Overview: Cable-Assist Ops

1. Terminology
2. Background / Operating limits.
3. System development (focus on NZ)
4. Risks and incidents
Terminology?

- “Yo-yo-ing” / “Bungy-harvesting”?
- Tethered?
- Traction-assist?
- Winch-assist / cable-assist = preferred
Traditional Steep Terrain:

- Cable logging systems with manual felling and choker-setting?
  - Relatively unsafe
    - 2 - 3 fatalities/10mil.m³
  - Relatively expensive
    - CAN$25 → CAN$55/m³
Steep Slope System development: Mechanisation

- In NZ – excavator based machines
  - Robust, powerful and ‘cheap’, good climbing
  - Less traction uneven terrain, less stable over obstacles
- Mechanised felling $\rightarrow$ mechanised extraction.
Machine Stability – failure modes

- To operate safely we want our machines to be ‘stable’
  - (ACOP rule “not compromised”)

- Two failure modes...
  - Roll-over
  - Loss of traction
Machine stability / slope

- Roll-over
  - favourable $>120\%$ → unfavourable $<15\%$

- Loss of Traction
  - favourable $70\%$ → unfavourable $<40\%$
Slope Limits* / Traction?

Lower limits:
- 30% (17 deg) = wheeled machines on poor soils
- 40% (22 deg) = tracked machines on poor soils

‘Normal’ operating limit:
- 50% (27 deg) = suitable harvesting machines with a good operator on good soil conditions

Upper limit:
- 70% (35 deg) = (1) purposed built steep terrain machines (2) on strong stable soils (3) with an experienced operator.

* based on ‘Dominant hill slope’: average slope over the full length of the main slope in harvest area (R. Visser 2016).
Cable-Assist = Step-change in steep terrain harvesting systems!

- Adds to traction to increases operating range to $\approx 100\%$ (45 deg)
- NZ # systems: 1 in 2006 $\rightarrow$ 50+ in 2016!
- Increasing level of knowledge and experience in design, operating

- ‘Results’ to date favourable
  - Approx. 10mill m$^3$ harvested with cable-assist in NZ so 2 lives saved?

- & exporting machines (i.e. PNW, Chile)
Serious harm incident (June 2016)

- Anchor machine pulled off road towards felling machine
- Operator pinned under dozer
- Prob. cause: Winch failure
## Cable-Assist Machinery - NZ FFR / UC Survey

<table>
<thead>
<tr>
<th>Winch-Assist Machine System</th>
<th>Units in operation (total made)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClimbMAX Harvester</td>
<td>3 (6)</td>
</tr>
<tr>
<td>EMS TractionLine</td>
<td>18 (34)</td>
</tr>
<tr>
<td>Falcon Forestry (DC Equip Ltd)</td>
<td>14 (25)</td>
</tr>
<tr>
<td>Remote Operated Bulldozer (ROB)</td>
<td>8 (18)</td>
</tr>
<tr>
<td>Other NZ developed Systems</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total NZ Made</strong></td>
<td><strong>52 (90+)</strong></td>
</tr>
</tbody>
</table>
System Differences: Winch location

- Two-part system:
  1. Winch mounted on & powered by mobile anchor bulldozer / excavator
  2. Standard ‘steep terrain’ harvester (purpose built?).

- Flexibility of swapping machines for steep terrain (felling → shovelling).

- Mobility of anchor

- Purpose built
- Winch integrated into the chassis
- Can be secured at top of the slope using a stump, deadman (or mobile anchor).
- Cable winched in from the machine - not being dragged along the ground.
Single & double rope system?

Double:
- Lower tensions in each rope.
- Second rope if one is compromised through damage.

Single:
- More cost effective to build and operate.
- Easier to manage on the slope.
- Larger rope = more difficult end connectors.

SAFETY ALERT
Broken Tether Rope

Background
Unbeknown to the operator the ropes of a twin drum cable-assist machine crossed over one another in front of a stump. The machine began to inhale and, under tension, one of the winch ropes broke at the ferrule.

Neither the tether nor the harvesting machine lost its footing.

No one was injured.

Contributing factors:
The ropes crossed below a tree stump and outside of the operator’s line of sight.
Cable-Assist: Risks and Incidents

- Overloading wire rope (rule: limit to 33% of breaking load)
  - Excavator = heavy and powerful machines!

- Rigging systems
  - Weakest link: end connectors and rope bending

- Operating practices
  - Changing direction using trees / stumps
Tension Monitoring – Research

- Systems ‘react’ differently, but still some clear similarity...
Tension: Movement → Impact on rope

- Most 'shocks' are caused by movement – not felling / shovelling!
Tension: Two-rope system & operator machine setting

- Both ropes share the load evenly
- Winch-setting shown as black line...
Tension: Downhill / Uphill & New machine

- Machine working downhill, then comes back up at 20min mark
- New machines manage improve tension loads with travel?
Extreme tension events...

- Machine ‘stuck’ behind obstacle, operator put on highest setting and used boom
- Operator put into manual feed (i.e. brake still on) and drove downhill.
Rigging System

- ‘System’ is only as strong as its weakest link!

- Many options – none perfect..
Common end connection options

- Pressed eye
  - Approved, but cannot be installed at logging site

- Wedged socket
  - Rated, but abrasion issues and jams?

- Split-wedge ferrule + Swivel Dee
  - Susceptible to impact loading and bending

- Loggers eye-splice
  - ‘Approved’, ugly, but effective?
Operating practices: Use tree to change direction?

- In NZ, most operators use trees to change rope angle to facilitate better machine utilisation.
- Some manufacturer guidelines specifically allow for it, with some indicative restrictions.
Operating practices:
Use tree to change direction?
Operating practices: Use tree to change direction?

What we know:
- Tension drop through friction around tree
- Pull over trees
- Rope can cut / bind into the tree
- Rope and tree heat up!

Winch at 20 tonnes, force difference for a cable being pull around a tree (J Palmer 2016).
HAZARD ALERT!
TETHERED FELLING MACHINE ROLL OVER

Background:
A felling machine was traveling back up the same path he came down on, towards the tethering machine, bunching trees as he went. At the time of the incident he was parked on, or near, a rocky outcrop and was moving wind thrown trees out of the way. As he slewed the felling head around the left side track lost traction, which caused the right track to lift off the ground. This in turn caused the felling machine to start tipping over. The operator hit the control to get the tethering machine to increase the tethering rope tension, which momentarily held the felling machine but because it was at such a high angle it continued to tip, then rolled onto its roof, where it came to a stop. The operator exited the machine, uninjured, through the main door.

Learning from this incident:
• The machine was positioned incorrectly over a small rocky outcrop – it should have been above or below the small rocky outcrop to get stable footing. This was due to the operator being too complacent, as he had been working on relatively gentle slopes for most of this
Future Developments…

- Transition to remote-controlled purpose-built machines?
  - JohnDeere 909 conversions
  - Now operated out of trailer on landing
  - New cab-less designs

- Autonomous felling machines?
Conclusions: Cable-Assist (NZ)

- Overall very positive
  - Expanding range of ground-based systems
  - Mainly safety, but also other improvements
- Gaining experience
  - 50+ machines in NZ, 40+ sold overseas
- Not without risks
  - Manage tension / impact loads
  - Learn from incidents
- Work towards Best Practice Guides