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HARVESTING THEME

Real time Productivity Data Collection

Task No: F20001
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An Evaluation of the MultiDAT (Senior-model) Datalogger

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EXECUTIVE SUMMARY

Equipment managers, contractors and operators share a common need: to obtain accurate information on machine productivity so they can improve the performance of their operations. The use of dataloggers installed on forestry machines is one way that managers or contractors can monitor performance and improve the economics of their operations. The MultiDAT, an electronic datalogger for application in the forest industry, was designed by the Forest Engineering Institute of Canada (FERIC). It has been used extensively in Canada to monitor forestry machine productivity and has recently been introduced to Australia and New Zealand.

This report describes an evaluation of the MultiDAT Senior datalogger where it was installed on four different forestry machines: a Thunderbird TTY 70 cable hauler; a Madill 124 swing yarder; a Komatsu PC220 excavator loader; and a Tigercat 630 grapple skidder. Machine operating time in the evaluation ranged from 8 to 15 days in order to investigate set up time, ease of use, different applications and recommendations for improvement.

Data were then analysed using the supplied MultiDAT 5.1 software, and examples of analyses for periods of a single day, and in more detail, a single hour, are reported.

This evaluation shows that MultiDAT is an effective tool for contractors to monitor machine availability and utilisation. In terms of research, the datalogger can be used for shift-level studies and, if hardwired to machine functions, for time study, possibly supplemented by video footage.

Suggested improvements to the system (MultiDAT Senior) include:

- Provision for production or payload data entry (e.g., for number of hauls, butts or top pieces).
- Provision of increased number of input channels (for linking to other machine sensors).
- A single button depression to indicate a change of activity or state.

BACKGROUND

Monitoring of machine performance has the following advantages: it focuses attention, establishes present position, and records progress. The results of monitoring can also provide the motivation to make appropriate and necessary changes, as well as indicating improvement or results of changes made.

In forest harvesting, time studies (comprising work measurement and method studies) have long formed an important basis of monitoring and managing operations, especially for rate setting and planning. Time studies are expensive, labour-intensive exercises, and results are often applicable to specific conditions of the study.

Consequently the use of work measurement has decreased over the years and historical performance, to a harvest setting level, is used in its place. Often, historical data are not available until well after the completion of a setting, and although production data (such as volume produced, average daily production or average piece size) are useful, little is known of the actual productive time taken or the utilisation of the harvesting system assets (people and machines). Historical performance data are of little use in improving the efficiency of harvesting systems because more detail of delays, interference between processes, and the reasons, is required.

A datalogger is an electronic device that records data over time or in relation to location either with a built-in instrument or sensor, or via external instruments and sensors. Dataloggers usually record performance data, such as machine hours worked, delays, machine utilisation (uptime), and productivity (when linked to production data). However, interpretation of the data is necessary to provide meaningful information so that management decisions can be made, tested and refined. By measuring and understanding productive time, managers, contractors and operators can take corrective action to decrease delays and maximise productive time. Delay information can be linked to cost data to improve the economics of harvesting operations, or focus training efforts for operators. In addition to providing performance data, dataloggers equipped with the Global Positioning System (GPS) have the ability to record where machines have been, or are currently working (i.e., in real time). This can provide information on actual haul distance, area harvested each period, or a record of environmental performance such as proximity to boundaries, riparian zones, etc.

Dataloggers currently used in the forest industry can be classified into several kinds:

1. Proprietary equipment integrated (embedded) into the machine, e.g., harvester control systems – recording and displaying production and processing data, sometimes with remote communication, by satellite or mobile phone circuits (using General Packet Radio Services, GPRS).
2. After-market installed equipment for the tracking of leased equipment (by location, engine performance and possibly other functions) or embedded at manufacture, e.g., Komtrax (Komatsu), Matris (Volvo), Product Link (Caterpillar) or Minorplanet Greenlight. These systems may have remote communication capability by satellite or mobile phone circuits to internet sites or to the client's server.
3. Custom-made equipment to record/monitor a number of machine functions, such as the MultiDAT. Download of data is carried out on-site by PDA, laptop computer, or remotely via radio, mobile phone or satellite connection (MultiDL software).
4. Data logging equipment available for GPS tracking and recording of location. This is specifically designed to aid the application of chemicals or fertiliser, information necessarily available in real-time to the operator, e.g., TracMap, or aircraft guidance systems, such as that used to monitor and record swath area in the Painted Apple Moth spraying programme.

MultiDAT Evaluations and Current Use

In one assessment of the MultiDAT (Davis and Kellogg, 2005), the datalogger was installed on three different machines (a yarder, an excavator and a grapple skidder) and results were compared between operator-entered time values and those of an observer. Operators believed that data entry errors, which impacted on observed time, might be reduced with experience. The study concluded that the MultiDAT and the associated software offered a good analysis tool at the contractor level for monitoring productive efficiencies. As far as research use was concerned, the authors saw potential in the MultiDAT's use in long term shift–level studies.

Approximately 2500 MultiDATs are in use in the Canadian forest Industry (Dey, pers.com), with many being linked to payment systems dependent on Operator ID, machine use and entry of accurate stoppage data. Many of these units are configured to record Operator Identification (ID) and stop codes only. MultiDL (Multi Down Load) hardware and software, available in Canada from 2005 but not yet offered to other users, enables remote download by a combination of radio, mobile phone or satellite communication.

MultiDATs are currently being evaluated in Australia by the Cooperative Research Centre for Forestry (CRC Harvesting and Operations Group, Mark Brown and Martin Strandgard, pers.com). Some 20 units are available as research tools. Seven of the units are installed at three sites and configured to collect GPS and delay data in machine evaluation work (harvesters, forwarders, and a chipper). In the future, researchers aim to collect data on travel and loading times for forwarders. The CRC Harvesting and Operations Group also sees future development of on-board monitoring of operational parameters to include systems such as those currently available on harvesters, which are better suited to measuring production data.

MultiDATs were first evaluated in New Zealand in 2005 (Schrider, 2005) when the dataloggers were involved in a nine-month trial focused on collecting data from a number of different forest machines. MultiDAT units are currently in use in a number of forestry operations around New Zealand. Users reported that the MultiDAT software is easy to use but requires reliable operators to enter useful data. One user reported an increase in crew production following an extended installation following a three-month trial (Walker, McBride, pers.com).

This project was aimed at evaluating the MultiDAT as part of the Future Forests Research programme in the Harvesting theme (Real-time productivity data collection project).

The MultiDAT Datalogger

The MultiDAT was designed by the Forest Engineering Research Institute of Canada (FERIC, www.feric.ca) and has been described as a second-generation datalogger that monitors forest equipment and allows contractors to maximise machine uptime by recording and reporting activities and productive time (Brown et al, 2002).

MultiDAT is manufactured in Montreal, Canada by Castonguay Electronique Inc. (www.castonguay-electronique.com) and marketed by GENEQ Inc., a Canadian instrumentation company (www.geneq.com). Forme Consulting Group Ltd has the southern hemisphere rights to distribution and support of MultiDAT(www.forme.co.nz).

The MultiDAT datalogger has the following features:

- A machine movement recorder using an internal motion sensor (not engine vibration) to monitor production time (worked time). In addition, the datalogger can record time when the machine is switched on if the datalogger's power is wired to the machine's master switch. Up to four machine functions can be monitored for occurrence and duration by direct wiring to the four input channels. One channel is required for GPS signal input (if used).

- A GPS option is available to collect positional data and determine areas covered or harvested – GPS Garmin 15 Low resolution (supplied for evaluation) and GPS SX1 High resolution.
- An additional device, the MultiPAD, can display the information being recorded by the datalogger, or combine a sequence of three signals or input values possibly representing a single function e.g., felling a tree (feller-buncher). The MultiPAD was not tested in this evaluation.

The MultiDAT available outside Canada is an earlier version than that currently available in Canada. This is because of a policy decision by FERIC's membership. Consequently, the more advanced communications features such as MultiDL (Multi-download) which include either satellite, radio or mobile phone remote download, are not currently available to users outside Canada. Hardware and software costs for MultiDAT are included in Appendix 1.

METHODS

A MultiDAT Senior unit (Fig.1) with Garmin 15 GPS and MultiPAD, was leased from the southern hemisphere agents, Forme Consulting Group Ltd in Wellington. Details of system set up, configuration, uploading and downloading, viewing, editing, and reporting of data can be obtained from these agents.

Figure 1: Two components of the MultiDAT system: MultiPAD (left), and MultiDAT Senior datalogger (right).

The MultiDAT system was installed on several forestry machines (Thunderbird TTY 70 hauler, Madill 124 swing yarder, Komatsu PC220 excavator loader and a Tigercat 630 grapple skidder). The operators of each machine were introduced to the procedures of recording the designated activities. For each machine, a single representative day was edited and analysed, as the aim was to evaluate the use of the datalogger rather than the data being collected. The MultiPAD unit supplied with the datalogger was not tested in the evaluation because early communications with the distributor indicated that this unit did not have application and would have further confused operators using the MultiDAT. In retrospect, a MultiPAD display would have shown the operator what activity or delay code was currently running and removed any doubts whether or not a code had been entered.

RESULTS

Study One: Thunderbird TTY 70 Hauler installation

For this particular machine, the GPS was attached and enabled, and the motion sensor was enabled some days after installation of the datalogger because of difficulties with calibration. The datalogger recorded data for 15 working days. Activity codes used included Haul normal, End of day and Other; delay codes included Move/line shift, Break out, Chute full, Unhook, and Other. Inhaul and outhaul times were not recorded as activities, as it was assumed the operator would not have time to enter codes at the appropriate time, and operate the hauler controls efficiently and safely.

The contractor in this case had a special interest in recording unhook times. The operator sometimes had difficulty in recording unhook time as this is often a short time element. During the evaluation other operators commented on events not covered by a named delay or activity – “Other” became a catch-all for these undefined activities. Operator-entered Unhook data were extracted from the database and 219 values were considered for analysis (Table 1). Only element times of less than 180 seconds were selected, as some values were much longer and assumed to be errors.

Statistics	N	Mean	Std. Deviation	Min	Max
Unhook Time (sec)	219	98.9	38.8	3	179

Table 1 : Operator-entered Unhook data

By comparison, a previous study of a swing yarder operation (with slackpulling carriage) noted unhook times averaging 0.53 min (95%CL 0.3min) or 32 sec for 3 chokers (Robinson and Evanson, 1992). The times from the datalogger were much longer than the previous comparable study, and it is possible that this recorded time included “Other” delays or a combination of both inhaul and outhaul element times.

Of the total recorder time (4/8/08) 7.8 hrs (ignition key - on), 7.5 hr (93%) was identified as working time (utilisation). Other utilisation percentages during the study were 93%, 96%, 95%, 91%, 90%, 85%).

Study Two: Madill 124 swing yarder installation

The datalogger recorded data for 11 working days. Two chokers and butt rigging were used for the first 3.5 days. It was possible to access the yarder’s inhaul/outhaul hydraulic control circuits via pressure switches because these were fitted by the contractor at the service agent’s yard. In addition, grapple open and grapple closed circuits were monitored using the MultiDAT’s four input channels. Activity codes used included Inhaul (Channel1), Outhaul (Channel 2), Grapple open (Channel 3), Grapple closed (Channel 4), Haul normal, Other functions and End of day. Delay codes included Service, Lunch/Break and Move/Line shift. A distribution of Activity/delay times was obtained from the data (Table 2).

Of the total recorder time, 7.2 hrs, 6.7 hr (93%) was identified as working time (utilisation). The number of haul cycles and average cycle time for the entire recording period were not calculated from the database. Manual methods could be used to extract this data, but this would be time-consuming.

Table 2: Percentage time spent on activities, (grapple yarding 29/08/08)

Activity	Time (hrs)	%
Inhaul	1.7	38
Outhaul	1.8	40
Service	0.4	9
Lunch/break	0.0	
Move/Lineshift	0.6	13
Total	**4.5**	**100%**

On one day (25/08/08) the yarder was working with butt rigging and strops. In the hour from 09:45 to 10:45 seven haul cycles were recorded, with no delays, giving an average cycle time of 8.6 min/cycle. Unhook time was not apparent from the data because in many cases the inhaul/outhaul machine function records did not show a delay. In comparison, when the yarder had a grapple fitted (29/08/08), in one hour from 9:45 to 10:45 with no delays, 31 haul cycles were recorded. With minimal grapple open/close time, estimated cycle time is 1.94 min.

Study Three: Komatsu PC220 excavator loader installation

The installation of the datalogger required all inputs from the operator. The motion sensor was enabled but the GPS function was not. The datalogger recorded data for eight working days. Activity codes used included Sort and stack, Unload trailer, Load truck, and Docketing. Delay codes included Service and Breakdown. Some service and breakdown times were recorded by the operator, but for the most part activities such as Load truck, Sort and stack etc. were not recorded. This was due to two reasons: lack of understanding of the recording procedure on the part of the operator; and the operator not following procedure when changing from one activity to another.

Motion sensor data collected over the eight days indicated a high level of utilisation (93.2% average). It was disappointing not to collect any activity data. Of the operations where data were collected, an excavator loader should have presented the least difficulty because of the longer periods of each type of activity time. This highlighted the fact that the effectiveness of the MultiDAT datalogger was dependent on the active co-operation of the operator.

Study Four: Tigercat 630 grapple skidder installation

This was a normal installation with all datalogger input from the operator. The motion sensor and the GPS were enabled. The datalogger recorded data for 14 working days. Activity codes used included Outhaul, Grapple, Inhaul, Other, Blade drag and Blade skid. Delay codes included Other, Service, Lunch break, Repairs and Wait other equipment. A distribution of activity/delay times was obtained from the data (Table 3).

Table 3: Percentage time spent on activities (30/10/08)

Activity	Time (hrs)	%
Inhaul	3.3	29
Outhaul	2.7	24
Blade drag	0.6	5
Blade on skid	0.7	6
Other	2.6	23
Service	0.2	2
Undefined	0.1	1
Lunchbreak	1.1	10
Total	11.3	100

The number of haul cycles (7) and average cycle time were calculated from one hour's data from the database (Table 4). Manual methods were used to extract these data, or spreadsheet routines could be developed. Of the 10.7 hr total recorder time, 9.9 hr was identified as working time by the motion sensor (93% utilisation).

Table 4: Cycle time analysis in minutes (30/10/08 12:17hr - 13:17hr)

Cycle	Outhaul	Grapple	Inhaul	Blade Drag	Blade on skid	Other	Total
Sum	11.71	16.37	19.81	2.07	1.77	3.29	55.02
Mean	1.67	2.34	2.83	0.30	0.25	0.47	7.86
%	21	30	36	4	3	6	100
Occurrence	100	100	100	57	14	43	

GPS data points were collected at 60-minute intervals or if the machine had moved further than 100m (Fig. 2). The pattern indicates the activity "two-staging to a processing landing in the upper track", and the activity "extracting from the cutover in the lower track", with travel between the two sites. Selection of a shorter time period and distance would have given more meaningful data. However there was no indication from the Help information as to the capacity of the datalogger for point storage, and the unit was to be installed for as long as possible. If cycle time data are desired, the GPS could be enabled for a day only, and more detailed GPS data collected.

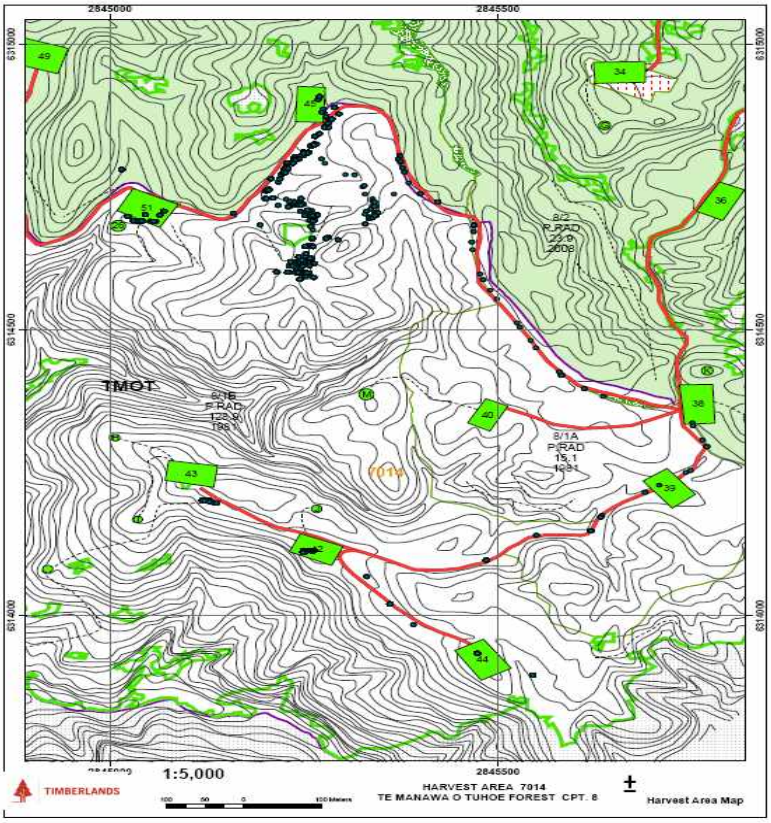

Figure 2: Plot of skidder GPS data

CONCLUSION

MultiDAT Ease of Use

In analysing the captured data, the most useful software features were the Graphical Data View and the database, viewed in Access™ The datalogger itself should be configured to minimise the data entry requirements from the operator. Regarding hardware, the calibration of the motion-sensor requires some care (mainly with stationary machines like haulers) and use of the MultiPAD display is recommended, as this informs the operator of the current recording code.

Research use

The attachment of input channels is limited to hardwired pressure switches or solenoids because the user manual recommends that channel wires should not be connected to a machine digital network (Can-bus or OpenCan). Time data are resolved to a level of one second and this may provide enough precision for time study. Davis and Kellogg (2005) suggested that MultiDAT data would enable activity sampling without the presence of an observer, but would miss observational data. The authors state that with multiple dataloggers the interactions between several machines could be analysed.

Management use

For those concerned directly with forest machine performance on a day-to-day basis, there is a key question: Is the main extraction/processing machine producing at least the target output necessary to meet budget requirements? This is key because small changes in production can have a major effect on a contract's profitability (Riddle, 1994). Typically, the number of stems extracted will be multiplied by a mean stem or piece size to estimate actual daily production. The MultiDAT does not have a stem, butt log or piece counting feature. If the key extraction/processing machine is not producing an expected or target output, the manager needs to know why so that the control cycle can be modified to enable a return to budgeted production levels.

The MultiDAT could have application in identifying constraints or problems. On a day-to-day basis however, many problems or factors affecting production, such as length of the working day, average cycle time and average drag or haul size (Higgins and Buse, 1986) can be identified adequately through existing shift-level or daily records and by questioning operators or supervisors. For longer term or systemic problems with attaining or maintaining target production, the recording of significant delays on the MultiDAT together with motion sensor information may either explain lack of machine performance or enable corrective changes to be made.

For longer term (>1 week) collection of relevant data, the MultiDAT has the potential to be downloaded remotely and automatically entered into a database for standard reporting. This feature is helpful for smaller contract operations which often do not have the time or expertise to manage long-term data flows and meaningful reporting. These smaller-scale operations are also usually managed by experienced owner/supervisors who often work with their crew and have a "feel" for what factors are affecting their productivity. Longer term data can be used for budgeting of planned availability or utilisation levels e.g., for contract tendering. Typically these levels can be variable (each setting has its own unique features) and so nominal values are used (Blackburne, pers.com).

For the above reasons, a manager with one or two crews is unlikely to use a MultiDAT on a day-to-day basis to advantage. Larger groups, managing many more machines might use a MultiDAT for identifying the causes of poor performance in selected machines or systems. Harvesting management companies or accounting firms with many forest harvesting clients could find a MultiDAT useful to help identify the causes of poor machine performance in their client's contract operations.

Suggested key factors for machine managers to measure with the tool include:

- Duration, cause and frequency of significant delays (eg., >5 min).
- Motion sensor data – indicating the time that the machine is in productive use.
- Total time scheduled for work.
- Area worked by machines (recorded with GPS).

Suggested improvements to MultiDAT hardware include:

- A single button depression to indicate a change of activity or state.
- Development of a mechanism for recording time-stamped values such as hauls, butts and pieces.
- Additional channels for voltage or pulse input. The GPS uses Channel 4 for input, leaving only 3 other inputs.

In summary, the MultiDAT is a useful tool because it lets machinery managers (e.g., contractors, machine owners, forest harvesting managers) monitor important aspects of a machine's effectiveness or productivity. It differs from other products in that it allows for operator input of activity and/or delay information and has been designed specifically for forestry operations. Most other proprietary or embedded dataloggers (e.g., Caterpillar, Volvo) do not allow for operator input apart from operator identification (id), and software may not be compatible with that of other manufacturers. An appropriately configured MultiDAT system can benefit anyone concerned with forest machine management or harvesting research.

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- Timberlands Ltd.

APPENDICES

Appendix 1

MultiDAT costs $Can (22.01.09) Source: Forme Consulting Group Ltd

MultiDAT products price list

MultiDAT with installation hardware and 10 feet (3m) connecting cable	$2,300
MultiDAT with factory-installed **Garmin 15** GPS receiver, installation hardware, 10 feet (3m) connecting cable and regular GPS antenna.	$2,990
MultiDAT with factory-installed **SX** GPS receiver, installation hardware, 10 feet (3m) connecting cable and high precision GPS antenna.	$4,100
MultiDAT Jr. with installation hardware and 10 feet (3m) connecting cable	$1,600
MultiDAT Jr. with factory-installed **Garmin 15** GPS receiver, installation hardware, 10 feet (3m) connecting cable and regular GPS antenna.	$2,300
MultiDAT Jr. with factory-installed **SX** GPS receiver, installation hardware, 10 feet (3m) connecting cable and high precision GPS antenna.	$3,450
MultiPAD real time Display, for MultiDAT with Tree Counter	$860
GPS antenna **protector** High impact polycarbonate - with mounting bolts	$165
GPS antenna **protector** High impact polycarbonate - magnetic mount	$240
Software: MultiDAT Data Analysis Suite for Windows, with user guide (1 pack)	$930
Software: MultiDAT Data Analysis Suite for Windows, with user guide (5 pack)	$3,200
Desktop communication cable kit - 10 feet (3m) connecting cable - Communication cable, 5 feet (1.5m), 1/8" (3.5mm) @???? to female DB9 - Communication adaptor cable, 6 in (15cm), 1/8" (3.5mm) to male DB9 - AC/DC wall plug adaptor	$155
Installation hardware kit 10 feet (3m) connecting cable, fuse, fuse holder and mounting screws	$55
Communication cable 1.5 metre, 3.5mm @???? female DB9	$35
Communication cable adapter 15cm, 3.5mm to male DB10	$35
GPS antenna for Garmin 15	$55
GPS **antenna** for SX - high resolution, **without cable** **Coax cable** for SX GPS antenna 5 metres	$240 $50

All prices are in Canadian dollars. Shipping charges are not included