STSM Scientific Report - Cost action FP1301

Human factors in small scale forestry, the ergonomic advantage of using a new equipment for winching

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Background

Identifying operational challenges and providing solutions, so that logging operations flow efficiently, is crucial given the high costs of these types of activities. Small scale forestry work is in general a physical demanding job. When the extraction is performed by means of single drums winches the operator is usually reaching high level of workload especially when the terrain is uneven or steep. The high workload level of the operator has a repercussion on the system's productivity. Reduction in the workload of the operators can be achieved for example by limiting their movements on the skidding corridor through the introduction of specific tools such as a cable returning device.

Purpose of the visit

The main purpose of the STSM was to conduct field studies to determine if the use of a cable returning device (CRD) called "il Piccino"

Figure 1: The cable returning device "Il Piccino"

(Fig.1) had not only an effect on the operators' workload but also on the system's productivity. Such device is not available in Norway but a similar concept is used in small scale forestry extraction operations with tractors equipped with two drums winches. The two cables are usually connected together to form a ring, passed through a block attached at the end of a line and used in a manner of a highlead system.

Description of the work carried out during the visit

The trials took place at Riva Sud, in a mix-wood stand where the dominant species was Turkey oak (Q. Cerris L.). The age of the stand was 30 years. Clear-cut felling maintaining 80 standards/ha was completed on October 23rd 2014. The study was performed in good weather conditions throughout 5 consecutive days. The coppice stand was situated on a hill with and average slope of 34% (UTM 32N T 683923 4871781; 43.97616°N 11.29311°E) with an elevation of 244 m above sea (Fig. 2).

Figure 2: The harvesting site

A forest road was running at the bottom of the hill along a shallow ditch. A farm tractor (Same Silver 130) equipped with a single drum winch (Shwarz 80) and the cable-returning device (CRD), were placed along the road at the bottom of the slope.

The tractor was used to winch whole trees downhill to the road edge.

The skidding task was performed with a second tractor equipped with a grapple.

The trees were skid from the road to a truck landing, for delimbing, crosscutting and stacking.

The extraction was performed along parallel lines with an average length of 64m.

Six forest workers were identified and tested. They all had significant experience with this type of operations and tasks. They all agreed to participate in the test voluntarily.

They were entitled to withdraw at any time, or decline to answer specific questions or complete specific tasks if desired.

The workers were examined in the two different harvesting system settings: extraction with CRD (Treatment 1); extraction without the CRD (Treatment2).

- *Assessing the overall system productivity*

For assessing the system productivity a detailed time study was performed in addition to standard measurements about the stand and of the productivity of the system in the two different settings. A cycle was defined as the period between picking up the chokers at the landing in order to be sent out and the moment in which the timber extracted from the harvesting site was dropped at the landing.

The recorded work elements used in the time study are reported in table 1.

Table 1: Description of the work elements used in the time study

Work element	Description
Set block	The time used to walk the corridor with the CRD block and cables and to set up the block on the end tree.
Pull cable	The time between grabbing the hook on the cable and hooking it on the chokers.
Hook load	The time used to set the chokers around the felled trees.
Winch in	The time used to move the felled tree
Unload	The time used to release the chokers from the trees at the landing

In the time study all delays were recorded and defined according to their nature. Recorded delays definitions are reported in table 2.

Table 2: The delays definitions

Delays	Description
Study delay	Delays due to the researchers
Mechanical delay	Delays due to break downs
Personal delay	Delays due to the operators (phone calls, personal time out)
Operational delay	Delays due to organizational issues such as landing capacity etc.
Hang-up	When the trees were stuck during the winch in phase

Information concerning the amount of timber extracted was also collected. At the end of each cycle the DBH of the trees extracted was registered and the volume extracted will be calculated.

- *Assessing the operators' workload*

The physical parameters and the rest heart rate for each subject are reported in table 3. The rest heart rate was measured first thing in the morning while still lying in bed. VO2max was predicted through the Polar OwnIndex®. The OwnIndex® ranges usually between 20 and 95 and is comparable with the VO2max commonly used to evaluate aerobic fitness.

BMI was calculated with the formula BMI= Mass (Kg)/(Height(m))^2.

The age-predicted HR_{max} equation (i.e. 220-age) was used to establish the maximum heart rate of the six subjects. HRR is the heart rate reserve which is the difference between the maximum heart rate and the resting heart rate. It is used to establish how strenuous a task is. In general a worker should not be exposed for more than 8 hrs shift above 40% of the HRR.

Table 3: the subjects' physical and physiological parameters

Subject	**Birthdate**	**Height**	**Weight**	**HR_{rest}**	**VO_2max Own polar index**	**BMI**	**HR_{max}**	**HRR**
A	10.06.1991	165	75	73	30	27,5	197	124
B	28.01.1986	171	97	70	35	33,2	192	122
C	10.06.1962	172	71	59	57	24,0	168	109
D	08.03.1971	177	98	66	31	31,3	177	111
E	09.05.1993	176	88	72	44	28,4	199	127
F	24.07.1972	167	86	67	33	30,8	178	111

Each subject was provided with a Polar GPS3 watch in order to record the heart rate (BTM) throughout the whole working day (Fig.3). The time and motion study performed was synchronized with the heart rate monitoring in order to be able to couple the heart rate analysis with the task performed.

Figure 3: Setting up the HR monitor

In order to avoid noise in the data the winch was operated by the same person throughout the whole study. This person did not participate in the ergonomic study. The extraction in treatment a) was performed by a single man; for treatment b) there were two men on the slope as this is the usual working setting as the work is too heavy for only one man.

The team worked on parallel lines, on a maximum winching distance of 80 m.

The lines were worked alternately with and without the Piccino CRD. Operators were performing the extraction with the CRD in the morning (Treatment 1) and the extraction without the CRD (Treatment 2) in the afternoon after the lunch break which was usually lasting for around two hours. Each participant was assessed for at least twelve cycles under Treatment 1 and at least twelve cycles under Treatment 2.

Figure 4: The load cell pulling analysis

In order to evaluate the actual pulling effort exerted by the hook tender when working without the CRD a load cell was used. It was applied to the cable while the subject was pulling it on a 32% slope 64 m long line (fig. 4).

Description of the preliminary results obtained

To determine system productivity, the amount of time used for each cycle was estimated separately by analysing various factors predicted to affect efficiency such as stems per load, their size class and the yarding distance.

These preliminary results are based on part of the full dataset because of close deadline and the late implementation of the STSM.

In such a short time and with the dataset to be prepared, a full analysis was not feasible. It will be performed within the end of this year in the framework of the scientific article (articles) production.

The results, presented in table 3, show how the use of the CRD might be beneficial not only for the time consumption but also for the wellbeing of the workers.

It is apparent that the effort for implementing the operation under Treatment 1 is lower than that needed to implement the same operation under Treatment 2 i.e. without the use of the CRD.

Table 4: Preliminary results

Subject	**Treatment**	**Minutes/cycle**	**AVG HR**	**40%HRR**	**Difference (BTM)**	**Workload Severity (Åstrand)**
A	1	10,58	90	123	-33	Moderate
B	1	11,57	104	119	-15	Moderate
A	2	15,51	141	123	+18	Very heavy
B	2		136	119	+17	Very heavy

The additional test done in order to assess the force the subjects were exposed to when they were operating in the setting without the CRD showed that the force was increasing with the distance and the slope (fig. 5). This result is quantifying the workload that under treatment 2 the workers are exposed to.

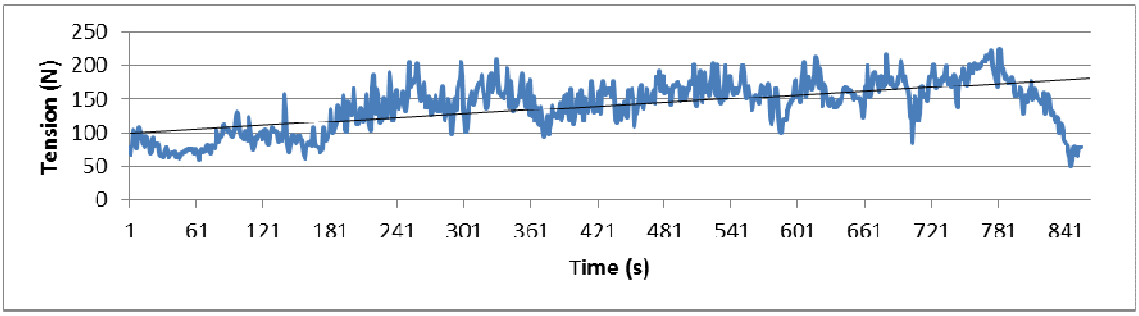

Figure 5: The force data

Future collaboration with host institutions

Both Institutes are interested in future collaborations concerning exchange of methods and experiences in human factors research applied to forest operations.

Projected publications/articles resulting or to result from the STSM

One or two papers (productivity/cost and ergonomics) are planned. Discriminant will be the quality of the results. If good it will allow for more than one publication.

Confirmation by the host institute of the successful execution of the mission

(see below)

Other comments

I would like to thank the Norwegian National Coordinator for COST, Ms. Trude Dypvik for facilitating the process allowing me to perform this STSM and the FP1301 COST office for supporting my participation in the COST action.

COST Action FP1301
STSM of Dr. Giovanna Ottaviani Aalmo , Researcher
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I hereby certify that the STSM was carried out by Dr. Giovanna Ottaviani Aalmo with great effort and success. I also approve her final report.

Dr. Raffaele Spinelli