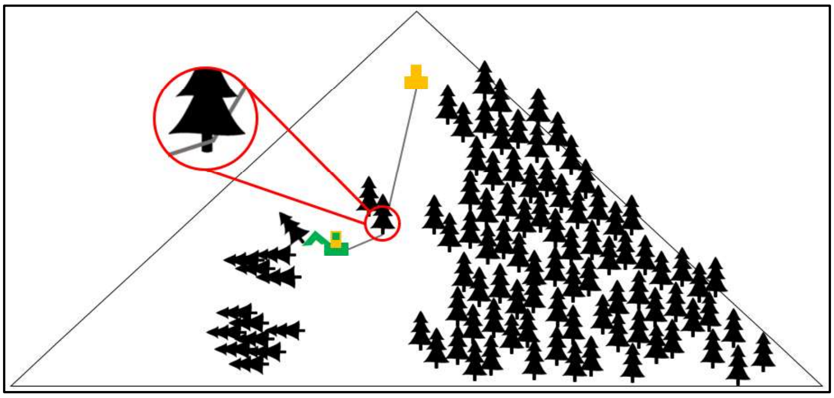

Figure 4. Feller Buncher working 'out of lead'

Binding, where the tethered rope is hooked around trees to allow for sideways movement, helps the operator to optimise the output of a single run (Figure 4). Ideally, the rope around the 'bind' tree is placed as low as possible as the friction can cause it to bore into the tree. It is not unusual for the 'bind' tree to be pulled over, particularly if the trees have a smaller diameter. It is possible to pull over several trees at once with the tethered rope depending on soil conditions and tree size. To set up a 'binding' scenario, the rope is slackened down then tensioned to cause a flicking motion around the tree.

Binding is achieved most often when the feller buncher is proceeding uphill. However, the machine tracks must be kept vertical in line with the slope. It is uncommon for the rope to get hot from rubbing trees during binding. Therefore it may be assumed that the ropes do not fatigue as fast as would be expected. Binding at the top of the run could be achieved with a block similar to a Hauler tail-block if no appropriate trees are available. Focus group members using a digger anchor sometimes use a large block in the bucket of the machine to weight it down further to allow for 'out of lead' manouvering. In situations where the trees are smaller it is not uncommon for the operator to fell a tree at the two-metre mark to improve its stability as a bind tree. If there are no other options, then the ground can be used to bind but this restricts weight available on the rope and is therefore rarely used.

Hazard Plans

Nowadays, most contractors have a map of the block they are harvesting. Red sections on the map identify areas with slopes of 45 degrees or more which are a no go for felling machines. The maps are generated based on 15-metre placings. In Canterbury and south of Canterbury, generally any slopes over 50 degrees are a bluff or rocky outcrop. Several of the focus group members had operated tethered systems on slopes with sections up to 65 degrees. Agreed among the focus group members, this is typically only done if certain conditions are met such as a run off at the bottom of the slope. Some operations use a Hazard Plan before starting work to assure as far as is reasonably practicable the risks are appropriately managed and identified within that particular block. For example, a Hazard Plan might require a further discussion with another operator if there are three or more slip hazards (like slopes steeper than 40 degrees, wet ground or shingle) present.

Machines

Mobile Anchor

When adjusting the anchor position, the operator can change from remote to local controls. In certain conditions (for example, when it is excessively wet and slippery underfoot), it may be prudent to have a crew member monitor the stability and movement of the anchor machine especially if it is a bulldozer. Unanimously agreed was that the more the boom stretches forward, the more stable the anchor is. One system has a sticker on the boom to assure a good position – 'green' is better than 'red'. Rollers mounted on the boom achieve this. However, the accounting for the fleet angle is required – that is, the roller must be at a specific distance that allows the rope to unroll to the edge of the drum. Fleet angle is typically eight times the width of the drum; for example, if the drum is a metre wide then the roller must be at least eight metres away from the drum (see Figure 5).

Figure 5. Anchor Machine setup on an excavator
https://www.dcforestryequipment.com/en/falcon-winch-assist/ (retrieved 27 November 2017)

Remote Controls

While some are paired through Bluetooth nowadays, most tethered system setups use radio waves to communicate remotely between machines. A signal is transmitted approximately every three seconds between the machines. In one system if the signal is lost and the Feller Buncher has the park brake off the power will continue at a preset tonnage (typically 10-12 tonne). Some systems activate the winch brakes when the signal is lost. The winch brakes are disc rotors and in this scenario will come on progressively over five seconds to a full lock at the braking strain of the rope (which differs across machine types). The movement monitor alert (buzzer) will not sound if communications are lost or out of signal. This can occur in situations where the Feller Buncher might move behind rocks or a dense stand of trees. The focus group attendees maintained that signal disruption is rare.

Winch

Where possible, the focus group suggested that the operator dial down on the power to protect the life of the gears within the winch system. Calculations suggest that in the incident scenario there was approximately 70 tonnes of pressure put on the ropes when the winch locked up. Operating in the top setting is very hard on the gears within the bulldozer winch. The setting maximum can be adjusted, and the benefit of installing a tension monitor to do this was suggested. This will protect gear, reduce continuous wear and lengthen its life. In a study monitoring rope tension, the highest tensions observed were while the harvesting machine was felling (Visser, 2013). The recommendation was that the winch gears should be checked during routine servicing to minimise a similar outcome to that which occurred in this incident.

There can be a signal delay in remotely controlled designs from the Feller Buncher back to the winch assist machine. That is, when adjustment occurs in the setting of the winch power in the Feller Buncher, it can take several seconds for the winch machine to respond. The focus group members have circumvented this delay with the addition of a camera to monitor the power setting in the winch machine for the bulldozer system. A tachometer monitors the working speed of an engine. The device usually displays the revolutions per minute (RPM) on a calibrated analogue dial. The camera shows the live tachometer readings in the mobile anchor machine. A chart showing the corresponding revs with each setting is pinned in the Feller Buncher to provide reassurance of the actual power placed on the tether, regardless of the signal delay. This is checked routinely for accuracy on a monthly basis at both a static pull and with the Feller Buncher walking away.

Leveling Cab

It is preferable to have the cab level at 0 degrees in slippery conditions where the operator is required to respond quickly by swinging around. The focus group members agreed that the angle of the cab could be anywhere from -6 degrees to 6 degrees but any more will restrict their ability to move the boom and dig the felling head in to halt the loss of traction. However, it does take only a couple of seconds to change the level of the cab, and the focus group operators maintained even when moving on gentle slopes they have their finger resting on the button should they need to adjust quickly in response to sliding.

Operator preference for non-leveling versus leveling cab was varied in the focus group. All agreed that they level the cab when they are felling and shoveling trees as it is less physically fatiguing on the body by saving the need to contract muscles to twist around. One operator who had operated both non-levelling and levelling cab machines commented that in the levelling cab machine he would often not level the cab to get a feel for the terrain, especially when moving down or up from the anchor.

Movement Monitor

The movement monitor (Figure 6) sets off an alarm if the anchor machine moves. Although, there can be a delay of a few seconds in signals reception to the tethered machine. This sensor comes with most of the newer tethered systems but is an aftermarket addition with the bulldozer setup. There was no movement monitor on the incident bulldozer. The movement monitor can be attached to a stake hammered into the ground or a heavy D-shackle or even a bucket of water. Focus group members mentioned that depending on ground types it can be difficult to get a stake firmly in the ground.

Figure 6. Movement Monitor on an excavator tethered system.

If an alert sounds, the operator's reaction time to lift their feet off of the pedals (to cease all movement) is a determinant in pulling weight applied at the critical tipping point. Reaction timed tests carried out have shown 0.5-3.0 seconds to respond to the movement monitor alert by lifting feet off the pedals (to stop all movement so as not to dislodge the anchor machine further). Some of the focus group members found it easier to lift feet quickly off the pedals in machines with a five-point racing harness seatbelt as the straps secure them. In machines with a retractable seat belt, it is harder to remove their feet from the pedals swiftly. One of the focus group attendees had installed a clip between the two retractable seatbelts in his machine at chest height to prevent them from slipping off his shoulders.

Secondary Stopping System

Each tethered system is unique in its secondary stopping system – some have a blade on the Feller Buncher to dig into the ground, some have two ropes instead of one, and others have a rope management system. Common to all is a hydraulic mechanism and band brakes. The Feller Buncher has three methods of reducing slippage: (1.) a braking system; (2.) the tethered rope or ropes; and, (3.) resting the tracks against a stump or terrain feature like a bank or hole. In the incident system, there was an emergency stop (e-stop) button on the Feller Buncher display. When pushed, this activates the band brakes on the winch. Initially, a shock load is triggered followed by the band gradually applying the brakes. If the engine cuts out for whatever reason, the brakes come on.

Figure 7. Potential damage point on the connecting chain from the Feller Buncher drawbar
https://www.youtube.com/watch?time_continue=124&v=Md8A5E9C9xg
(retrieved 27 November 2017)

The focus group attendees believed that if anything were to fail in the tethered system it would be the attachment between the rope and the Feller Buncher. In most systems, this is a chain. The drawbar of the Feller Buncher can rub or bash against the chain depending on the features of the ground (see Figure 7). Several methods of protection have been investigated – including industrial shrink wrap and PVC piping - without success. Most of all, time must be invested to inspect and maintain both the rope(s) and the chain. Some systems have two ropes, so if one rope breaks for whatever reason (like fatigue or damage), then the Feller Buncher will jolt but not slip.

Human Factors

Cognitive Factors

Operating a tethered feller buncher is both physically and mentally demanding. When positioned on a steep slope in a machine, the operator is hanging from a five-point harness facing directly down a near vertical face (to the naked eye). The operator's muscles must remain tense to hold him in place in the bouncing seat, sometimes while at a near vertical angle. The shovelling motion of the machine exerts pressure on the operator's body, typically in one direction. The newer self-levelling machines can reduce this demand. However, this type of cab may minimise the ability of the operator to feel specific functions of the machine and may introduce a false sense of security and stability. From a cognitive perspective, this task is mentally exhausting as a result of consistently facing the risk of falling off the slope. While the actual likelihood of this is minimal, the operator's brain has to work hard to counter its natural instinct when in such a precarious position. Furthermore, a high level of concentration is required to monitor the rope, manoeuvre the machine and operate the controls throughout the day. There are numerous obstacles to avoid and control nuances to manipulate such a large machine over variable terrain, and these factors serve to divide attention further. The operators maintained that it is easy to become very familiar with the machine and controls. Nonetheless, focus group members mentioned that it was more likely that the operator had to get used to the ground conditions and this can take anywhere from one to two weeks.

Ergonomic Assessment

A report for Future Forest Research as part of the Steepland Harvesting programme involved interviewing two operators, both had experience with tethered systems and spoke about their perceptions of the cab layout and controls, visibility for the operator, seating and machine maintenance (Evanson, Amishev, Parker & Harrill, 2013). In general, although the cab was considered well sound-insulated and spacious, with good visibility, the operators questioned had concerns over access to and from the cab from ground level - especially with the machine parked on a steep slope. Reduced visibility can reduce productivity and also increase the risk of accidents. Nevertheless, the cab windows have bars/grills for protection but also affect operator vision. The operators thought the visibility was satisfactory. They suggested that lights outside the cab help with visibility when felling on overcast days. The operator's seat should be fully adjustable to give favourable support for the thighs and back and make it easy to reach the controls. Armrests should also be fully adjustable and comfortable. The operators interviewed had few issues with operating on steep terrain in a non-levelling cab. Both operators found no discomfort from working on very steep slopes, and they both liked the ability to feel the steepness of the ground and felt they never became complacent because of it.

Training

Training an operator to use a tethered system is costly. All learning is done on-the-job in a tethered system. Typically, a worker will first learn how to operate a digger followed by a digger with a felling head. Once comfortable operating these machines on flat ground, the operator will progress to steeper and steeper terrain. The operators learn by doing because every situation is different. As part of the on-the-job training, operators are taught to stay in the machine should an adverse event occur. Focus group members all agreed that when an operator first begins and is learning they find the machine (more) stressful to operate and at the end of a day they tend to be tired, both physically and mentally. As they gradually built up confidence this reaction became less pronounced. A simulator does not capture the feel of a machine. However, a simulator can enable specific options that would not otherwise be available to try in a real environment such as particular techniques. Bigger cabs help training as the trainer can sit behind to supervise the novice operator, or conversely the novice operator can sit behind the expert operator to observe.

Many contractors operating a tethered system typically only have one operator trained and capable of working the machines, so if he is sick or injured work will cease until he returns to work. In such scenarios, there is production pressure to catch up. Often this means that the feller buncher will be operated at the angle limits of the ropes where possible as it is faster than undertaking a full shift of the mobile anchor.

Best Practice Guideline & Regulations

The revised Approved Code of Practice for Safety and Health in Forest Operations (MBIE 2012) contains a section for winch-assisted harvesting on steep slopes. This section states that *"…all mobile plant using the assistance of a wire rope and/or winch shall be specifically designed, tested, demonstrated to be safe"* and that *"…the tension on the wire rope shall be restricted to 33% of its breaking load at all times"*. Any references to specific slope limits have been removed (MBIE, 2012). This is further delineated by the Worksafe New Zealand Factsheet: Winch-assisted Harvesting on Steep Slopes (2016). This document gives examples for meeting the requirements listed in the ACOP, including reference to emergency back-up systems like a second winch rope, a blade or other hydraulic attachment, and/or a warning device to warn the machine operator of anchor movement.

Several Competenz Best Practice Guidelines can also be related to steep slope harvesting, but not winch-assisted systems specifically. The Cable Logging Best Practice Guideline gives instructions on how to secure a mobile anchor, while the Mechanised Harvesting & Processing Best Practice Guideline lists the features and tasks of a feller buncher. There is an outdated reference to the ACOP regarding maximum slope steepness in the Mobile Plant Best Practice Guideline:

> *The Approved Code of Practice for Safety and Health in Forest Operations states that as a guide, mechanised harvesters should not operate on slopes that exceed 22° (40%) unless otherwise specified by the manufacturer. Where weather or ground conditions adversely affect machine stability, the maximum slope will be actually less than this. (p.8)*

The International Labour Office (ILO 1998) published a revised Safety and Health in Forestry Work to account for the new developments in steep slope machinery. The British Columbia Forest Safety Council developed a steep slope resource package to help manage safety of tethered harvesting operations (BCForestSafe 2011). The resource package has a Steep Slope Hazard Assessment Tool to evaluate site-specific and machine-specific hazards and develop a plan to mitigate machine stability risks in operations when exceeding slope limits. The focus group attendees argued that the BC Tethered Harvesting Pack is not relevant and applicable to New Zealand operations however. Common to nearly all guidelines (including machine manufacturers) is the fundamental principle that the machine must remain stable and have traction without the cable, as such it must be able to sit independently and unsupported on the slope. Therefore the winch tether is a traction assist mechanism only.

The following recommendations, developed by the project team in conjunction with the expert tethered machine operators and crew who participated in the focus groups and vetted by the New Zealand forest industry representatives, are intended to result in improved system resilience and responsiveness without the over-incorporation of rule-based procedures.

4.1 Operational Recommendations

Recommendation 1	*Explore incremental braking options to reduce shock loading that can jolt the anchor machine.*	
	Expected Responsible Party	FISC in cooperation with machine manufacturers

If an excessive spooling rate triggers the winch brakes, the system assumes the feller buncher is falling and locks the brakes on to arrest the momentum. Several other operational scenarios can also trigger a brake lock up including but not limited to: mechanical failure, running out of fuel, some loss of signal situations, and the e-stop to name a few. Such an action adds immense pressure to the pull tension which can potentially jolt the anchor machine out of position, as it did in this incident. It is suggested that a mechanism that applies incremental braking pressure in such situations may eliminate this risk. As such, it would be useful to inform machine manufacturers and other tethered system specialists of this finding to encourage a focus in this area.

Recommendation 2	*Explore options for a Mobile Anchor Bind System.*	
	Expected Responsible Party	FISC in cooperation with educational institutions.

Explore options for setting up an offset pulley system for bulldozer anchors if there are no appropriate trees to utilize binding at the top of the run. Such an approach would also be advantageous in operations with limited room along the ridge where the anchor is set up. However, due to the maximum length of the rope (500 metres long) this method may not be able to be employed on particularly long slopes. Ideally, the winch drum would always have 50 metres of rope left on it. Depending on available resources, this setup may require a larger investment of time at the start but will save time overall because there is less need to reposition the anchor machine at the completion of each run. It is recommended that this suggestion be shared with the educational institutions so it may form the basis of a student thesis or post graduate project.

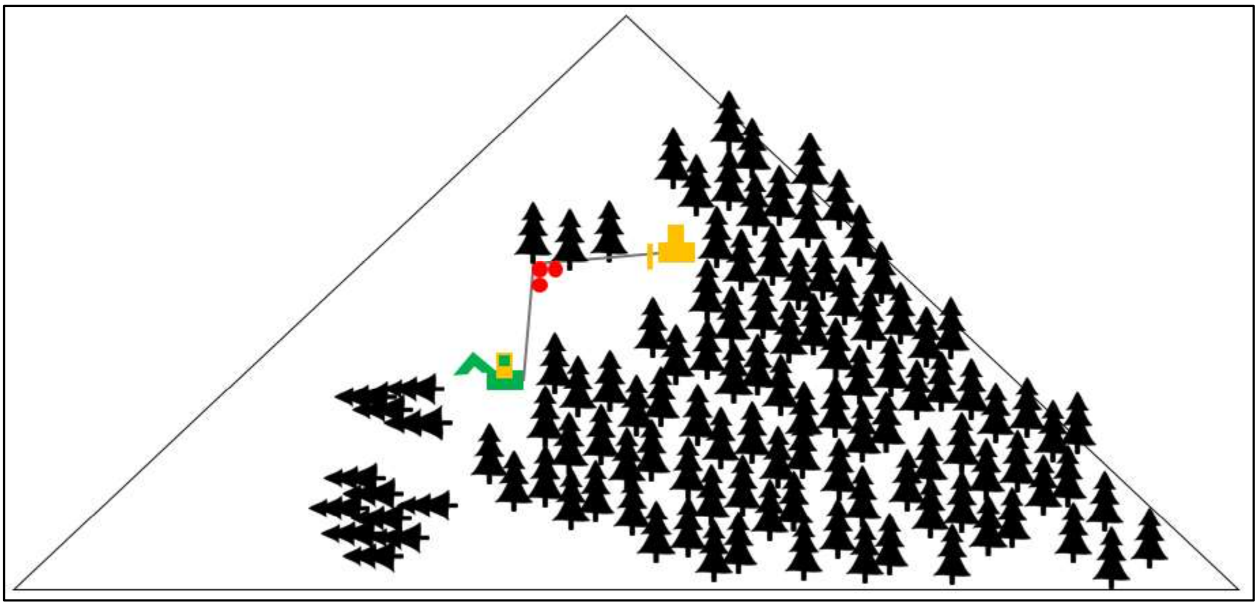

Figure 8. Example Mobile Anchor Bind System

Recommendation 3	*Winch power setting and rope tension monitoring in the tethered system information sharing*	
	Expected Responsible Party	FISC in cooperation with industry stakeholders/manufacturers

All tethered systems will monitor the tension of the ropes. Contractors are encouraged to attach the device near the drawbar of the felling machine to enable the representation of live weights during operations. Thus when combined with a display conveying the actual winch power setting (likely using a tachometer on the bulldozer anchor machine) without the possible misinformation resulting from any signal delay in remotely controlled designs, the operator will know the accurate amount of weight on the tether aiding his movement decisions. Furthermore, there is potential to explore ways to monitor the total weight placed on the rope over its lifetime to assist in servicing obligations and identifying routine wear. For example, workshop gantry's often have a load monitor that stores the weight information over time for reference in routine servicing and for certification requirements.

4.2 Organisational Recommendations

Recommendation 4	*Use a Tethered System Expert Advisory Group to inform the development of a Best Practice Guideline for Tethered Operations*	
	Expected Responsible Party	FISC in cooperation with industry stakeholders/Competenz.

The revised Approved Code of Practice for Safety and Health in Forest Operations (MBIE 2012) has one paragraph referencing winch-assisted harvesting on steep slopes (see Figure 9).

6.4 **WINCH-ASSISTED HARVESTING ON STEEP SLOPES**

6.4.1 All mobile plant using the assistance of a wire rope and/or winch shall be specifically designed, tested, demonstrated to be safe, and certified by a Chartered Professional Engineer to be safe when operated on steep slopes.

6.4.2 The tension on the wire rope shall be restricted to 33 percent of its breaking load at all times.

6.4.3 The maximum operating weight of the mobile plant shall not exceed the rated breaking load of the wire rope.

6.4.4 An emergency back-up system shall be incorporated into the operation to ensure the stability of the mobile plant should the winch, wire rope or anchor fail.

6.4.5 All winch-assisted mobile plant operations shall have a documented safe working best practice, including as a minimum:

- hazard management
- machine and wire rope inspection and maintenance routines
- operator fatigue plans
- work alone procedures
- an emergency plan.

6.4.6 All winch-assisted mobile plant shall be constructed to provide adequate emergency access and egress points that can be activated internally and externally.

Figure 9. Excerpt from the ACOP for Safety and Health in Forest Operations (MBIE 2012)

Additionally, the International Labour Office, the British Columbia Forest Safety Council and machine manufacturer guidelines all advocate the critical standard for winch-assisted harvesting is that the tether is a traction assist mechanism only. While these guidelines and regulations are direct, they do not address specific slope and/or stability limitations of cable-assist machinery and as these types of operations become more prevalent, it may be a good idea to develop standardised operating guidelines. It is recommended that a Tethered System Expert Advisory Group is formed using experienced operators from the industry to inform the development of a Best Practice Guideline. This way the existing knowledge about how the job is done safely is incorporated into a resource as more and more contractors adopt this method of harvesting, as opposed to the inclusion of well-meaning but ultimately inpractical rules.

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