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AN EVALUATION OF THE HUMAN COMPUTER INTERFACE IN THE WARATAH 234 HARVESTING MACHINE

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Executive Summary

An evaluation was carried out on the human computer interface in the Waratah 234 harvesting machine. The evaluation was designed to identify problems with the computer interface and develop solutions to solve them.

Five methods were used to gather information during the evaluation:-

Extensive observations of the interface were conducted. A questionnaire was developed and distributed amongst operators to probe subjective perceptions of the interface. A comprehensive job analysis was conducted on ten current operators in order to determine the specific functions and tasks that the controller is involved in performing. A comparison was made between all aspects of the interface and the standards, guidelines and recommendations established in the Human Computer Interaction (HCI) and ergonomic literature. And finally, further HCI specific interviews were conducted on three operators in order to more closely examine user perceptions of the interface.

The results of the evaluation and the subsequent recommendations are structured around four key areas of the Waratah interface. The first area evaluated was the software utilised in the interface design. A number of software considerations were taken into account.

The evaluation indicates that the interface could be improved by the following:-

- increasing the font size,
- including all upper case characters for the soft key functions, menu options and screen headings, including a glossary of difficult terms used in the interface in the user manual,
- including a prompt for rest breaks and measuring wheel checks,
- rearranging the order of the menu options,
- providing operators with notification of the time it takes to load the system,
- developing an alternative data input method that removes the need for operators to lean forward and interact directly with the display.

The second area that was considered was the hardware associated with the Waratah interface. This included the size, shape and placement of the input devices, the hand controls and arm rests and the characteristics of the graphic display module's position and design.

A number of problems associated with the interface were identified. These include; problems with the viewing distance and angle of the display, glare effects, dust collecting on the display, the hand controls and arm rests forcing operators to adopt awkward working postures, problems with the current data input method, visibility problems when operating at night, and the buttons on the hand controls containing sharp edges.

The solutions include using the side mount as opposed to the middle mounting position, using a fully adjustable display mount and easily adjustable button panels, encouraging operators to clean their screens regularly, including a glare filter, adopting an alternative data input method such as using the modem, an attachable keypad, or more closely combining the functions of the display with the hand controls.

The third area of consideration was the presentation of the reference materials or user manual associated with the system. Recommendations include improving the language used in the manual, removing redundant features from the manual, including examples of instructions, and developing an interactive manual in which operators are led systematically through the systems functions. The inclusion of an online help system is also recommended.

The final area of investigation was directed towards evaluating the quality of the training that is associated with the Waratah interface. The evaluation indicates that the operators do not receive adequate training on how to use the interface and its functions. It is recommended that a standardised training programme be established in which operators are provided with careful instruction on the systems functions, purposes and limitations. The development of an interface simulator could also be of use for training purposes.

The problems identified during the evaluation and their subsequent solutions are compiled into tables according to the key principles of human computer interaction design and included in the appendix. Also included in the appendix is a copy of the questionnaire and an outline of the human computer interaction interview utilised during the evaluation.

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Introduction

Recent developments in mechanised harvesting have led to an increased reliance on and use of modern technologies. This has led to the development of computer based harvesting machines and harvesting systems. One of the most widely used types of harvesting machines is the Waratah group of hydraulic tree harvesters.

For over a decade Waratah have been including computer based displays with their harvesting equipment. The latest Waratah interface is the HTH logrite controller. This is an integrated harvesting computer system designed to provide operators with the optimum control of log transportation and communication.

Developments in mechanised harvesting have a number of benefits associated with them, including higher quality output at a faster rate, minimised site damage, and removing workers from exposure to dangerous conditions. However, operators of modern harvesting equipment are being faced with different types of problems including overload injuries to the neck, arm, and spine (Hansson 1990), and increasingly high levels of mental workload (Sullman & Kirk 1998)

An evaluation of the latest human computer interface in the Waratah harvesting machine was conducted to identify any problems and to develop solutions. The information obtained in the analysis can be used in the future design and refinement of the harvesting machines.

Human-Computer Interaction

The study of human computer interface design falls within the larger subject area of human computer interaction. Human Computer Interaction (HCI) is an area of research concerned with improving the design of computer systems so that they are safe, functional, and enjoyable to use (Preece 1993).

When it comes to conducting an evaluation of any human computer interface there is one vital perspective from which all evaluations need to be made - the perspective of the user. In fact, Weimer (1995) argues that all research in the area of human computer interaction should be devoted ultimately to improving the working conditions for the user or operator, and as such it is important that computer systems are designed from a user-centred perspective.

When it comes to user-centred design, there are two key factors that need to be considered. These are how well an interface helps the user to accomplish the task for which the interface has been designed, and how easy, or pleasant the interface is to use. These two areas are referred to as utility and usability (Sutcliffe 1995).

Utility and Usability

The utility of an interface is determined by how well it helps the operator to complete their given tasks, how well the interface matches what the operators need it to do and how they understand the task should be done. The degree to which a system or interface has been over-engineered or provides the operator with too many functions and unnecessarily complicates the task also influences the utility of a system (Sutcliffe 1995). The usability of an interface on the other hand is determined by how easy it is to operate, how easy it is for operators to learn the system's functions and how much help or support is provided with the interface (Kalawsky 1999). Both of these terms are inter-related and vital considerations when it comes to evaluating an interface. Although there is not a single measure for assessing the quality of an interface, utility and usability provide us with important qualities upon which the evaluation or evaluative judgements can be based.

In addition to the key factors of utility and usability there are a number of important principles or guidelines that have been established in the literature for good quality interface design. Macaulay (1995) has summarised these principles and grouped them into five categories; naturalness, consistency, non-redundancy, supportiveness and flexibility. These principles are intended to provide overall guidance during the design process and may also serve as a set of criteria against which an established interface can be evaluated (Sutcliffe 1995, Macaulay 1995). As such they will be used to frame the findings of the present evaluation in the form of tables at the end of the report (Appendix 1).

Naturalness

The naturalness of an interface is determined by the degree to which it is familiar or natural to the user. This principle relates to whether or not the interface is consistent with how the user would conduct the task if the interface were not involved. An example of this is whether or not the sequence of inputs needed to complete a task (such as processing a tree) is similar to the normal order of tasks needed to do the job. Also included in this principle is the type of language that is used in the interface. The language that is used should be that of the users and not that of the product designers or manufacturers. It must be language that is 'natural' to the user and any jargon that is used in the interface must be that of the user population and not that of the designers.

The more natural an interface is the more consistent it is with its intended users. The naturalness of an interface also determines to a large extent how useable and learnable an interface is, and whether or not operators will feel comfortable using the system.

Consistency

Users are continually looking for patterns within a system so it is important that an interface remains consistent within itself. This reduces the need to learn new things and increases ease of learning of an interface. A consistent interface is one that presents information in the same place and manner on the screen, one that uses the same terms and descriptions throughout the entire system and one that conforms to pre-established norms and conventions. For example using enter or return to register an input.

Non-redundancy

A non-redundant interface is one in which the user only has to enter the minimal amount of information for the system to function. Similarly, the interface should not present the user with unnecessary information or unnecessarily complicate the tasks for which the interface has been designed. Users should also not be required to activate buttons any more times then necessary. Sutcliffe (1995) elaborates this principle by asserting that 'an interface design should be economic in the sense that they achieve an operation in the minimum number of steps necessary and save users work whenever possible' (pg 54).

Supportiveness

A supportive interface is one in which the user is provided with clear and complete instructions, is informed of any errors that they may have made and informs the user of what the system is doing at all times. Instructions can be provided by the use of prompts, error messages, and any additional help facilities such as an on-line help system or user manual. Users should be required to confirm inputs that will result in irreversible actions such as deleting information or closing out of the system. The support material associated with an interface such as the user manual, on-line help system and any direct help from product support people also comes under this principle.

Flexibility

The system should also be capable of adapting to the skill, experience level and characteristics of its users. Some operators will be more familiar with the system and may want to speed up a particular set of instructions. On the other hand more inexperienced users should be able to locate all the help that they need.

HCI Evaluation

One of the primary reasons for conducting an interface evaluation is to assess whether or not a system meets the needs of its users (Helander 1991). The information obtained throughout the course of an evaluation can be used to assist in the design process by identifying areas in which the interface can be improved or refined. In this respect the evaluation process helps to ensure that a system remains consistent with the key ergonomic principle of fitting the 'task to the man' (Grandjean 1988).

Consistent quality evaluation is essential to the healthy development of any product and is in fact a type of quality control. Through the process both the users and the product designers gain a better understanding of the strengths and weaknesses of their product and subsequently, information is obtained that is useful in its refinement.

An evaluation can be carried out at two distinct stages in a product's development. It may occur during the very early stages of product evolution while in its prototype stages prior to being released onto the market. Or alternatively, an evaluation can occur any time after the release of the product. This can provide useful feedback for any future re-design.

Although the logrite controller is in itself a completed product, it is still subject to re-development and refinement. This ongoing development is characteristic of all successful systems and reflects Waratah's commitment to providing purpose built harvesting machines of the highest standard. Testing, checking, evaluations and re-evaluations should be a continual process to ensure that high standards are maintained (Sutcliffe 1995).

Schneiderman (1992) argues that, 'A carefully designed and thoroughly tested system is a wonderful asset, but successful active use requires constant attention from dedicated managers, user-services personnel and maintenance staff. Everyone involved in supporting the user community can contribute to system refinements that provide ever higher levels of service' (pg 482). This constitutes the main purpose of human computer evaluation in general, and the present evaluation in particular.

Objective of the Current Evaluation

The objective of the current evaluation was to identify any problems that may be occurring with the HTH logrite controller and provide recommendations as to how these problems may be solved, eliminated or minimised. The evaluation took place on a number of levels and utilised a variety of methodologies.

Human computer interaction does not occur in isolation, and a good quality, thorough evaluation needs to consider the interactions that occur between the individual and a number of proximal and more distant factors (Murrell 1965). The current research evaluated four key areas of the interface.

Areas to be Evaluated

1. The first area to be evaluated is the software utilised in the interface design. A number of software considerations need to be taken into account. These generally relate to the type of information that is presented to operators and how it is presented.

2. The second area to be considered is the hardware of the interface. The hardware aspect of the evaluation includes the size, shape and placement of the input devices, the hand controls and arm rests and the characteristics of the graphic display module's position and design.

3. The third area of consideration is the presentation of reference materials, user manuals, user guides and on-line help systems. Helander (1991) suggests that two types of questions need to be considered when evaluating the effectiveness of these materials. What information needs to be presented and how should this information be presented?

4. Similar considerations will need to be applied to the fourth area of investigation that is directed towards evaluating the quality of the training that is associated with the Waratah interface.

Evaluation of the Logrite Controller

The evaluation of the HTH logrite controller is unique as far as human computer evaluations are concerned. This is due to the nature of the task for which the interface has been designed and the unique environment in which it is being utilised. The harshness of the environment within which the logrite controller is expected to perform accentuates the difficulties that exist with adhering to ergonomic and human computer interface guidelines.

The present evaluation utilised five major approaches to identify the problems or areas that can be improved with the interface. These included;

1. Extensive observation of and interaction with the interface.

2. The development of a questionnaire designed to probe operator's subjective perceptions of the interface .

3. A comprehensive job analysis on ten current operators in order to determine the specific functions and tasks that the controller was involved in performing.

4. A comparison of all aspects of the interface to the standards, guidelines and recommendations established in the HCI and ergonomic literature.

5. Further Human Computer Interaction specific interviews with three operators to more closely examine user perceptions of the interface.

Methodology

Observation

Both direct observation in the form of on site, within context observation of the interface in action and indirect observation in the form of videotaped footage and photographs were used. These methods provided useful exposure to the specific environmental and contextual factors within which the controller is being used. It also allowed close inspection, analysis and measurement of the interface to be conducted for later comparison to the standards and guidelines established in the literature. Two half-day observation sessions were conducted in two different locations.

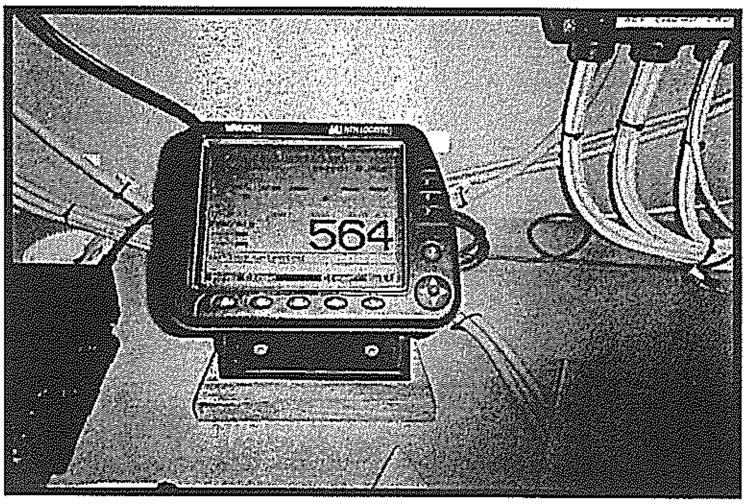

Figure 1 Display on the Control Simulator

Two further half-day observation sessions were conducted at the Waratah factory on their controller simulator. These sessions provided useful time with the interface in which the researchers were able to navigate the system. Further measurements, video and photographic footage were obtained from these sessions.

The controller used in the simulator differs to those used in the harvesting task in that it is removed from the working context. As far as simulators go it is quite basic comprising of the display, the hand-controls and printer. The hand controls are attached to a desk with the display erected on a moveable stand (Figure 1). The screen adjustment functions on the simulator do not work.

Questionnaire

Questionnaires are useful for obtaining subjective information about an interface in the form of user's attitudes, opinions, and subjective experiences (Sutcliffe 1995, Oborne & Clarke 1973). More specifically, the evaluation questionnaire (Appendix 2) used in this study was designed to provide general information on the quality of the software and hardware of the interface and investigate attitudes towards and opinions about the user manual.

The questionnaire consisted of 26 separate items assessing the operators attitudes towards the hand controls, button configurations, graphics display module, user manual, and general harvesting related activities such as the amount of time taken to enter different log lengths. The items required the operators to either tick the appropriate box that related to their answer or write a brief paragraph in response to the question.

The questionnaire was administered at the conclusion of the job analyses interviews to eight operators currently using the Waratah interface. The operators were encouraged to complete the questionnaire and post it in an envelope provided. Not all of the operators who received the questionnaire were presently working with the latest Waratah interface. Their responses to the items on the hand controls and other factors however could still be used as it is only the software and screen design that has altered throughout the development of the interface.

The responses to the current questionnaire were combined when and where appropriate with the responses obtained in a previous LIRO report (Cummins 1998). In addition to providing useful information, the questionnaire served as an introduction to the subsequent human computer interaction interviews.

Job Analysis

A job analysis was carried out as part of the fulfilment of another LIRO project. The information derived from the analysis was also needed for the interface evaluation as one of the most important criteria to consider when evaluating an interface is the degree to which it relates to the task for which it has been designed (British Standard 1997a). Before an interface can be evaluated, it is important to understand the context and the specific task related requirements and demands found on the job.

The Position Analysis Questionnaire (PAQ) (McCormick, Jeanneret & Mecham 1972) is one of the most respected and widely used job analysis methodologies on the market today (Fine 1996). The analysis consists of 196 separate items that are separated into six key areas designed to represent all aspects of the job. These are information input, work output, mental processes, job context, job demands, and other job characteristics. The PAQ was a particularly useful methodology to employ due to its focus on manual activities or physical work outputs.

In addition to the PAQ, a more generalised job analysis interview containing elements of the critical incidents technique (Flanagan 1954) was employed to elicit more descriptive qualitative information on the Waratah operator's position. A structured interview format was used in which operators were asked to describe the main responsibilities and tasks associated with their position, what they believed separated a good operator from a not so good operator, and how they knew when they had done a good day's work. This component of the analysis also served as an opportunity to more closely examine the tasks and nature of the work in which the interface was being used.

The two components involved in the job analysis process of the evaluation each involved one and a half hour interviews with the operators at their own homes. The PAQ was conducted on seven different operators and the Job Analysis interview on four different operators. It is worthwhile mentioning that not all of the operators used in the job analysis were familiar with the latest logrite controller. During this component of the analysis exposure to the latest controller was not necessary as it was the job or tasks involved in the position itself that were under investigation.

Comparison to the Literature

A central feature of the current evaluation was the comparison between the characteristics and specifications of the Waratah interface, and those established in the literature as being the ideal or recommended characteristics of good quality interfaces. With respect to this, the evaluation was able to capitalise on the huge wealth of knowledge available in the areas of human computer interaction and ergonomics. More specifically, all aspects of the interface were compared in a critical manner to the standards, guidelines, and empirical findings in these areas.

All information obtained from the literature searches was critically assessed for quality, relevance and appropriateness to the unique conditions within which the waratah interface is expected to perform. Conflicting sources or those which presented seemingly contradictory information were discarded.

HCI Specific Interviews

Due to the small number of operators currently using the latest Waratah interface and the difficulties associated with conducting such intensive, time consuming interviews with busy people, arranging the HCI interviews was difficult. Nevertheless, HCI specific interviews were conducted with three experienced operators.

The interview consisted of a collection of smaller methodologies employed in a one on one structured interview type setting (see Appendix 3). Each operator was run through a detailed elaboration on the questionnaire and a small battery of tests and exercises to gain further insight into the utility and usability of the interface. The focus group sessions consisted of the following methodologies.

Elaboration of the questionnaire

The questionnaire that was used in the evaluation was elaborated upon during the HCI interview sessions. This involved investigating more closely the operator's perceptions of and attitudes towards the interface. In addition to the logrite controller questionnaire, a comprehensive systems evaluation tool known as VRUSE was adapted and used (Kalawski 1999).

This special type of questionnaire was designed to assess the usability of a virtual reality system according to the attitudes and perceptions of its users. The questionnaire was selected because it asked a variety of unique and interesting questions of a systems users. The questionnaire consists of 100 separate items broken down into 10 separate 'usability factors'. These are: Functionality, user input, system output (display), user guidance and help, consistency, flexibility, simulation fidelity, error correction/handling and robustness, sense of immersion/presence and overall system usability.

From these a collection of 20 items were selected to be included in the interviews (See appendix 3). Questions relating to simulation fidelity, sense of immersion/presence and more specific virtual based questions were omitted.

An ergonomic investigation of the usability of the interface.

A common problem associated with the design of documentation supporting an interface is that they have been written from the perspective of the designer or manufacturer (Flyte 1998). This perspective is often very different to the needs, limitations and culture of the people the interface has been designed for and as such the usability of the logrite controller user manual was also assessed during the HCI interviews.

Six separate user manual tasks were utilised in the evaluation of the user manual. The tasks were similar to those that are commonly employed to assess the usability of reference materials (Brockman 1990). During the sessions a selection of passages and parts of the manual were presented to the operators. They were asked to read the passages aloud or view sections of the manual and then describe in their own words what they believed the manual was describing or instructing them to do. More specifically, the operators were asked to;

1. **Read and interpret the 'bark offset' formula found on page 6-1 of the user manual**

   Determining bark offset

   1. Select a typical log, which has a clean-cut end.

   2. Measure the overall diameter (D) and the inside of bark diameter (d).

3. Calculate the bark offset using the formula shown below.

$$\text{Bark offset} \quad \left(1 - \frac{d}{D}\right) \times 100\%$$

To enter the species bark offsets refer to the **Species Menu** in the **Cutting Systems Menu** Section.

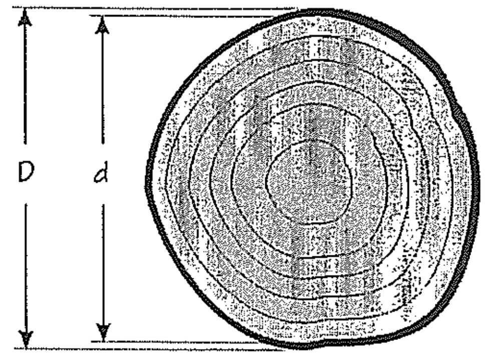

Figure 2. Bark offset diagram.

2. **Read and interpret the paragraph on page 6-4 that describes the process by which the cutting list from one species is copied to another. The paragraph reads;**

To copy one cutting list to another species select the **Copy List sub Menu** from the **Cutting by Length Menu.**
The **Source List** is selected by first highlighting that parameter by pressing **<Scroll Up/Down>** then selecting that parameter's details by scrolling through a number list using the **<Scroll Up/Down>** key. This operation is repeated for **Destination List** values. The **Copy from Source to Destination** is selected by highlighting that parameter by pressing **<Scroll Up/Down>** key.
Press **<Enter>** to copy.

To copy another cutting list, repeat the procedure.

3. **Describe what the 'feeding and measuring logs' chart is conveying.**

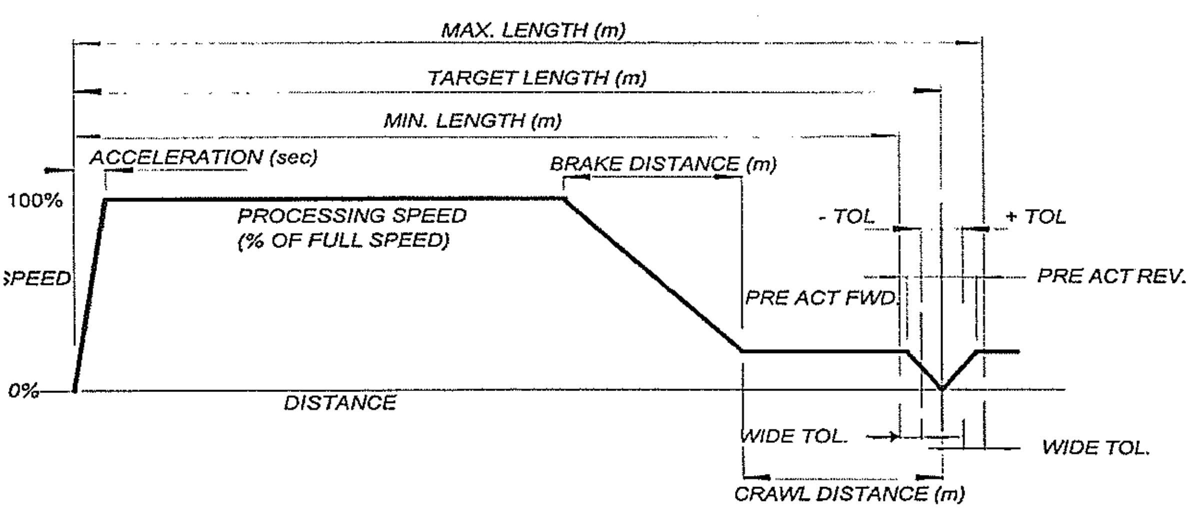

Figure 3. Feeding and measuring logs chart taken from controller manual.

The operators were also asked to locate within the manual three important yet somewhat obscure pieces of information;

1. Find the page in the manual that describes what it means when the error indicator on the printer is 'steady' and 'flashing'.

2. Using the manual, provide me with three reasons why the diameter readings might not be consistent.

3. Using the manual could you please tell me exactly where Waratah suggests you should mount the oil junction box.

These tasks were designed to assess two factors. How natural the information contained in the manual is to the operators, and how user friendly the manual is in terms of operators being able to find the information they need to find. The passages and parts of the manual that were included in the assessment were selected randomly.

The usability tasks were in no way designed to be an exhaustive or thoroughly rigorous test of the user manual. Instead they sought to highlight the types of problems that operators can have while using the manual and provide some indication of the reasons behind the problems. They were designed to provide examples of the types of problems operators may encounter with the manual.

Readability Assessment

Prior to the HCI interview a selection of key passages were entered into the readability assessment of Microsoft Word (Microsoft Publications 1997). The readability assessment makes use of research by Flesch (1948) and attributes readability scores to text based on the average number of syllables per word and the amount of words used per sentence. Two separate scores are produced by the assessment. The 'Flesch reading score' rates text on a 100-point scale with the higher the score the easier the document is to understand. Standard documents should aim for a score of about 60-70.

In addition to this the 'Flesch-Kincaid grade level score' rates text on an American grade-school level with a score of 10.0 representing that the document is pitched at the reading level of a tenth grader or fourth former in the New Zealand schooling system. Word indicates that most standard documents should be aimed at a grade level of approximately 7.0-8.0.

The passages included in the assessment were the manual layout and menus paragraph (pg 1-1), the paragraph describing the modem facilities in the controller (pg 2-2), the 'bottom delimb mode' paragraph in the system functions menus section (pg 11-1), the paragraph on calibrating the controller (pg 12-1), and the introductory paragraph on the electrical installation (pg 20-3).

At all times during the evaluation process the key factors of utility and usability were considered, as were the principles of naturalness, consistency, non-redundancy, supportiveness, flexibility and the more general ergonomic principles and guidelines established in literature.

Outcomes of the Evaluation

The outcomes of the evaluation in terms of the problems found and their recommended solutions will be presented under the subject headings of software, hardware, user manual and training.

Software

The majority of information that is presented by a computer is displayed visually on some form of screen, monitor or display. Regardless of the type of display utilised with an interface, the type of information presented and how that information is presented will have an impact on the utility, usability and general efficiency of an interface (Helander 1991). The relationship between the Waratah operators and the software component of the HTH logrite controller is a factor that can have a large impact on the performance of the mechanised harvesting task.

The graphics display module associated with the Waratah interface is used to display and access all the menus, controls, adjustments and calibrations as well as all log specifications. The current state of the systems software in terms of what information is presented to the operators and how that information is presented was evaluated.

Generally speaking, the software aspects of the interface are excellent for the purpose for which it was designed. Providing operators with the option of returning to the 'run' screen from any position on the interface is an excellent idea.

The first aspect that was evaluated in the presentation of information was the size, shape and spacing of the figures and characters. A number of operators have asserted that the size of the letters on the display are too small. Character size and the presentation of text on the screen is an area that has been heavily investigated and it is an area in which there are slight discrepancies regarding the optimum characteristics of text presentation. Pheasant (1987) has suggested a minimum character size of 3mm while Giddings (1972) has suggested a minimum size of 4mm. Most standards and guidelines fall somewhere in between these two recommendations (Helander 1991).

The characters used in the controller are within the recommended size characteristics being 4mm for upper case letters and 3mm for lower case letters. However, the larger then normal distance between the operator's head and the position of the display when placed in the centre of the operator's legs (30 inches), may mean that the text needs to be increased by half a millimetre or so. Regardless of the possible explanation for the operator's dissatisfaction, their concerns should be taken into consideration.

In addition to increasing the size of the characters it is recommended that the soft key functions be adjusted to include all upper case letters instead of their current conventional upper and lower case combination. Most guidelines support the use of all upper case lettering for items that need to attract attention (Helander 1991). This is supported by the work of Vartabedian (1971) who found that search time for words containing all capitals was 13% shorter then for lower case words. The same recommendation should be applied to key items such as the target, diameter and screen headings and even the titles in the menu.

The HCI interviews revealed that some of the language used in the Waratah interface is foreign to the operators and as such proves to be difficult to comprehend. More specifically, terms such as 'calibrations', 'diagnostics', 'commissioned defaults', and even the terms 'scroll' and 'prod' which is a shortened version of production caused problems for the operators.

Although these terms may be clearly understood by the designers and eventually by more experienced operators, they are in conflict with the 'naturalness' principle outlined by (Macaulay 1995) which asserts that the language used in an interface must be the kind that is familiar to the user population. It is possible that these terms do in fact need to be learned by operators and if so should be included in an instructional period that is recommended at a later stage in the report. In addition to this it is recommended that a glossary of explanations be included in the manual describing and defining the more difficult terms included in the interface.

When it comes to the design of menu systems within an interface, there are two important factors that need to be considered. These are the description of the options that are available, and the ordering of those options (Helander 1991). Besides the language issues outlined in the preceding paragraph, the options descriptions involved in the interface are acceptable due to the small number that are available (Sutcliffe 1995).

The ordering of the options is however inconsistent with the frequency of use principle (Oborne 1986) which asserts that the most frequently used functions in a menu or list of commands should be placed toward the top of the list or menu. This saves the operator spending unnecessary time and effort scrolling down through items that are of less importance to them.

Within the main menu, two of the optional screens are only available to Waratah personnel. These are the 'Factory Settings' and 'Service Settings' options. As these are unavailable for operators to access, they should not be placed in the centre of the list. According to the information obtained form the HCI interview sessions, the menu should be arranged in the following way:

-Cutting Systems
-System Functions
-Data Printout
-Calibration
-Diagnostics/Testing
-Screen Control
-Factory Settings
-Service Settings

Instead of the current ordering of:

-Cutting Systems
-Data Printout
-Screen Control
-Factory Settings
-Service Settings
-System Functions
-Calibration
-Diagnostics/Testing

The current selection technique that is employed in the interface requires operators to activate the large round scroll key that is located on the display. With this device, operators are forced to scroll down through each of the options individually until they come to the option that they need. It is recommended that numbers are assigned for each of the options in the main menu and in all subsequent menus in the interface. The menu options can then be assigned to the corresponding number on the remote joystick keypad. For example, to access the 'Cutting Systems' option on the menu, operators activate button 1, to access the 'Systems Functions' option they activate button 2 and so on. Once operators are back on the run screen the keypad automatically corresponds to the cutting list again. Alternatively, a completely separate set of buttons corresponding to the menu systems could be incorporated into the keypad.

Number based identifiers are the best option to fulfill this recommendation as they have been found to produce faster interactions times than alternative letter based identifiers (Perlman 1984). They are also useful for the present purposes in that their activation could be incorporated into the functions of the remote joystick keypad.

This recommendation would involve combining more closely the functions on the remote joystick keypad with the functions on the graphics display module. This would be beneficial in that it would eliminate the need for operators to lean forward and select the functions from the soft keys, as all functions could then be accessed from the keypad. This is the one of the clever design characteristics used in the interface of one of the worlds leading harvester manufacturers. The operators are able to access all of the system functions without the need to remove their hands from the hand controls.

If a digit based activation system is adopted it is important to bullet-proof the replies that are available (Sutcliffe 1995). This will mean that if digits 1 to 7 are the options for the menu, any other keystroke needs to be followed by an error message.

Due to the extreme conditions within which the Waratah is expected to perform, the measuring device located in the harvester head is subject to wearing down and gradual erosion. This can lead to inaccurate measurements on the part of the machine and subsequently lead to incorrect cutting on the part of the operator. It is recommended that the interface should include a prompt for operators to assess the accuracy of the measuring wheel by conducting manual measurements.

Harvester operators are subjected to very high physical and mental demands (Sullman & Kirk 1998, Inoue 1996) and as such previous research has highlighted the need for operators to take regular breaks throughout the working day (Kirk 1998, Byers 1995). It is suggested that an option be included that prompts the operator to take regular rest breaks. The exact nature of the prompt schedules would need to be further examined. Research by Boucsein and Thum (1997) indicates that short rest breaks (7.5 min every 50 working minutes) are more effective in promoting recovery from mental and emotional strain in the morning, while a longer rest break (15 min every 100 working minutes) is more effective in the afternoon.

A variety of alternative prompt schedules could be made available for operators (and contractors) to select the most appropriate. The prompt could appear in an audible or visual form which serve as a reminder that the operator is due for a micro-pause or rest break.

The approved code of practise for the use of visual display units (Department of Labour 1996) recommends that these small breaks should be taken frequently, 5-10 seconds every three minutes for the greatest relief of muscle strain. Although a prompt occurring every three minutes would be unreasonable to incorporate, a prompt should be made for hourly breaks.

Currently the system takes a period of about 30 seconds to boot up once the computer has been switched on. During this time the screen remains blank and there is no indication that the system has responded to the start up. In the past this has caused a number of operators to turn the computer on and off a number of times as they had thought that the computer had failed to respond to the start up. This failure to inform the operator of what the system is doing is in conflict with the supportiveness principle. It is recommended that a brief message be included that informs the operator that the system is loading up. The message could read something like the following:

Greetings, the logrite controller will take about thirty seconds to warm up

Hardware

The Logrite controller has nine main hardware elements (see figure 4.).

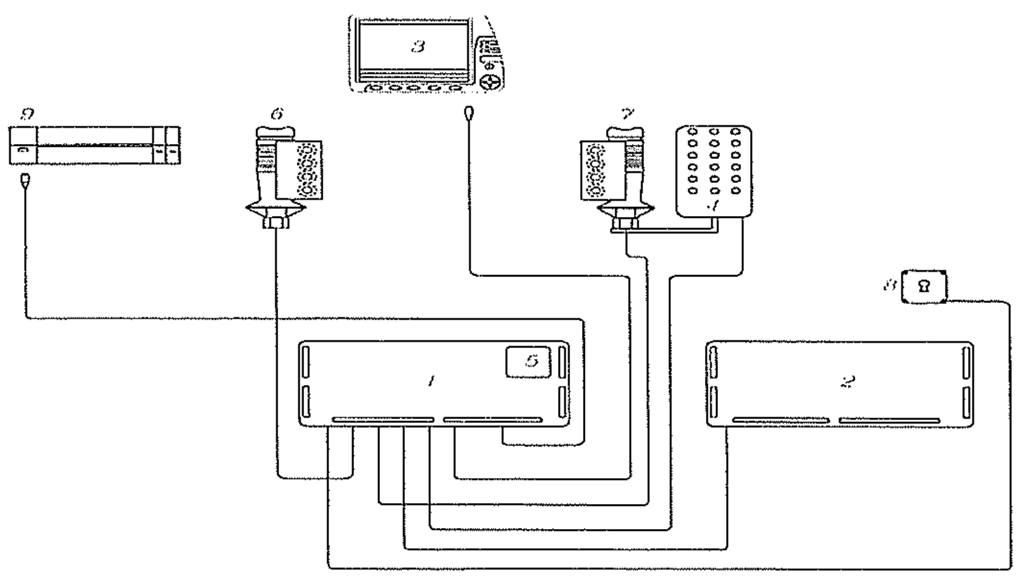

Figure 4. Nine main hardware elements in the Waratah harvesting machine

As far as the human computer interface is concerned, it is the graphics display module, the joystick keypad, the modem, the left and right hand joysticks and the printer that are the focus of the evaluation. More specifically, to be covered in this section is the position, size and characteristics of graphics display module, the left and right joysticks, the remote joystick keypad, button placements and configurations, arm rests, and the possibility of alternative data input methods and technologies.

Graphics Display Module

The evaluation of the graphics display module currently employed with the logrite controller has produced a number of recommendations.

A number of operators have commented upon the problem associated with dust collecting on the screen and in particular in the corners of the screen. This can lead to visibility problems and obscuring of information, particularly in the bottom left and right hand corners of the screen where the soft key descriptions are located. This problem can be alleviated quite simply by the inclusion of a flat face screen on the display. This will remove the edge or rim that is currently running around the outside of the monitor face and will aid in cleaning the display.

The size and position of the display are two factors that interact with one another and may lead to problems with the interface in its current form. Presently, there are two alternative locations where operators may choose to place their display.

The first location (position A) (Figure 5), and the one that is recommended in the Waratah manual is directly in front of the operators viewing position, between the legs and just below the front windscreen. The second location (position B) (Figure 6) is on the window frame of the right hand side of the front wind-screen. Unfortunately there are a number of problems associated with both of these positions.

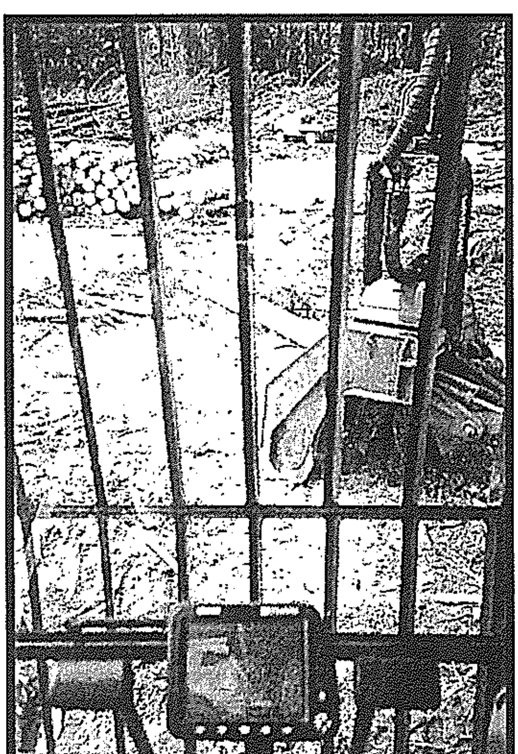

Figure 5. Position A.

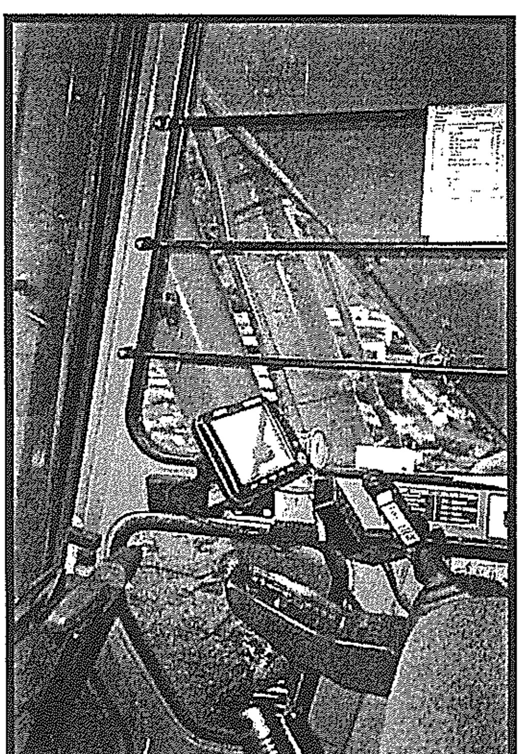

Figure 6. Position B.

Position A, in the middle of the operator's legs has a number of problems associated with it. Firstly, when in this position the viewing distance is beyond that of the recommended distance given the size of the display. The approved code of practise for the use of visual display units (Department of Labour 1996) and the majority of ergonomic guidelines (Pheasant 1987) recommend a viewing distance of somewhere between 400-700mm. Position A produces a viewing distance of between 750-840mm depending on the operators position in the seat. This extended distance can led to visual fatigue (Dillon & Emurian 1996) and associated problems such as headaches and postural fatigue (Rutter 1997).

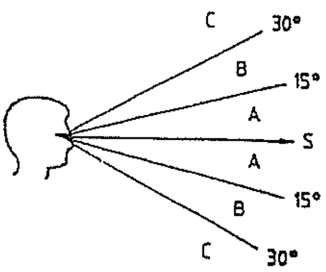

Figure 7. Viewing angles

Secondly, the position is too low below the operator's horizontal line of vision. Position A is placed at a viewing angle of between 30 and 40 degrees below the operator's line of vision. The Department of Labour (1996) and the British Standard (1997b) recommend that the screen be placed at a viewing angle of 10 to 30 degrees below the line of vision (Figure 7) and that viewing angles in excess of 30 degrees should not be used. Display positions above or below this can cause postural discomfort (Hunting, Laubli & Grandjean 1981), and decrease the efficiency of visual signal detection (Rutter 1997).

Thirdly, with the display placed in this position, the current nature of the interface requires operators to lean forward and interact directly with the display (Figure 8). Continual leaning forward in this way can lead to postural discomfort and complaints (Alden, Daniels & Kanarick 1972).

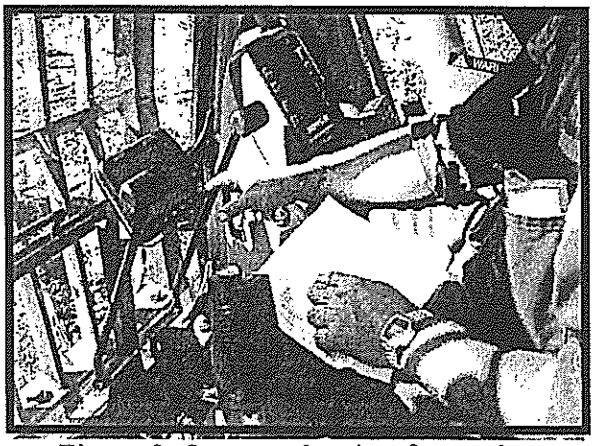
Figure 8. Operator leaning forward to interact with controller.

Position B can alleviate some of the problems associated with the viewing angle of position A and as such is the better of the two alternative locations for the display. It is also useful in that operators can view the display when they are slewing around to pick up the next log for processing. Operators can also view the display without the need to alter the head position too much as they only need to make small alterations in the viewing angle of their eyes.


Figure 9. Poor viewing angle as a result of improving the viewing distance in position B.

The position of the display however is often still beyond that of the recommended viewing distance, with measurements similar to those associated with position A. The viewing distance can be decreased by moving the mounting panel and display closer to the operator. Unfortunately as this is done the viewing angle becomes less optimal (Figure 9). Currently, the design of the cab interior and window frames dictates the amount of variation you can have with the display position as it is mounted on the window frames. Custom designed mounts may need to be included.

Presently, the logrite controller is placed in a fixed position in either position A or position B. Although the angle of the display can be adjusted, operators are unable to adjust the height of the display. An adjustable visual display unit stand should be included that allows for operators to position the screen where it is most suited to them. It is recommended that position B be used and an adjustable mount that can be attached to the right hand window panels be included. The mount should be adjustable in both the horizontal and vertical planes (similar to Figure 10) allowing for operators to position the display in their preferred way.

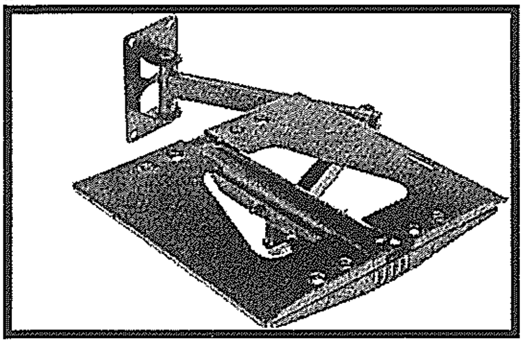

Figure 10. Adjustable display

A major problem associated with the use of visual display units is glare. Glare is usually caused by reflections of natural or artificial light on the screen, excessively bright areas in the field of vision, or some combination of these two factors (Sellers 1994). Glare can cause irritations to a user's vision, increase fatigue, and can also indirectly effect various musculo skelatal injuries as workers adopt awkward postures in an attempt to compensate for the glare (Aronoff & Kaplan 1995). Due to the nature of the working environment, balancing these light sources with the logrite controller is rather problematic.

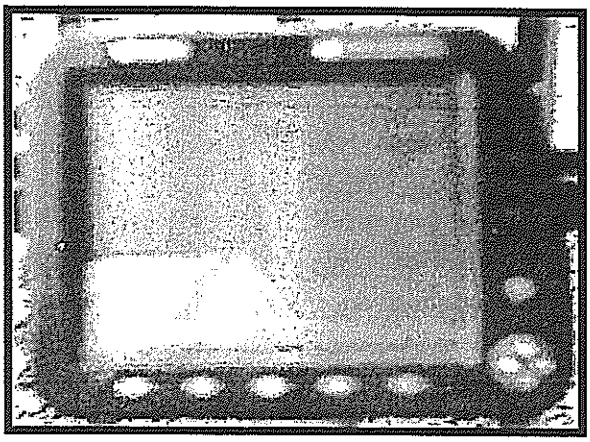

Figure 11. Glare from the controller display.

A number of operators have complained about glare from the display and the authors own observations confirm that it is a major problem (Figure 11). At times it is very difficult to read the information on the display. A number of things can be done in an attempt to minimise the effects of glare as much as possible.

- Operators should be encouraged to clean their screens regularly (this will be aided with the inclusion of a flat surface screen made of more durable materials).

- The inclusion of an anti-glare filter into the display hardware. A filter that maintains the quality of the displayed image is essential. Snyder (1986) suggests optical filters are more effective then neutral density or coloured plastic filters. The filter may also serve the double purpose of protecting the display.

- Remove the high gloss finish from the display module or make it a more neutral density.

- Shade, tint or filter cab windows.

- Provide more adequate sun visors in the cab.

A similar problem is related to the somewhat extreme differences in viewing distance between the tree that operators are cutting to length and inspecting for defects and that of the visual display. This is likely to cause fatiguing of the muscles in the eyes and can lead to eyestrain and headaches (Sellers 1994). Although this discrepancy in viewing distance or working envelope is an unfortunate necessity due to the nature of the operator's task, the negative effects associated with it can be minimised by adhering to the following recommendations:

- Reducing glare (see previous list).
- Incorporate an adjustable stand for the display.
- Encouraging small rest breaks.
- Encouraging operators to refocus their eyes on a distant object during breaks.

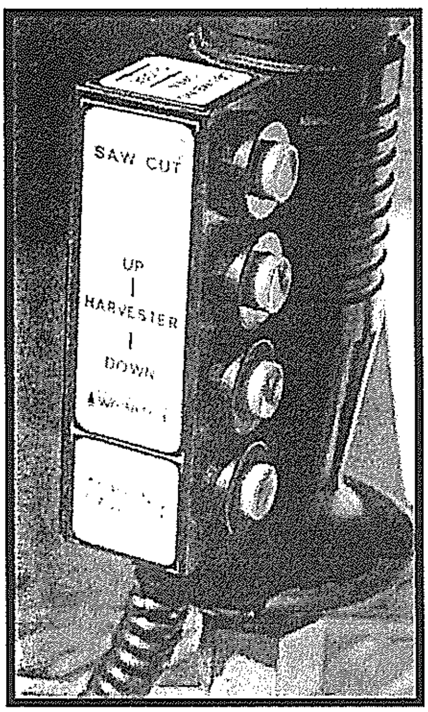

Figure 13. Sharp edge of buttons used in the interface.

The evaluation has also found that the large round scroll key (Figure 12) located on the display is in need of some improvement. It is a round multi optional activating device that requires operators to press either the top, bottom, left or right of the button, depending on what function they are wanting to activate. The button in its current state requires operators to be very precise in their activation of it, as it is quite easy to accidentally activate the 'Scroll-Up' and 'Scroll-Right' or 'Scroll-Down' and 'Scroll-Left' functions at the same time. It is recommended that the button be made larger or alternatively be broken down into four smaller buttons representing the different functions available on the larger button.

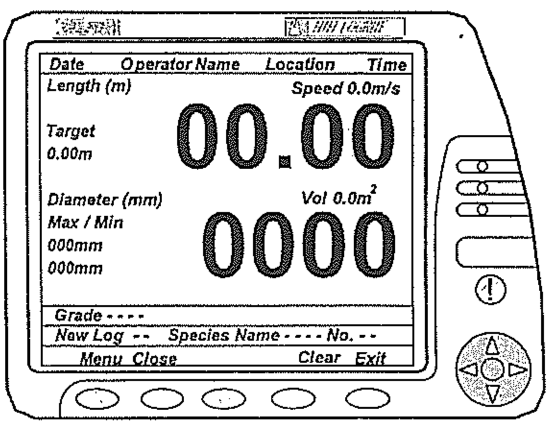

Figure 12. Large round scroll key (highlighted).

Hand Controls

A number of operators expressed dissatisfaction with the button and control design associated with the Waratah interface. Due to the large size and shape variation of forestry workers in this country (Holland, Laing & Webster 1997), the arrangement of the buttons on the joysticks that are appropriate for one operator, may not be for another operator. While observing one operator, he complained that the current position of the 'drive-arm', 'saw cut', 'options' and 'harvester' buttons forced his hand's and wrist's into very cramped and uncomfortable positions. The operator asserted that this was leading to quite severe wrist and forearm problems. Similarly, the controls in their current form are only appropriate for right-handed users.

It is recommended that these button panels be made easily adjustable to accommodate for the individual operators preferred placement of them on the joysticks. Even allowing the button panels to be rotated further around the joystick would alleviate some of the problems encountered by the operators. The panels would need to be made easily and quickly adjustable given that the majority of machines are operated by more then one individual. In addition to this recommendation it is suggested that more research be conducted into the hand controls associated with the Waratah.

Another problem associated with the Waratah's joystick / button configuration is that the buttons used on the joysticks contain a sharp edge running around the top of them (Figure 13). More specifically, the 'drive arm closed / open' buttons, the 'option' button, the 'saw cut' and the 'harvester up-down' buttons and some buttons on the remote joystick keypad all have sharp areas around the tops of them. These sharp, hard edges conflict with ergonomic standards for actuating devices (Carson 1995) and can lead to problems in the fingers that are continually using them. The operators have suggested that they are activating these buttons 95% of their operating time. The edges of these and all buttons included in the interface should have smooth rounded edges.

Similarly, the motor and de-limbing controls on the tops of the joystick could be improved with the inclusion of a soft padded cover. A number of operators have reported developing sore thumbs through the continual use of these functions. The pad should however not be too soft as bits of metal and sharp objects may become embedded and cut the operators (Carson 1995).

Joystick Keypad

A number of operators have suggested that the buttons be illuminated for night and early morning work. Although much of the operation of the Waratah is done through highly coordinated, over-learned actions, the activation of some buttons, particularly those on the remote joystick keypad and the display would be made easier by the inclusion of illuminated buttons. This would save having to turn on the light on the inside of the cab to see what buttons the operators need to activate and also the occurrence of incorrectly hitting the wrong buttons.

Other Factors

The evaluation has also identified the apparent deficiencies associated with a number of the arm-rests used in the cabs. Although arm rests, seating and general cab conditions are outside of the direct responsibility of Waratah, it is difficult and possibly impractical to consider human computer interaction outside of such factors (Murrell 1965). In fact, it is possible that Waratahs hand control design adds to the problems associated with the arm-rests. Poor arm-rests can lead to postural problems which can indirectly influence perceptions of the Waratah interface (Golsse 1990).

As can be seen in Figures 14 and 15, the operator's forearms are completely unsupported by the arm-rests. This lack of support to the operator's forearms and wrists, adds to the strain placed upon the neck, shoulders and back (Hansson, Kihlberg, Andersson, Aoki, Carlsoo, Friberg, Isaksson & Wilhelmi 1992). Similar problems with the arm rests used in conjunction with harvesting machines in this country were outlined by Parker & Gellerstedt (1998).

Research suggests that moveable arm supports in the horizontal plane can reduce muscle activity in the shoulder region (Feng, Grooten, Wretenberg, Arborelius (1997). Pheasant (1987) asserts that arm-rests need to provide 200 mm of arm support. It is recommended that the design of arm-rests used in conjunction with mechanised operations be more carefully and critically examined and further research be conducted in the area. It is essential that operators receive forearm support while using the Waratah.

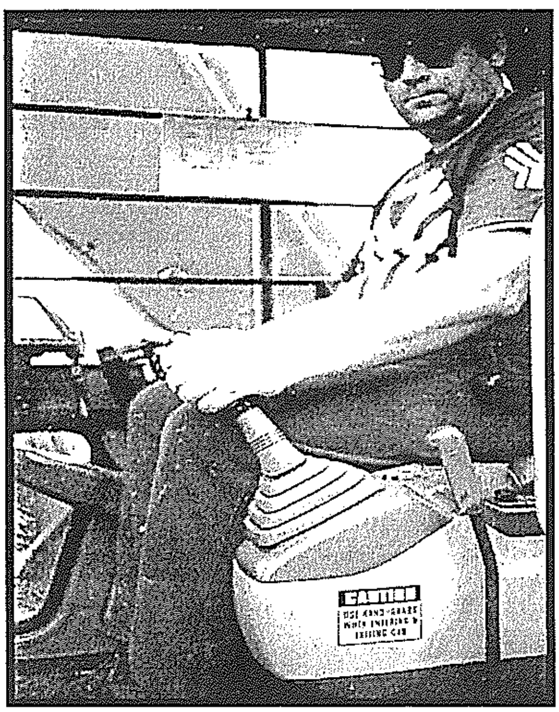

Figure 14. An example of the poor arm rests used with some interfaces.

Figure 15. An example of the poor arm rests used with some interfaces.

Data Input Methods

One further area that needs to be addressed is the variety of alternative data input methods that are available. Currently, the system requires operators to individually enter all log specifications for anywhere up to 25 different log lengths and their associated diameter measurements (Figure 8). Full cutting instructions are entered on a weekly basis, but changes can occur mid week and sometimes daily. This can take up to an hour at times depending on the number of lengths and the operators familiarity with the system. In such an environment as mechanised harvesting where time translates into dollars, such a time expenditure is unjustifiable, especially given the technology that is available today which can alleviate the need for such manual data input.

Alternative input technologies are available and should be implemented. This however is not under the direct control of Waratah as it is affected by the working relationship between contractors and the mills. In overseas locations such as Canada and Europe, forestry has capitalised on the new technologies that are available for communicating between the machine and the office (Sionneau 1996), making the transfer of information more efficient.

The logrite controller does have modem capability that allows for remote access and loading of updated cutting lists, down loading of production data and remote service support (Waratah HTH Logrite Controller Manual). The sooner this technology is utilised the better in terms of operational efficiency and operator comfort. The modem would also be ideal for the purpose of remote fault diagnosis, software support and upgrades. Currently, even minor system malfunctions and operator confusion can cause productivity consuming down-time in which Waratah personnel have to come out to the processing location.

Failing this, alternative input technologies in the form of a detachable keyboard or remote control has been suggested by operators and could be implemented. This could be plugged into the display when entering or updating cutting instructions is needed and then placed behind the operators seat or slipped into a protective cover attached to the cab interior.

The inclusion of the input buttons currently located on the display into the remote joystick keypad as recommended in an earlier section of the report, would alleviate some of the problems associated with operators leaning forward to enter the details. It would also speed the process up quite significantly. At the time of entering the cutting specification, the species buttons could act as an input device. In order to enter a log length of 7.8 for example, the operator would activate 7 – .-8 instead of the current process which requires the operator to repeatedly activate the large round scroll key located on the display in order to enter the specifications. This conflicts with the minimal work principle.

A key stroke comparison between the number of times the operator is required to activate the controller buttons to enter the log lengths 7.8, 5.5, 3.9 in its current form (Table 1), compared to what would be required if the above recommendation is adhered to (Table 2) reveals the significant difference there would be in time and effort to enter cutting specifications.

Length to Enter	Number of Keystrokes	Total Keystrokes
7.8	7+8	15
5.5	5+5	10
3.9	3+9	12
	Total Keystrokes to Enter Lengths	37

Table 1 - Amount of keystrokes required to enter lengths using the round scroll button.

Length to Enter	Number of Keystrokes	Total Keystrokes
7.8	1+1+1	3
5.5	1+1+1	3
3.9	1+1+1	3
	Total Keystrokes to Enter Lengths	9

Table 2 - Amount of keystrokes required to enter lengths using an alternative input device such as an attachable keyboard or keypad.

User Manual

The third area of the Waratah interface that was evaluated was that of the logrite controller user manual that corresponds to version 2.02 of the logrite controller. The manual describes the operation of the Waratah HTH Logrite Controller, and its use in operating and controlling the Waratah HTH series hydraulic tree harvesters. The manual includes operating procedures, setting options and calibration but does not cover installation of the system (Waratah HTH Logrite Controller Manual). More specifically, the manual covers the controllers cutting system functions, printing, screen control, factory and service settings menus, system functions menu, calibration, diagnostics, harvester functions, using the controller for production/measuring, using the modem, sensors, trouble shooting and diagnostics.

Designing good quality support material is not an easy task. It requires a complete understanding of the technical aspects of the interface while at the same time remaining sensitive to the needs and limitations of the users. This balance of what at times may seem like contradictory obligations is difficult to obtain and as such involves a process type of approach to the design in which the product is refined through trial and error.

A well prepared user manual and other forms of supporting documentation can provide the user with an invaluable source of task related information and clarify unclear system functions that would have otherwise gone on misunderstood (Schneiderman 1992). Unfortunately, user manuals and documentation are often viewed as being of peripheral importance and as such do not receive the time and effort that is needed to develop them properly (Brockmann 1990).

Darby (1996) defines a 'useable document' as one in which;

- The information can easily be found.
- The information once found, can be easily understood.
- The actions suggested in the manual are easily discerned by the readers.

Of central importance to the above features and in-line with optimal principles of human computer interface design (Macaulay 1995), it is the perspective of the user that is of utmost importance. Often this perspective is overlooked, ignored or misunderstood as the responsibility of the manual design and production falls into the hands of engineers or product developers who are unaware of the capabilities and limitations of the people who will actually be using the product and it's related documentation (Flyte 1998).

Although the manual associated with the logrite controller is well presented, laid out in a stylish and useable manner and generally of a very high quality, there appears to be somewhat of a discrepancy between some of the content of the manual and the specific needs and limitations of the Waratah operators.

The three operators that were used in the assessment of the user manual were particularly useful as they were each at differing experience and confidence levels. Two of the operators were familiar with the manual while one of the operators asserted that he had only browsed through the manual on one or two occasions. This third operator provided a useful perspective in terms of HCI evaluation as he provided insight into some of the problems more naive users may have with the manual.

The two operators who were familiar with the manual asserted that they had referred to the manual on a number of occasions and had found it both informative and helpful. They both asserted that the latest version of the manual was superior to the earlier ones that were available. One operator however made the comment that it was sometimes difficult to find information if one was not sure how it was described in the manual as some of the terms and words used were unfamiliar to the operators.

The operators performance on the user manual tasks revealed some potential usability issues and highlighted the importance of designing manuals according to the needs and limitations of it's users. The importance of a well-designed manual to the overall effectiveness and quality of an interface was also highlighted throughout the course of the evaluation.

Microsoft Word Readability Assessment

The readability assessment obtained from Microsoft word indicated the following about the logrite controller manual:

- Flesch Reading Ease = 40.7
- Flesch-Kincaid Grade Level = 12.0

This indicates that the reading ease of the manual is somewhat below that recommended for standard documents which is 60-70. The grade level score also indicates that the manual is pitched at 12th grade level or at about the sixth form level in this country. This is a somewhat unfortunate assessment given that 56% of the loggers surveyed in 1989 had left school before the start of sixth form with only 18% of those questioned having school certificate passes (Gaskin, Smith & Wilson 1989).

Usability Tasks

Usability task 1: Do you understand the bark-offset formula?

Not one of the three operators used in the analysis understood the formula. One operator said that he had failed mathematics at school and was daunted by the apparent complexity of the formula. This finding raises the question of why the bark-offset formula is actually included in the content of the manual? The general lack of operator understanding of the formula indicates that it is a somewhat redundant feature.

Redundant features such as this only scare less confident and less experienced users away from the manual and the interface it is designed to support. All three operators asserted that they were unsure of the concept of bark offset and were uncomfortable using this function of the interface.

Usability task 2: Do you understand the 'copying cutting lists' paragraph on page 6-4?

Operator 1 read the paragraph well. He asserted that he understood what the paragraph was describing, but that he felt that it could be put in a less complicated way. The excessive repetition of the instruction <Scroll Up/Down> makes the reading of the passage difficult to process and comprehend. The operator also made an insightful comment in that he believed that if he was not so familiar with the system and the operation of the Waratah then it would not have made much sense at all. This was exactly the case with operator 2.

Operator 2 was less confident with the interface and its functions, asserting that he just liked to keep to the basics. This operator read the paragraph out aloud and began to laugh asserting that he did not know that he could speak Japanese. By this the operator meant that the passage sounded like a different language to him.

This is an unfortunate response given that the disclaimer in the manual and on the display itself asserts that it is important that an operator read and understand the operation and safety instructions of the harvester manual before commencing operation. Due to the nature of the harvesting task, the manual itself and the lack of training given to operators however, they do not understand the operation of the interface until after they have begun processing.

Operator 3 was more familiar with what the passage was trying to explain although he too suggested it could possibly be worded differently. Terms such as 'Parameter', 'Destination List' and even 'Highlighting' may be readily understood by more experienced operators, but for the naive user they only serve to complicate the procedure.

Usability task 3: Do you understand the feeding and measuring log chart on page 15-2?

All three operators were reasonably comfortable with the feeding and measuring log chart understanding both the content and the intent of the chart. All three operators however believed that it was unnecessarily complex and could be simplified.

Usability task 4: Find the page in the manual that describes what it means when the error indicator on the printer is 'steady' and 'flashing'

All three operators initially searched for this information under the printer section of the index. After a brief time of shuffling through the pages, they all found the correct section and information without any difficulty.

Usability task 5: Using the manual, provide me with three reasons why the diameter readings might not be consistent.

All three operators completed this task without too many difficulties.

Usability task 6: Using the manual could you please tell me exactly where the manual suggests you should mount the oil junction box

All three operators had difficulty finding this piece of information. Admittedly the oil junction box is a rather insignificant, obscure aspect of the manual to try searching for, but it again highlights the problems associated with finding a new piece of information that the operators were not exactly sure where to start looking for. Operators 2 and 3 had never even heard of the oil junction box and as such were unsure of where to find it in the manual. They both scanned through the index until they came to the information. Operator 1 however filtered through the entire manual and only after giving up on that technique decided to use the index.
It was interesting to note that all three operators relied very heavily on the index when searching for information. This indicates the need for a well structured useable indexing system. The manual's indexing system and the manual itself is well organised and the majority of the problems encountered by operators appear to revolve around the language that is used. More specifically terms such as 'graphics display module', 'light emitting diodes', 'configurations', and 'print machine variables' are unnecessarily complex and only cause confusion amongst the operators. A list of suggested alternatives can be found in Table 3.

Problematic Term	Recommended Replacement
• Graphics Display Module	Screen / Display
• Light emitting diodes	Lights
• Configurations	Arrangements
• Print Machine Variables	Print Machine Variations

Table 3. Problematic terms and suggested alternatives.

Brockmann (1990) has outlined nine separate stages involved in the development of effective user-centred documentation:

1) Developing document specifications

2) Prototyping the document

3) Drafting the document

4) Editing the document

5) Reviewing the document

6) Field-Testing the document

7) Publishing the document

8) Post project reviewing

9) Maintaining the document

The current status of the Waratah user manual appears to be located at stage nine or the maintaining of the document stage. During this stage the manual is updated to remain consistent with the system that it was designed to support and any feedback from users is incorporated. When newer versions of the manual are released it is important that the user's attention is brought to any updated or changed sections in the new versions. This can be achieved by sending out a covering letter outlining the alterations that have been made or inserting a 'list of changes' page in the new version (Brockmann 1990). Allwood and Kalen (1997) have also argued that constant user testing is an important factor in enhancing the usability of manuals.

One minor adjustment that would increase the usability of the manual in general and the problematic passages such as the one tested in the usability tasks in particular would be to provide examples and samples alongside any instructions that are given (Schneiderman 1992). An example of this would be to provide a fictitious cutting list that serves an illustration of how to copy the cutting list from one species to another. More specifically, instead of describing the steps involved in the process, the manual could provide pictures of what the display is showing and what buttons need to be activated at each step in the process. This will provide operators with a visual representation of the transitions from one step to another.

Waratah operators could also benefit from a type of guided instructional manual or on-line tutorial in which they work through the manual while interacting with the interface. Carrol, Mack, Lewis, Grischkowsky and Robertson (1985) have developed a concept of the 'minimal manual' with the purpose of encouraging users to actively interact with the systems functions while following the instructions outlined in the user manual.

On-Line Help

The sooner the on-line help system is up and running on the interface the better. There are a number of advantages associated with making user manuals available on the computer (Schneiderman 1992).

- It enables the operator access to the information on screen saving them the need to find a paper version of the manual.
- Operators do not need to allocate work-space for using the paper versions.

- Information can be updated relatively easily compared to the costs and effort associated with updating written materials.

- Specific information can be accessed easily if the system provides indexing or key word search options.

It is however important that Waratah avoid simply placing the manual itself directly onto the interface as there are a number of problems that can be associated with this. The small display will mean complete pages will not be able to be displayed on the screen and the formatting associated with the paper manual may not convert directly to the on-line format. It is also helpful if the on-line version is enhanced as much as possible by the availability of key word searches, indexing, electronic bookmarks, string searches, automatic history keeping, page numbers and a variety of different scrolling functions.

Another important aspect of document design is to provide the individuals responsible for it's development with recognition in the form of signed authorship. This will involve allocating the name or names of the people involved in the design of the manual somewhere in the inside cover. In this way the designer(s) receive the credit for any praise that comes as a result of the manual, and conversely receive any of the complaints or queries. Assigning individual responsibility to document design is a simple but effective way of promoting quality design (Brockmann 1990).

Operator Training

The fourth and final area of HCI that was investigated throughout the course of the evaluation was to do with operator training or formal operator instruction. There is unfortunately a significant lack in the availability of formal training or instruction for machine operators in this country (Cummins 1998), (Kirk, Byers, Parker & Sullman 1997). In Europe and Australia on the other hand, specialised courses are offered to machine operators and potential machine operators (Hakanpaa 1989).

Parker, Kirk and Sullman (1996) have argued that the benefits of operator training include; reaching a faster rate of productivity in a shorter period of time, less machine damage, lower site damage and reduced operator injuries such as OOS and musculo skeletal disorders. Both Johansson and Strehlke (1996) and Sullman and Evanson (1998) have also argued that operator training is imperative due to the large costs associated with operator inexperience, machine down-time and repairs.

In addition to this, research on the economic viability of forest worker training has indicated that the costs associated with training are recouped through increased productivity and safety indicating that training is cost effective in such settings (Garland 1990). Recent changes in the accident insurance scheme in this country might also influence the long-term financial benefits associated with training.

The need for more standardised training procedures within forestry in general and mechanised systems in particular has been outlined on numerous occasions (Cummins 1998, Byers 1995). The present evaluation intends to reinforce this recommendation. The majority of the previously mentioned references have focussed on general training needs for operators in regard to the skills necessary for successful harvesting. The current evaluation however was more concerned with the type, and availability of the training that is associated with the Waratah interface in particular. Without a formal training program in which the operators are given instruction on the many different functions available in the interface, the operators remain naive to the type of functions that are actually available to them.

Results & Recommendations Regarding Training

Not one of the nine operators used in the evaluation had received any formal training or instruction on the use of the logrite controller. Most of the operators asserted that the only instruction they had received was during the calibration process or when any mechanical or technical problems had occurred and Waratah personnel were called in to remedy the situation. The majority of operators had to learn through experience with the interface while on the job or rely on being shown by more experienced peers.

All of the operators asserted that they believed that an instructional period from trained Waratah staff or someone familiar with the interface, machine and mechanised harvesting in general would have been an invaluable experience. This instruction would be useful for a number of reasons:

- Enable less confident operators to increase in confidence.
- Inform operators of the functions available on the interface.
- Increase operator and machine efficiency and productivity.
- Decrease learning time, down-time and breakdowns.
- Provide Waratah with increased contact with operators.

Timberjack, a world leader in the manufacture of forestry equipment provides extensive operator training to all operators that make use of their equipment. In addition to the training that Timberjack provide for their operators they have also an advanced machine simulator for operator training (Pelkonen 1997). In simulator training, operators sit in the seats, use the joysticks and visual display identical to what they would use in a real harvesting machine. The system creates a virtual display that simulates the working environment and the machine functions.

Operators are presented with a screen displaying realistic forest environments in which they are required to control the machine to accomplish a variety of programmable objectives. Progress reports on the trainees performance can be obtained highlighting where the operator needs to improve. In this respect the system can also provide a type of objective assessment of current operators ability. The benefits associated with simulator training include:

- Training prior to delivery.
- Less damage and higher productivity from the start.
- Better utilisation of machine features.

- Safe, low cost training.

- Development of better harvesting techniques which lead to higher levels of log optimisation.

It is recommended that a formal training program be made available to Waratah operators and potential operators. Eventually such training may be made available through polytechnics and training establishments as they are in Europe but for now, more standardised training should be made available. Waratah could also make use of their controller simulator and possibly upgrade it to resemble that used by Timberjack.

Training should also include sessions on operator health and well being involving aspects of ergonomics, occupational overuse syndrome, rest breaks, health and nutrition and covering general health and safety issues. In particular, ergonomics training in relation to the interface should encompass sitting posture, eyes, vision lighting, exercise and interface adjustability (Springer 1997).

It is understood that at this stage this recommendation may be difficult to implement as Waratah themselves are largely unaware of who is involved in the operation of their equipment. More often then not, contractors and foreman engage in haphazard selection processes involving the random selection of workers who are then given a crash training course on how to use the interface. These workers are unfortunately then expected to learn the systems functions and utilise the machine to its full potential.
The need for operator training in general, and specific training on how to effectively use the interface needs to be made an explicit recommendation by Waratah to purchasers at the point of sale. Waratah should state that before an operator begins to work with the interface it is highly recommended that they participate in a formal training program, or undergo an instructional period.

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Appendix 1 -Summary Tables of Problems and Recommended Solutions

Ergonomic Principles- Problems identified that conflict with ergonomic principles.

PROBLEM	RECOMMENDED SOLUTION(S)
• Font used in the display too small given the viewing distance.	Increase the font size used in the display by ½ mm.
• Soft key functions and titles include upper and lower case type.	Adjust to include all upper case (this is not so much a problem but an improvement)
• Dust collects in the corners of the display, obscuring visibility.	Include a flat face screen. Remove the edge running around the outside of the screen.
• Display position A; -Beyond the recommended viewing distance -Below the recommended horizontal line of vision -Requires operators to lean forward which leads to postural difficulties.	Include an adjustable stand, move the display to position B or include an alternative input device
• Position B beyond recommended viewing distance. • As viewing distance improves the viewing angle becomes more of a problem.	Include an adjustable mount for the display. Custom design mounts for cab specifications.
• Unable to adjust the height of the display.	Include an adjustable stand or mount.
• Glare (reflections in the screen) obscures vision and can cause visual problems.	1. Encourage operators to clean their screens more often. 2. Include an anti-glare filter. 3. Remove high gloss finish from the display and replace with a more neutral density. 4. Shade/tint/filter cab windows. 5. Provide more adequate sun visors in cab.
• Large round scroll button requires precise activations.	Enlarge button or alternatively split scroll functions up into four separate buttons. Have an alternative input device
• Differences in viewing distance between display and tree being processed can lead to visual fatigue.	Minimise by; 1. Reducing glare 2. Including an adjustable monitor position 3. Encourage operators to take small rest breaks and refocus eyes
• Activation buttons on the hand controls contain hard, sharp edges.	Replace with buttons with smooth, rounded edges.
• Motor and de-limbing controls on the top of the joysticks cause sore thumbs.	Include soft padded cover on tops of joysticks.
• The fixed position of the control buttons forces operators hands into cramped positions.	Make the button panels easily adjustable to accommodate individual characteristics.
• Many of the arm-rests used in conjunction with the harvesting task do not support the	1. Height and length adjustable arm rests need to be included in the cabs.

operators arms correctly.	2. More research needed into Waratah's responsibility.

Naturalness Principle- Problems identified that conflict with the naturalness principle.

PROBLEM	RECOMMENDED SOLUTION(S)
• Some of the words and terms used in the display are foreign to operators.	Liase more closely with operators to identify problematic terms and words then develop alternatives. Include a glossary of definitions in the user manual for the more difficult terms. Have an instructional period clarifying any unclear terms.
• Operators believed the 'copying cutting lists' instructions in the user manual was unnecessarily complex.	1. Reword the paragraph. 2. Conduct a training course which clarifies ambiguous terms. 3. Provide examples and samples in the manual.
• Operators believed the 'bark-offset' formula was too complicated.	Same as above.

Consistency- Problems identified that conflict with the consistency principle.

PROBLEM	RECOMMENDED SOLUTION(S)
• Soft key functions change depending on what screen the operators are on.	Have an alternative input device.

Non-redundancy- Problems identified that conflict with the non-redundancy principle.

PROBLEM	RECOMMENDED SOLUTION(S)
• The main menu ordering conflicts with the frequency of use principle.	Adjust menu ordering to order outlined in the report.
• Large scroll button takes too long to scroll down through menus and lists.	Assign numbers to menu options and assign to the keypad. Incorporate display functions into the keypad.
• Operators forced to turn on lights at night to see species panel.	Illuminate buttons on keypad for night work.
• Input of cutting instructions far too time consuming.	1. Utilise modem capabilities. 2. Incorporate an attachable keyboard or remote control. 3. Incorporate buttons on display into the keypad

Supportiveness- Problems identified that conflict with the supportiveness principle.

PROBLEM	RECOMMENDED SOLUTION(S)
• Measuring wheel deteriorates corrupting the accuracy of measurements.	Include a prompt for measuring wheel checks every 6 months or so depending on the conditions to which exposed.
• Operators working long hours without any rest breaks.	Interface should prompt for rest breaks and micro pauses.
• Interface takes a while to boot up without any message informing the operator.	Provide notification to the operators that the interface has responded to the start up in the form of a message.
• Operators occasionally activate wrong button at night because they cannot see the panel.	Illuminate buttons for night work.
• No authorship is attributed to the controller manual.	Attribute name of developer to the manual.
• On-line help system is currently unavailable.	Develop on-line help system and make it available to operators adhering to the recommendations presented in this report.
• There is a lack of standardised training for operators.	1. Develop a standardised training program for use of the logrite controller. 2. Inform contractors of its availability and the benefits associated with such training. 3. Develop further and make use of the interface simulator.
• Updates of manual coming out.	Include a 'changes to version page' in new versions.
• Remote service support and fault diagnosis and remote software support and upgrades unavailable.	Implement and utilise modem capabilities.

Flexibility- problems identified that conflict with the flexibility principle.

PROBLEM	RECOMMENDED SOLUTION(S)
• Fixed position of control buttons forces the hands of some operators into cramped positions.	Make controls panels more easily adjustable.
• Interface is not very sympathetic to left handed operators.	Same as above.

Appendix 2 - Questionnaire for Waratah operators

The following questionnaire has been designed to assess your experience of the computer and the joysticks/hand controls used in the Waratah harvesting machine. The information obtained from this questionnaire may be taken into consideration in the future designs of Waratah machines. Please take your time in completing the questionnaire and attempt to answer every question. Your responses will be considered confidential and the questionnaire is in no way going to be used as an assessment of your abilities.

Where appropriate, please tick the box next to the answer that you want. The following questions provide you with examples of the type of responses we are wanting:

Example question 1

How many different log lengths do you usually have to enter?

- [x] 1-3
- [ ] 4-6
- [ ] 7+

Example question 2

Have you suffered from sore eyes while working in the Waratah?

- [x] Yes
- [ ] No

Example question 3

Please describe what you have for breakfast in the morning:

I have ten Weet-Bix, four pieces of toast and a cup of coffee.

Questions

1. How often do you have to enter new log specifications?
   - [ ] Less then once a day
   - [ ] Once a day
   - [ ] More then once a day

2. How long does it usually take?
   - [ ] 0-10 minutes
   - [ ] 11-20 minutes
   - [ ] More then 20 minutes

3. How many log lengths do you usually have to enter?
   - [ ] 1-3
   - [ ] 4-6
   - [ ] 7-9
   - [ ] 9+

4. Have you ever been given any formal training on how to use the Waratah computer?
   - [ ] Yes
   - [ ] No

5. If you have had training, briefly explain what it involved:
____
____
____
____
____

6. Has the new Waratah computer made your job:
   - [ ] Easier
   - [ ] Harder

7. How do you think the computer could be improved to make your job easier?
____
____
____
____
____
____
____
____
____

8. Do you find glare form the monitor a problem?
   - [ ] Yes
   - [ ] No

9. How do you think the screen display could be improved?

____
____
____
____
____
____
____
____

10. Do you find the numbers/words on the display big enough to read?

- [ ] Yes
- [ ] No

11. When it gets dark can you read the screen?

- [ ] Yes
- [ ] No

12. Is there any language or are there any words that are used in the display that you are not familiar with?

- [ ] Yes
- [ ] No

13. If there is, can you describe what these are?

____
____
____
____
____
____

14. What do you think about the size of the joysticks/hand control?

- [ ] They are too small
- [ ] They are good
- [ ] They are too big

15. What do you think about the placement of the joysticks?

- [ ] They are placed too closely to me
- [ ] They are good
- [ ] They are placed too far away from me

16. What do you think about the shape of the joysticks/hand control?

- [ ] I find them uncomfortable in my hand
- [ ] I find them comfortable in my hand

17. Please add any other comments that you have about the joysticks/hand controls:

____

____

____

____

____

____

18. Tick as many of the following that you feel are appropriate:

The buttons on the joysticks/hand controls are:

- [ ] Hard to reach
- [ ] Uncomfortable for my fingers
- [ ] Poorly placed
- [ ] Well placed

19. Any other comments about the buttons on the hand controls?

____

____

____

____

____

____

20. Describe your shift system:

____

____

____

____

____

____

21. How many breaks do you usually take in a day?

- [ ] 0
- [ ] 1
- [ ] 2
- [ ] 3 or more

22. Have you ever suffered from sore eyes while working with the Waratah?

- [ ] Yes
- [ ] No

23. Have you ever experienced any wrist problems while working in the Waratah?

- [ ] Yes
- [ ] No

24. Are you right or left-handed?

- [ ] Right
- [ ] Left

25. Could you please describe in as much detail as possible the ways that you interact with the computer to do your job: (e.g. I need to enter the log specifications into the computer…….)

____
____
____
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____
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____
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____
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____
____

26. At the end of each shift, please describe how you or someone else would know that you have done a good job in using the Waratah for cut to length operations:

____
____
____
____
____
____
____
____

Please feel free to make any other comments that you want to about the Waratah computer or the joysticks/hand controls used in your job:

Thank you for taking the time to complete this questionnaire

Appendix 3 – Human Computer Interaction Interview Outline

General

1. Do you understand what the small lights on the side of the display mean?

2. Where do you have your display placed?, do you think this is the best place for it?

3. What information / functions do you think could or be included in the interface?

4. How / when do you use the joystick keypad?, how activate a log length?

5. How many log lengths do you usually enter?

6. What other log details do you have to enter?

7. What parts of the menu do you use most? (Pg 1-1)

8. Are there any parts of the computer that you do not use?

9. What do you think are the most important functions of a Waratah comp?

10. Do you ever make any mistakes when using the computer?

11. Have you received any training from Waratah?

12. How did you learn to use the computer?

13. How do you think the screen display can be improved?

14. Do you think the hand controls are good enough?

15. What about the buttons?

16. Do you understand the language used, the meaning of the menus? Does it relate to the work you are doing?

17. How do you pick up logs and cut them? - What button sequence do you use? E.g. open drive arms, close drive arms, topping saw etc.

18. Do system / computer failures occur?

19. Does the interface tell you any information about the mechanics?, inform of any problems?

20. How much time of the day spent using buttons on controls?

21. How many times do you hit the buttons to enter a log length?

VRUSE type of Information

Functionality

1. Do you understand all the functions that the computer provides? - Describe.

2. Do you find it easy to get into all of the functions?

3. Do you remember all the functions?

4. Do you need to use all of the functions?

User input

1. Do you find the input devices easy to use? (Soft keys, buttons, keypad)

2. Would you prefer other types of input devices?

3. Does the system respond to your input in an acceptable way?

4. Do you feel like you have control over what you want to do with the computer?

User Guidance & Help

1. Do you use the on-line help system or user manual?

2. Do you find the support helpful?

3. Do you find it easy to get the information you need off the help system?

4. Can you access the help system from any point in the system?

Consistency

1. Does the sequence of inputs to perform a specific action match your understanding of the task?

2. Were the menu and soft ley systems consistent?

Flexibility

1. Do you think that the computer interferes with how you would like to do the job?

2. Have you learned any shortcuts in using the computer?

3. Are you able to tailor the system to suit your own needs?

Error Correction

1. Do you find it easy to undo mistakes that you make with the computer?

2. Are you informed of when you make mistakes?

3. Does the system provide protection against trivial errors?

Think-Aloud Protocol

- Could you please think about and describe everything that you do with the computer from the moment that you get into the cab until the moment you get out.

User Manual Information

1. Have you ever read the controller manual?

2. Did you find it helpful / useful in learning to use the controller?

3. Do you have any problems with the manual?

Tasks

1. Turn to page 6-1. Do you understand the 'bark offset' formula?

2. Turn to page 6-4. Read aloud the highlighted paragraph? Did you understand what the paragraph was describing?

3. Turn to page 15-2. Do you understand the 'feeding and measuring logs' chart?

4. Using the manual, can you please find the page that describes what it means when the error indicator on the printer is steady & flashing.

5. Using the manual, can you please tell me three reasons why the diameter readings are not consistent.

6. Using the manual, could you please tell me exactly where the manual suggests you should mount the oil junction box.