The Owren mini 400: a unique 1:3 scale electrically powered tower yarder for research, training and demonstration

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Abstract: *This paper introduces a 1:3 scale tower yarder modeled on the Owren T400. The yarder was developed in Norway to promote steep terrain logging activity by increasing awareness through demonstrations at exhibitions and field days, to contribute to the theoretical and practical training of new logging crews, both with regard to rigging and operation, and finally, to be used as a research and development tool for testing new working methods and auxiliary equipment. Results from a comparative study of three people with differing levels of experience showed that both a beginner, and a part-time machine operator, rapidly approached the time consumption and line tension profiles of an expert. The risk of total system failure is high for early stage operators of cable yarders. Eliminating tension 'spikes' through training on the mini-yarder is likely to prove valuable in preventing downtime, reducing the risk of accidents, and increasing yarder productivity.*

Keywords: cable-yarding , training, simulator, steep terrain

1 Introduction

Recently, the Norwegian government has advocated an increase in forest based activity, partly to stimulate rural economies, to maintain cultural landscapes, and to contribute to timber and renewable energy feedstocks. At 9 million m^3 per annum, Norway harvests less than 30% of the annual forest growth, and the standing volume of timber has doubled over the past century.

Since the early 1990s, interest in steep terrain logging in Norway has waned significantly, in line with falling real timber prices, increasing costs of infrastructure, and increases in the level of affluence in society at large. In this period, cable yarding activity has accounted for less than 1% of the annual cut. In the meantime, considerable volumes of timber are coming online for harvesting in steep terrain (> 40% slope), more than 70 million m^3 in the coastal region and 40 million m^3 in the inland region within the next 20 to 30 years (Vennesland et al., 2006). Present operating capacity in the country is less than 100 000 m^3 per year (roughly 15 000 m^3 per yarder on average). Many of the skilled crews of earlier times have gone into retirement, leaving only a sparse distribution of individuals with potential know-how in contributing to any future upswing.

Any noticeable increase in activity in steep terrain would require (i) vastly increased awareness of the existence of the work opportunities in local areas (ii) a marked increase in recruitment of human resources into the sector (iii) a need for more research into the productivity, ergonomics, economics and systems configurations in cable yarding under these conditions, and (iv) capacity building and vocational training of cable yarder crews.

In an effort to counter this, the specialist machine company Trygve Owren AS received project funding to develop a true scale 1:3 version of their Owren 400 tower yarder. The Owren 400 is a popular yarder in the boreal zone, and can be used as both a fixed or a running skyline. Heinimann et al.(2001) provide a comprehensive categorisation of yarder types and functions. The 'mini' yarder, with its retractable 3 m tower, is mounted on a fully contained standard car trailer, brutto mass is 1350 kg.. Including trailer and frame, the top of the tower is 4.3 metres above the ground. It is fitted with drums for the strawlines and guy lines, as well mainline, haulback lines, skyline and slackpulling line (fig. 1). Technical drum capacity on the skyline is 192 m of 6 mm cable, though in practice only 150 m are installed. The mainline and haul-back line are 4 mm, allowing 400 m in normal operating conditions. The winches are electrically powered by a 15kVA generator. The line speed has not been tested specifically but is estimated at 0.75 m s^{-1} in the centre of the drum. While it is designed for use as a running skyline system (the system of choice in Norwegian conditions), it can also be used in a static skyline configuration (i.e. also has a skyline drum).

Figure 1: The trailer mounted Owren mini 400 yarder

Training of new yarder operators is a somewhat risky business. Given the high cost of tower yarders, and the need to keep them working productively, any operator training traditionally takes place under normal working conditions, which by definition are high risk zones for early training. Sudden tension spikes can break the rigging, uproot tailspars, or snap one of the lines, while uncontrolled downhill yarding poses a significant threat to the tower and crew below the load. Therefore, there is a recognised need to train cable yarding crews offsite, but in similar conditions – especially in developing motoric skills for smoother operation. For ground based harvesting systems, simulators have been available and improved upon since the 1980s. Ovaskainen (2005) used 6 skilled machine operators to test the sense of 'reality' of a harvester simulator, and found that while there was generally good correspondence on methods and controls, the visual environment caused a number of discrepancies. However, they have been found to greatly advance learning, especially in the initial stages. The learning curve for forest machine operators has been shown to follow a sigmoidal improvement over a long period. In a study of 32 operators, Purfürst (2010) showed that the majority began their career at 50-60% of what would become their mean performance. He found that an average operator reaches the end of the learning phase of work after 9 months.

2 Aim

The main objective of this paper is to present a quantitative evaluation of the Owren 400 tower yarder as a training tool. However, the paper also discusses recruitment and other aspects of yarder training such as rigging and functionality.

3 Material and Methods

The main objective of the study is to assess how the Owren 400 mini works as a training tool. Five subjects participated in a 3 day training programme. We tested learning progress of two of the subjects against the instructor. The two subjects had varying background experience with forestry machines. Subject A was a forestry student with experience as a forwarder and excavator operator. Subject B was a doctoral student without previous experience. Subject C was the instructor, who had roughly 30 years experience with full scale Owren yarders, and was used as the control (table 1).

Table 1: Details of the 3 subjects tested

Subject	Year of birth	Occupation	Previous exposure
A	1987	Undergrad. Student	Forwarder /excavator operator – 15 min. on simulator
B	1970	Doctoral student	5 min. on simulator
C	1951	Professional instructor	Unlimited

The training included all aspects of yarder work, where the rigging is especially important. This involves a series of activities requiring special skills and theoretical knowledge. Rigging and down rigging was carried out before and after each session, and performance was also studied but is not reported here.

3.1 Corridor layout

The yarder was rigged with a running skyline setup in a 41 m long corridor and 17 % slope (fig.2). The term running skyline refers to a yarding system of two or more suspended moving lines (mainline and haulback line). Once properly tensioned, these lines provide lift and travel to the loaded or unloaded carriage. The end-block was rigged 6.4 m above the ground. Maximum deflection at mid-slope was 5.2 m. Five small logs were laid out on permanently marked course. The first at 10m, the second at 15m, the third at 21 m, the fourth at 30m and the fifth at 37 m. A solid 1.5 m high obstacle was placed between the second and third logs. Obtaining lift with a running skyline requires simultaneous tensioning of the mainline and the haulback line. This tension needs to be maintained while using the same lines to move the carriage to and fro, requiring significantly more skill than simply winching the logs in.

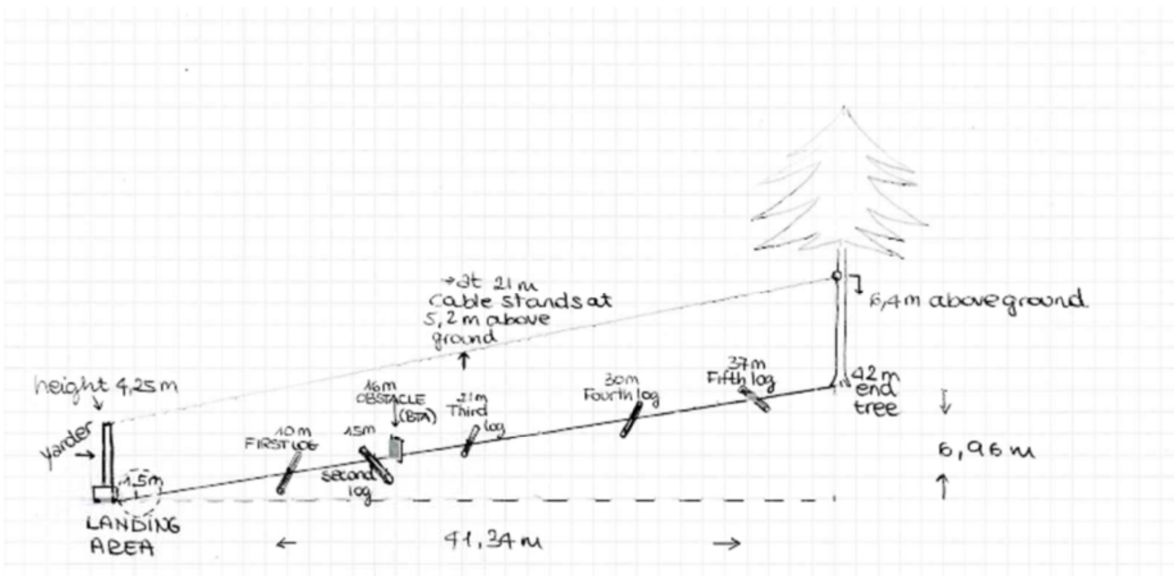

Figure 2: Layout of the training corridor

3.2 Study measurements

The study was repeated over 3 days. After initial instruction on the functioning of the winch and winch controls, each of the 3 subjects had to yard all five logs to the landing area, giving one replication. In total there were 6 replications of the 5 logs per subject.

Performance was measured for each replication in two ways. Firstly, a time study was made for each subject and replication using SIWORK 3 software on an Allegro™ datalogger. The cycle times for each log were recorded according to the breakdown given in table 2. The five cycle times (1 for each log) were summed to give the replication time.

Table 2: Breakdown of variables used in the time study

Variable	Description
Out-haul	the time required for the empty carriage to travel from landing to each log's position – starts when the carriage leaves the position next to the tower, ends when the carriage stops on the slope
Line-out	the time required for pulling the drop line out of the carriage to the log – ends when the drop line has reached the log
Choke	the time required to hook the log – ends when the choker releases the hook
Haul-in	the time required to yard the logs to the landing - ends when the carriage stops next to the tower
Targeting	The time required to release the drop line once the carriage has stopped over the landing area, ends when the log touches the ground within the target area and the drop line is slack
Un-choking	the time required to release the chokers and lift them back close to the carriage ends when the dechoker releases the hook – new observation
Delay	All time not included in the above mentioned categories

Secondly, a wireless 3.5 kN dynamometer was attached to the end block to continuously measure the tension in the lines, and provide some indication of the 'smoothness' of the operation (fig 2 – left). Tension spikes should be avoided as they can cause system failure, breaking the guylines or snapping the mainline or haul-back line. The ability to operate with low tension is one of the main advantages of the running skyline.

Figure 3 (left) the wireless dynamometer attached to the end-block, (right) rigging the end-block at 6 m.

4 Results

The combination of time and tension monitoring provided useful profiles in assessing the regularity of the operation. Continuous tension logging makes all spikes explicit, while the simultaneous time study makes it possible to identify the work operation responsible (fig.4) Results on the time consumption per cycle were consistent with expectations, showing a clear decrease with each replication of 5 log batch (fig. 5). For subject A, who has experience with joystick operated forestry machines, time is quickly reduced, and by the 5th repetition, it equals the time consumption of the instructor (subject C). Subject B also shows rapid improvement, with time consumption continually decreasing with each repetition. The instructor showed consistent time consumption over all repetitions, which was to be expected.

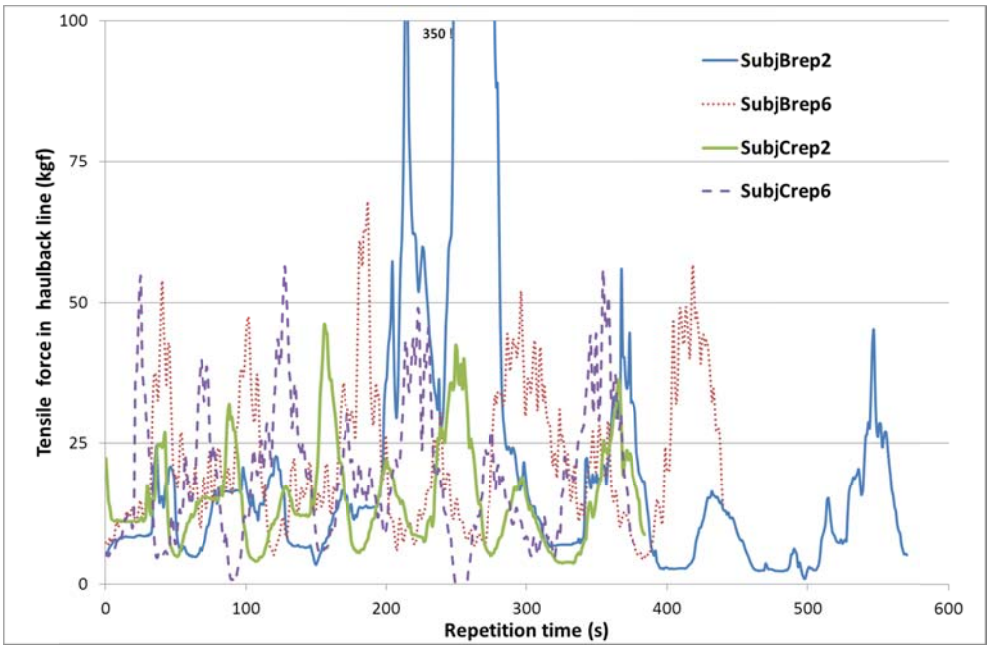

Figure 4 –Continuous force and time profiles for subjects B & C, repetition 2 and 6 respectively. For subject B repetition 2, a spike of 350 kgf (7-8 times the control value) was measured.

With regard to the tensile force measurements from the dynamometer, subject A is able to halve the cumulative tensile force experienced after just 1 repetition. From repetition 2 and onwards, performance is indistinguishable from the instructor (subject C). Subject B also shows substantial improvement after 3 repetitions, and remains more constant after the third. The improvements in cumulative tensile force are more remarkable considering that time consumption decreases simultaneously, thereby indicating real repetition on repetition improvement.

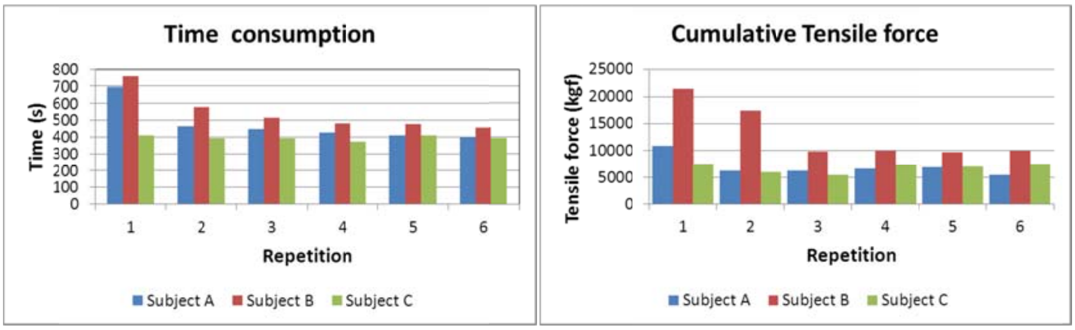

Figure 5 A (left) Time consumption (s) by subject and repetition, B (right) Cumulative tensile force measured over the entire repetition (5 logs), by subject and repetition

5 Discussion

This presentation reports on experiences gained from using the mini yarder in training teams of operators over the past 2 years. The yarder is used in teaching and understanding rigging theory and practice, the functionality of the drums and lines, and the working principles of the carriage. Operators get to use the same control system as for the full size version, and thereby gain a good feel for the machine without the dangers of the high tensile forces otherwise present in normal working conditions.

This study shows that rapid improvements in understanding and motoric function can be made in a short time, and in a safe environment. Performance figures approached those of the expert instructor after only 6 replications. This is important for future expansion of tower yarder activity in Norway, where new entrants have little or no experience with yarding.

For research and educational purposes, the unit provides an excellent basis for testing new rigging or operating techniques, but is also useful in teaching time study and systems analysis to graduate students or research assistants.

The Owren mini yarder has been used numerously at forest and career exhibitions, and has proven to be a crowd-puller in attracting people to take a closer look at the technology. This is an invaluable role in stimulating potential new entrepreneurs in consider yarding as an interesting and viable choice.

Presently, a novel carriage concept (with yarder controlled slackpulling capacity, but requiring only two winch drums) is being constructed to the same scale by the Norwegian Forest and Landscape Institute, and the mini yarder will play an integral part in testing the prototype before a full scale version is developed.

6 Acknowledgements

We appreciate the financial support from the Norwegian Forestry Development Fund and cooperation with the forestry training school 'Midt-Norsk Skogsenter. Thanks are specifically due to scientific engineer Morten Nitteberg for assistance with the instrumentation and data collection.

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