



HARVESTING TECHNICAL NOTE

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Optimising Work Organisation for Maximum Performance

Summary

Arising from concerns that the logging industry in New Zealand has a culture of working undesirable hours (overtime, early rising, long working hours and often taking only one break per day), this research explored the range of work organisation and scheduling factors contributing to worker fatigue in cable logging operations. Site data was collected from a sample of four cable logging operations with varied skid site layouts and organisational methods. Mixed study methods were used, including interviews with contractors and crew members, process flow assessment and analysis of the roles and tasks of 'time-pressured' activities.

Shortcomings in many areas of the work system were identified such as equipment and machinery design, layout and work environment, job design, work scheduling and procurement. The results, whilst from a small sample size, enabled a number of recommendations to be made for intervention at both a site and organisational level. These include: equipment usability; site layout; cost-benefit analyses of operational alternatives; job design and workload, and organisational factors. In order to improve conditions contributing to operator fatigue the highest importance is placed on addressing the system and cultural failures that have made undesirable work conditions 'the norm' in the logging industry. This Technical Note summarises findings and provides recommendations from the main project report (Hide, Tappin and Parker, 2010).

Sophie Hide, David Tappin and Richard Parker

Centre For Human Factors and Ergonomics (COHFE), Scion.

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INTRODUCTION

Problems with scheduling of logging operations have been identified in recent research (Hide *et al.* 2009a; Hide *et al.* 2009b). Findings indicated that the logging industry has a culture of working undesirable hours, with regular overtime, early starts, long hours and taking only one break per day (especially in the North Island). The early arrival of log trucks to site is often the trigger for early start to the work day yet this, in turn, may be influenced by barriers or bottlenecks to operational processes such as the size, layout and accessibility of the skid site and the demands of sawmill and port operations.

The hazards associated with worker fatigue are generally well understood, but interventions are largely directed at worker behaviour change (such as good hydration and nutrition). This project aimed to identify work organisational and scheduling factors that may also contribute to fatigue, and to explore remedial measures. The study involved a literature search, field studies with four cable operations and identification of appropriate intervention measures that might facilitate more desirable work scheduling.

This research aimed to provide a picture of work organisation in the New Zealand logging industry and was not designed to be full scale empirical research.

Literature Review

A literature search explored international and New Zealand data on the effect of time on physical and psychological workload, in addition to other factors, such as work hours and scheduling, affecting New Zealand logging operations. It also explored measures employed in other NZ industries to manage working time.

Time Related Factors

International data described a range of health impairments associated with duration of exposure to adverse work loading. These included noise, whole body / hand-arm vibration, upper extremity disorder / OOS, musculoskeletal disorders, heart & vascular disorders, heat stress, mental stress and strain. New Zealand publications provided guidance to prevent fatigue and boredom for both specific logging



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activities, as well as for general forestry and harvesting tasks. Recommendations included aspects such as job rotation, micro-pauses, rest breaks, light exercise, replacing lost sleep, limiting shift length to less than 4 hours and using extra operators on extended work days.

For all New Zealand industries, a baseline of minimum rest and meal breaks (e.g. two 10-minute paid rest breaks and one 30-minute unpaid meal break when working from 6 – 8 hours) is specified in the Employment Relations (Breaks and Infant Feeding) Amendment Act 2008 (which amended the Employment Relations Act 2000). In other industries such as aviation and road freight, flight crews and truck drivers have mandatory working hours and rest break provisions.

Workload Scheduling and Planning

Research associated with scheduling, such as work measurement, has often been criticised for its lack of attention to the range of broader systems issues (required in a comprehensive approach to workload planning), and inadequate consideration of individual differences in performance and ability (Moores, 1972). Evaluation of sample international material concerning logging work study (e.g. Samset, 1990) identified such draw backs. However, further analysis would be needed to establish whether these work study measures are currently applied in the logging industry in New Zealand.

Best Practice for Skid Layout

Best practice guidelines were reviewed to identify issues concerning skid site layout. The Forest Roding Manual (Larcombe, 1999) addressed the planning, design, construction and maintenance of forest roads and landings. It advised that 12 factors influence landing design (including terrain, tree length, type of machinery to be used and number of log sorts) and provided two formulae to guide determination of either hauler or skidder landing size. However it is not known whether any impediments in timely

log uplift from site were accommodated in these calculations.

The Best Practice Guidelines for Loading (FITEC, 2000) identified typical loader operator responsibilities and criteria for planning loading operations. Landing layout is also addressed in the Best Practice Guidelines for Manual Log-making and Processing (FITEC, 2001). Descriptive advice is clearly presented in both these publications, but there is no pictorial guidance on optimum layouts.

METHODS

Three core elements from a toolkit of data collection techniques used in manufacturing studies (Jackson *et al.* 2004) were adapted to evaluate logging operations:

- a) Process flow observation and identification of bottlenecks and impediments to free flow;
- b) Analysis of tasks and roles of bottleneck activities identified to establish the work content and demands of these activities;
- c) Collection of interview data from crew members and the contractor / crew manager concerning factors that impact upon workload and which might impede process flow.

GPS trace data was also collected from three different activities within each site studied to identify frequency of machine travel, distance and travel speed.

Four sample cable logging operations, with varied skid site layouts and organisational methods, were studied in the central and east coast regions of New Zealand during the period Dec 2009-April 2010.

INTERPRETATION OF RESULTS

Equipment, Tooling and Machinery

Time pressure and inconsistencies in handling capacity were identified. Differing operational speeds of equipment (i.e. hauler, mechanical processor (Waratah) and loader operations) used sequentially in the process flow appeared



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to contribute towards time pressure.

Of the three key processes identified, *hauler related problems* appeared the most significant as they stopped process flow from breaker-outs through to many of the skid site operations. There were also comments from crew interviewees of being slowed down, or peaks in work pace and the adverse impact on their work day length from managing maintenance or breakdowns and hauler related problems such as rope breakages and line shifts.

A Waratah was used in two of the operations. In the first, time pressure was considered likely when working at a pace to match output of the hauler and demands of the forwarder. However, for the second operation, the Waratah operated from a buffer stock and appeared to have a less pressured work pace.

Concerns about the potential for time pressure in *loader operations* were identified – primarily as a result of concurrent demands upon their time, such as operation of a static delimber, sorting and stacking, loading trucks and clearing residues. Opportunities to take short breaks / get out of the cab and move around appeared limited, unless they arose by chance when their route on the skid was blocked and they were unable to work.

Potential design-task incompatibilities with the loader were identified:

- i) double handling needed to move stems / logs any distance along the skid;
- ii) poor control of (especially longer) logs by the log grapple;
- iii) the amount of fine tuning movements undertaken by the grapple to position logs in stacks.

Potential design alternatives for these tasks, or whether alternative design / techniques might alleviate some of these task components could be explored.

The *breaking out* phase of the operation appeared to offer opportunities for short breaks between hooking up. However one operation

appeared to experience time pressure due to particularly difficult terrain (extending hook up time), and training was also in progress. Some crew members felt that breaking out was a task that was more pressured than others and these discrepancies indicate that data from other operations would be needed to explore this point further.

Layout / Space / Environment

Small skid sites and problems arising from this were described. There were concerns about layout and the presence of other machinery and vehicles that could restrict accessibility and opportunities to move around site, in turn inhibiting productivity.

Opportunities for de-phasing the extraction and processing work by *2-staging* (thus extending the work area) were available to three of the crews yet these layout configurations appeared to have a mixed reception with the contractors surveyed. An alternative practice was for the crew to modify the landing / roading themselves. Potentially this compromises production time and suggests that the necessary communication and planning for the contractor's production needs are not being met.

Work Scheduling, Pace and Procurement

Almost half the crew interviewees regularly worked a six-day week. In addition the majority of workers interviewed (especially machinery operators) were *not taking breaks* recommended for those undertaking harvesting tasks, or taking the minimum rest and meal time allowance stipulated in the 2008 Amendment to the Employment Relations Act. Diminished output may result from improperly scheduled work pauses.

Most of the logging machinery operators in this sample had an early start (3.30-4.00am) and worked 12 hours a day, excluding travelling time. Whilst the workload of machinery operators is not physically demanding they are still vulnerable to more *isolated risk factors* (such



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as OOS potential) and *mental workload demands*. The literature revealed a time related relationship between varied machinery operations and adverse health effects and draws attention to the potential of ill health risk factors amongst this workforce.

In this sample there was evidence of reduced number of hours of rest between work shifts. The hours of sleep for those rising before 4.00am ranged from 4-6.75 hours. The literature indicated changes in daily patterns of sleepiness and wakefulness, with lower levels of alertness before 7.00am, and industrial efficiency at its lowest between 3.00am and 4.00am (Folkard and Tucker 2003). This highlights a concerning issue for those driving at night. The majority of New Zealand forest workers have been shown to 'sometimes' experience fatigue (Lilley *et al.* 2002) and fatigue is significantly associated with involvement in a near-miss injury event. Fatigue has been reported as responsible not only for safety concerns and machine damage, but also damage to forest stands through careless practices (Nicholls *et al.* 2004).

Concern was expressed regarding inconsistency / unpredictability of truck arrivals. Better truck scheduling was recommended in one previous landing study (Mythen, 1987) and it was apparent that this is still an issue today.

There appeared to also be widespread lack of acknowledgement concerning apparent inadequacies of existing systems in setting or agreeing to achievable production targets. The need for payment of competitive and realistic harvesting rates based on realistic production targets has previously been called for (Nicholls *et al.* 2004).

Job Design

It is apparent that previous research into the development of work-shift rosters, work load assessment and job rotation rosters for mechanised operations is not being applied. Data from crew interviews indicated that where job rotation occurred it was generally a reactive process to absenteeism – the potential

advantages from alternative job designs are not being realised here in New Zealand. *Job rotation* has been shown to have a positive effect on job satisfaction and musculoskeletal symptoms (Hanse and Winkel, 2008).

RECOMMENDATIONS FOR IMPROVEMENT

Recommendations regarding Equipment, Tooling, Machinery

- As a priority, review the design of hauler / cable configurations, cable quality and techniques adopted for cable line shifts. Establish what scoping for further improvement or redesign of this system has been proposed and undertaken, and identify ongoing intervention needs.
- Introduce buffer stocks to minimise time pressure between interdependent tasks; this will need to be trialled and supported with training and attention to necessary space and stock rotation requirements.
- Further investigate breaker out time pressure. Field work data collection was inconclusive, yet pressures were reported in this study.
- Opportunities to relieve loader operator workload and facilitate tasks should be explored. Ideas for consideration should include:
 - whether development of the loader grapple design, from single to multiple opposable prongs, would be advantageous for better controlled log / stem manipulation;
 - whether there is alternative equipment, such as an overhead gantry or conveyor that could be used for longer distance movements on the skid;
 - whether self-loading log trucks could be used economically;
 - whether all log movement / fine tuning manoeuvres are necessary – what is the tolerance in alignment of the ends of logs when stacking logs?
 - whether alternative storage means such as stillages (storage frames) to contain logs, jigs to upend and align ends of logs



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and/or strapping (bundling) together of logs is feasible.

- Further research and information provision concerning the relative merits / cost benefit of using different machinery types would be advantageous.

Recommendations regarding Layout / Space / Environment

- Explore alternatives in skid-site layouts. Identify a range of optimum layouts to manage access issues arising from trucks on site, wood storage needs and hauler position. Communicate optimum designs and means of accommodating a fluctuating cut plan through training materials and other industry communication.
- The relative advantages and disadvantages, and cost-benefit analysis, of alternative skid layouts and equipment choices should be identified, discussed and communicated within industry.
- Further work into improved planning and construction of appropriately sized and located, high quality, accessible and well laid out skid sites and roads is necessary.

Recommendations regarding Work Scheduling, Pace and Procurement

- Assess the mental workload and risk factors for occupational ill health of machine operated tasks and work related driving in order to explore optimum work/rest regimes.
- Consider incorporating a time concession into working hours for those driving to and from work.
- The underlying theory, criteria and culture relating to establishing an acceptable production target needs to be explored and addressed. Consider all barriers to production:
 - incorporate increased workload arising from the cut plan and reasonable time allowances for machinery breakdown / cable movement, until such time as remedial action can be sought for these problems;

- accommodate recommended break allowances and a standard working week that does not require overtime;
- employ measures to manage any cultural resistance / changes, through all levels of industry, that will accompany revised work scheduling.
- Conduct a collaborative project with representation from the forestry and trucking industries to explore common solutions to early starts, long working hours and inconsistent truck scheduling.

Recommendations regarding Job Design

- Further research into logging crew job design is suggested. This should incorporate a review of the Gellerstedt (1997) research to determine why job rotation has not been adopted, whether it remains applicable and, if so, how its use, understanding and application can be disseminated.

CONCLUSIONS

This research has explored work organisational and scheduling factors that may contribute to the development of fatigue. It was undertaken using data collection techniques that were developed specifically for the target group, and to ensure that a range of known problems were explored.

This research has both reinforced previous knowledge and produced new material concerning identification of time pressure activities in the process flow – notably those relating to hauler use and loader operations.

Shortcomings were found in many areas of the work system such as work layout, work scheduling, and job design. For some aspects findings were relatively isolated and this may have arisen as a result of the relatively small sample size. One draw back of this work is that the data collected only relates to the conditions experienced at the time of the study and it is acknowledged that there may be data variations arising from variables such as weather, tree size, machine breakdowns, haul distance etc.



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Despite these limitations, a number of recommendations for intervention at both site and organisational level have been made. At site level these concern improvements to equipment used for hauling, skid site layout and to job design (especially machinery operators). At an organisational level these include the development of cost-benefit analyses (of the various machinery / layout choices), and review of the criteria used in determining production targets (work measurement).

Logging crews regularly work undesirable and long hours, rise early, work overtime to meet production targets, and (especially in the North Island) often take only one break per day. In order to combat these risk factors for fatigue the highest importance is placed on addressing the system and cultural failures that have made these undesirable work conditions 'the norm'.

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