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INCREASING SEATBELT USAGE IN LOGGING SKIDDERS THROUGH  
BEHAVIOUR MODIFICATION AND  
SEATBELT REDESIGN

A thesis submitted in partial  
fulfilment of the requirements for the degree of Master of Science  
in Psychology at Massey University

Mark J.M. Sullman

1994

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## ABSTRACT

This study examined methods for increasing seatbelt usage in one type of heavy logging machine (the skidder). This machine is used extensively for extracting felled trees and transporting them from where they are cut down to a central processing area. Preliminary investigations suggested that the operators of these machines failed to wear their seatbelts because they were poorly designed and because the operators simply forgot.

A survey of the literature on increasing safety behaviours found that the two most powerful techniques were behaviour modification and human factors engineering (or ergonomics). Therefore, these were the two techniques used here.

The standard seatbelts were redesigned to make them easier to use and an orange flashing reminder light was installed into the machines of seven full-time skidder operators. These machines were operating in either Kaingaroa, Rotoehu, Tahorakuri or Te Whakao Forests in the central North Island of New Zealand.

The experiment used a multiple baseline single subject design, with the subjects receiving each treatment twice. With the installation of the redesigned seatbelt, mean seatbelt usage for six subjects rose from 21% to 31%. One subject refused to wear a seatbelt throughout the experiment. Installing the reminder light increased seatbelt usage by a further 1%. Removing the new seatbelt design caused usage to drop 16%. A further decrease of 5% occurred with the return to baseline phase when the reminder light had also been removed. The second introduction of the new seatbelt resulted in an increase in usage from 10% to a mean level of 46%. This was increased a further 22% with the reintroduction of the reminder light. The results showed that an easier to use seatbelt in combination with a reminder light can increase the level of seatbelt usage. The results also provide further evidence of the power of both behaviour modification techniques and human factors engineering in the field of occupational safety.

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## **CHAPTER 1: INTRODUCTION**

### **1.1 - Introduction**

The first chapter outlines the methods an occupational psychologist can use to solve problems in the field of occupational health and safety. The various sub-categories of the industrial/social approach are then outlined. This is followed by a brief description of the theory behind behaviour modification, which is the approach selected for the study, and an overview of relevant literature.

The problem and reasons for the ongoing failure of forestry machine operators to wear a seatbelt is looked at. This is followed by a description of the kind of environment in which these operators work, with special attention to new legislative requirements. The chapter then concludes with a brief summary of the chapters that follow.

### **1.2 - Approaches to safety in the workplace**

Landy (1989) identified three ways an occupational psychologist could approach the issue of safety in the workplace. Firstly there is the personnel approach. This involves such things as identifying characteristics of accident prone people so as to avoid hiring them. Undoubtedly "accident proneness", as originally described by Greenwood and Woods (1919; cited in Sheeny and Chapman, 1987), has been the most important concept in the study of individual differences in accident causation. However, the support for the existence of an accident prone person is very low (Landy, 1989). While it is clear that some individuals have more accidents than others, this may be due in large part to differential exposures to potential accident-causing situations. For example, forestry workers have a higher rate of accidents involving personal physical injury than lawyers. This does not mean that forestry workers are a more accident prone group, as fairly obviously they are exposed to more potential accident-causing situations.

Secondly there is the engineering approach, which has often involved the development of 'defences' such as machine guards, crash packaging and protective equipment. This approach is time consuming and may be relatively expensive, as it not only requires the time of engineers and designers, but manufacturing and testing equipment as well. Machine guarding has been relatively successful, although the guards may be removed because they are cumbersome, interfere with workflow and make the job more physically difficult. Simply redesigning safety equipment to make it easier to use or more comfortable may not result in a significant increase in use. Ear protectors are a good example of this. They were redesigned to be more easily used (less discomfort, more portable, etc) and this alone was not found to significantly increase the level of their use (Cohen, 1987).

The third approach is the industrial/social approach, which suggests that a worker must be motivated to behave safely. This may seem strange as protection of life and limb should be motivation enough. Given the number of accidents that happen in forestry every year, it obviously is not. However, motivating people to act in a preventative fashion can be very difficult. There are a number of reasons for this, including the fact that there are usually no rewards to support such behaviour. As well, the unhealthy alternative to prevention is often followed by an immediate reward or convenience. For example drunk driving, excessive eating and smoking all lead to immediate rewards or conveniences, and the unpleasant consequences (e.g. traffic accident, heart disease or cancer) are all perceived as being distant or unlikely.

Engaging in safe behaviour can often take more effort to perform than careless behaviour. For example bending your back instead of your knees when "log making" (for a definition of this term see Appendix 1). In some work environments it is seen as unmacho to take safety precautions. This is an essential consideration in the forest industry as a macho self-image is very prevalent amongst forestry workers.

Workers may engage in the accident-causing behaviour many times, but seldom does this result in an accident. There is also the prevalent view that an accident will not happen to them, accidents only happen to other people. For example O'Hare (1990), in a study on general aviation pilots, found that the pilots

believed their chances of having an accident were well below those of other pilots. This type of study has also been attempted in the logging industry. The results from these studies, however, have indicated that New Zealand loggers are well aware of the risks involved in their work (Tapp, Gaskin and Wallace, 1990). Parker (1991), in a follow-up study, noted this phenomenon in most types of logging work except trimming while walking on top of the tree stem. The loggers markedly under-estimated the risk of serious injury resulting from this style of "trimming" (for a definition of this term see Appendix 1). Therefore, risk underestimation is also seen in sectors of the New Zealand logging industry. Not only do preventative behaviours usually have to compete with alternative behaviours which are immediately rewarding or more convenient, but they must also overcome all the above mentioned disincentives as well.

### **1.3 - The industrial/social approach**

The industrial/social approach can be divided into a number of sub-categories, for example safety training, safety promotion, human factors engineering, legislative enforcement, and behaviour modification. Safety training attempts to increase the subject's safe behaviours by giving them the skills to perform the safe act. This does not affect the behaviours directly, but allows the individual to emit the behaviour by training them to do so. Therefore, the behaviour still may not occur as giving the individual the skills does not mean they will use them. One example of this is the defensive driving course, which attempts to give drivers the skills to perform safe acts when in various situations.

Safety promotion does not attempt to influence the behaviour of subjects directly, but tries to make them aware of the problem and informs them of how to avoid it. These messages are presented to the general population through the use of television commercials, pamphlets, radio, and billboards. In this case the behaviour is again not directly affected at all, and the messages may fall on deaf ears. Even if the individuals take the messages on board and form a good attitude to the problem, there is still a large gap between attitude and behaviour (Mittal, 1988). An example of this form of the industrial/social approach is the

melanoma campaign that is run every summer. It informs the general public that melanoma is a form of cancer which can be avoided by limiting the individual's exposure to the sun.

Human factors engineering (also known as the ergonomic approach) is where equipment, buildings and the like are designed with the human operator in mind, to prevent errors or unsafe behaviours occurring. This directly affects behaviour by altering the action required to exhibit the behaviour. One good example of this is the altimeter in aeroplanes. The original altimeter had three needles, one for 100s of feet, one for 1,000s of feet and one for 10,000s of feet. This led to a number of altimeter reading/interpretation errors by the aircrew, which unfortunately resulted in a number of lives being lost. Therefore, the altimeter was redesigned and a new easier to read design was made which had two needles and a counter. This enabled pilots to read the altimeter quicker while also reducing the number of errors. Redesigning, however, is not always a feasible option given the expense that may be involved.

Legislative enforcement is an extremely common form of the industrial/social approach. This involves penalising those caught engaging in unsafe behaviours. In other words enforcement tries to directly influence behaviours by altering the punishment/reward structure associated with that behaviour. One example of this is the use of fines to prevent speeding. Unfortunately, this does not always work very well. This is particularly the case where punishments are seen as being very distant or the punishment does not regularly follow the unsafe behaviour. For example, a person can speed all the time and rarely get caught. Therefore, the use of enforcement in this case would have little or no effect.

Behaviour modification, as the name would suggest, attempts to directly influence behaviour by altering the rewards or punishments associated with that behaviour. In other words, if the result of a behaviour is something the individual sees as positive (positive reinforcement), the individual will then increase the rate at which that behaviour is emitted. However, if the result of the behaviour is something the individual sees as being undesirable (negative reinforcement) then the individual will reduce the rate at which this behaviour occurs. Behaviour modification is usually fairly cheap and has been found to be a very cost-effective method of achieving behavioural change (Van Houten and Nau, 1981).

In looking at all the different forms of the industrial/social approach, it becomes apparent that behaviour needs to be affected directly and if rewards/punishments are employed they need to be used regularly. This highlights both behaviour modification and human factors engineering as the two best approaches to problems in the field of occupational safety. However, when considering the expense in redesigning and testing the equipment, behaviour modification would appear to be the logical choice.

#### **1.4 - Behaviour modification**

There is no precise definition of behaviour modification (Krause, Hidley and Lareau, 1984), but the wide range of techniques contained within it, involve the application of conditioning principles to the acquisition of desired behaviours and the removal of undesired behaviours. Behaviour modification has been successfully applied in a number of settings, from individual homes and companies to entire communities. It has been successfully applied to a huge variety of societal problems, including energy conservation, littering, and prison management. These very powerful techniques for controlling behaviour have been known by behavioural scientists for many years. However, until recently they have seldom been used for industrial applications (Krause et al., 1984). This appears to be changing. Cohen (1987) notes that the literature demonstrating successful behavioural interventions in the area of occupational safety is growing rapidly.

A good example of the application of behavioural modification in the field of occupational safety is shown in a study by Komaki, Barwick and Scott (1978). Goal setting, positive reinforcement and feedback were used to increase safe work practices by the employees of a food manufacturing plant. They found that safe work practices increased from 70% to 95% in one department and from 77% to 99% in another. However, after feedback and reinforcement were terminated, safe work behaviours diminished to levels similar to the pre-intervention period. This is not particularly surprising as it has frequently been demonstrated that goal setting is of limited utility when the subjects do not receive feedback on how they are going towards achieving their goal.

Goal setting is not the only form of behavioural intervention and the effects of the behavioural interventions do not always discontinue as soon as the programme ends. An example of this is a study by Zohar, Cohen and Azar (1980). The problem of getting the workers in a factory to wear hearing protection was a particularly difficult one given that redesigning the protectors, promotional campaigns, lectures and posters had all failed. Zohar et al. changed the fact that there was no immediate reward for wearing hearing protection. They did this by showing each individual their hearing loss in terms of noise-induced temporary threshold shift (TTS) caused by the day's work. The information was plotted on a graph which all the workers had access to. The graphs showed three things. Firstly, the workers who had been there the longest (who had not worn the hearing protectors) had the poorest hearing. Secondly, the graphs revealed a substantial difference in hearing before and after work. Thirdly, the graphs showed a big difference in the TTS between those who wore the ear protection and those who did not. As a result of the graphs, usage rose from a baseline level of 30-45% up to 85-90%, where it remained stable for some years, despite a 65% staff turnover rate.

Behavioural interventions have also been applied to vehicle safety which has considerable overlap with the field of occupational safety. Considering the success associated with these behavioural interventions, it was considered likely that behaviour modification could be successfully applied to the problem of the low level of seatbelt use in forestry machinery.

### 1.5 - The problem

On a worldwide basis the accident rate in forestry is high (International Labour Office, 1992). This trend is also seen in New Zealand, where Cryer and Fleming (1987) reported that the average fatality rate in forestry was 11.5 times higher than the overall workforce rate. Some types of work in forestry contribute disproportionately to this rate. Forestry work can be divided into two groups, with logging being the harvesting side of the operations and silviculture being the tending of the trees (planting, spraying, pruning, etc). Logging is thought to be the more dangerous of the two, with statistics from the United States in the period 1977-1980 ranking logging as the most hazardous occupation (International

Labour Organisation, 1990). This is also seen in New Zealand where, in 1992, 28 lost-time accidents (with no fatalities) were reported to the LIRO Accident Reporting Scheme (ARS) in silviculture (Parker 1993a). However, even though the logging side of the industry employs over 1,500 people less than silviculture, there were 197 lost-time accidents and 9 fatalities reported to the LIRO ARS (Parker, 1993b).

Within the New Zealand logging industry itself the number of accidents involving forestry machinery is relatively high. For example in the period 1985 to mid 1993 there were 63 reported machine rollovers in New Zealand, and of these 6 (10%) resulted in fatal injury. The wearing of seatbelts has been highlighted as one method by which the number of machine-related fatalities and serious injuries may be reduced (Kirk, 1992).

Historically the level of seatbelt use in logging machinery has been low (Kirk, 1992). One particular type of logging machinery is the skidder (see Appendix 2 for illustration). The skidder is a rubber-tyred machine designed to haul logs from where they are felled to the "landing" (for a definition of this term see Appendix 1) for processing. When, during the preliminary stages of this study, the researcher informally asked a number of "skidder operators" (for a definition of this term see Appendix 1) why they did not wear the seatbelt, two factors stood out. Firstly, they said they just simply forgot to put the belt on. Secondly, they all mentioned the inconvenience of the standard seatbelt design (see Appendix 3 for photograph). As both ends of the belt are on webbing only, the belt is not conveniently placed for the operator to grasp. It takes quite a bit of effort to do up the belt. Consequently, the belts often lie on the floor of the skidder gathering grease, mud and "slash" (for a definition of this term see Appendix 1).

Another factor contributing to the low level of seatbelt usage is the lack of enforcement. This changed on the 1st of August 1992, when the Department of Labour decided to enforce seatbelt usage under section 12c of the Bush Workers Act 1945. This part of the Act enabled the Department of Labour's Bush Inspectors to give directions regarding the use of protective equipment. The Safety Code for Forest Operations (1992) was taken as the standard which all

logging operations had to reach. Anything below this standard was considered dangerous and was thus forbidden by law. With regard to ground-based extraction equipment this code states:

"specification for seat belt assemblies for motor vehicles or other operator restraint devices approved by an inspector shall be fitted on all machines. Such safety restraints shall be worn at all times while the machine is in motion. Exception: in cases where the operators do their own breaking out the safety equipment shall be worn once the completed drag is attached to the winch rope"(p 48).

To your average skidder operator this means that they are required to wear a seatbelt when travelling from the landing out into the bush and when travelling (after all the logs have been hooked on) from where the logs were hooked on, to the landing. Any operator who did not do this could be issued with a direction notice by an inspector. Failure to comply with the direction notice could result in either the operator or the contractor being fined up to \$5,000.

However, on the 1st of April 1993 the Bush Workers Act was replaced by the Health and Safety in Employment Act 1992 (HSE Act). This Act basically requires an employer to provide a safe working environment. For example, when a hazard cannot be eliminated or isolated the Act specifically states that the employer must ensure that all the appropriate protective equipment (including seatbelts) is provided, accessible and used.

If a contractor fails to comply with any section of the HSE Act they can be faced with a fine of up to \$25,000. Further, if the court can prove that the contractor knew a failure to use the seatbelt was reasonably likely to cause serious injuries, then the contractor can be faced with a fine of up to \$100,000 and/or 1 year in prison. The onus to comply is not only on the employers, the act also requires the employees to act safely. Consider for example, if a skidder operator who has been warned several times by the contractor to wear the seatbelt (which the contractor must be able to prove), still fails to do so, they may be prosecuted and fined up to \$25,000 under the Act. If an injury results from this failure to wear the belt then the Act allows the court to impose a fine of up to \$50,000 upon the skidder operator.

The Act is enforced by the Department of Labour's Health and Safety Inspectors, who can issue an improvement notice to any operator found not wearing the seatbelt. Failure to comply with an improvement notice can result in either the operator, or the contractor being prosecuted and fined up to \$25,000. Unfortunately, it is well known by the workers that the Inspectors visit relatively infrequently (about once every 3-6 months). This is backed up by the results of a recent survey conducted in the Otago/Southland region which was found that 71.9% of the loggers interviewed had seen the Inspector 3 times or less in the last year, with 11.6% not having seen an Inspector at all in the last year (Byers and Adams, in press). Taking this into account and the fact that most workers spoken to thought the only likely punishment would be being told to put on their belt, the impact of the Health and Safety Inspector is likely to be fairly minimal.

Given that enforcement is likely to have limited effectiveness, it was hypothesised that seatbelt usage could be increased by removing some of what the skidder operators see as deterrents. These factors, as mentioned above, relate mainly to convenience. Improvements were made by designing a seatbelt (see Appendix 3 for photograph) that required little effort to use. Attention was given to making the belt easy to grasp and easy to adjust. In addition to improving the conventional seatbelt design, the problem of forgetting was addressed through the use of a simple behavioural modification technique. This involved the installation of an orange flashing light to remind the operator to belt up.

The current study tests whether the above changes, both in combination or separately, will result in an increase in seatbelt usage. This is attempted by measuring the current level of seatbelt usage and testing whether this can be increased through improving the seatbelt design and/or installing a reminder light. These are tested to investigate and compare the effectiveness of each intervention.

## **1.6 - Organisation of chapters**

The next chapter covers the various approaches to the problem outlined above. It then carries on by reviewing the relevant literature on the two approaches which were chosen to improve the level of seatbelt use in skidders.

Chapter 3 describes the experimental design and the rationale behind it, the subjects, measures, equipment used and the procedure. The chapter also mentions a number of practical problems that forced changes in the experimental design and shows how the design changed as a result. This chapter ends by developing the research hypotheses with the rationale behind them.

Chapter 4 presents the results, in two parts. Firstly, objective results based on data collected through recording instruments during the study. Secondly, the subjective results and event diary contains comments made by the operators of the machinery and important events that happened during the course of the study. The combined results are then looked at, followed by a summary of the operator's evaluation of the seatbelt design and usefulness of the reminder light.

Chapter 5 contains the discussion of the results in terms of their relationship with the research hypotheses. The generalizability of the observed findings are discussed, followed by a brief mention of the problems encountered during the study. The chapter concluded with the implications for future research and the overall conclusions able to be drawn from the study.

## **CHAPTER 2: LITERATURE REVIEW**

### **2.1 - Introduction**

Chapter 2 briefly reviews behaviour modification, outlining both the theory and the history of this approach to behaviour change. The chapter then investigates the application of behaviour modification in the area of vehicle safety. This is then narrowed to specifically look at seatbelt usage. Research on the chosen behavioural intervention is covered, focusing on application issues. This chapter then outlines some of the more common engineering approaches advocated for increasing seatbelt usage. The chapter concludes with a brief overview, and the research hypotheses for this study are developed.

### **2.2 - What is behaviour modification?**

Thorndike (1898) was possibly the first psychologist to emphasise the importance of consequences in shaping behaviour. Thorndike observed the behaviour of cats when they were put into a cat box or maze. He found that the cats quickly learned the connection between opening the latch and escaping. This was shown by the fact that the cats got faster and faster. Thorndike described this process as "trial and error" learning and concluded that the escape from confinement served as a reward to strengthen the correct response.

The next major advance came from another American psychologist, Skinner (1938). Skinner believed that in order to investigate the laws governing behaviour, it was best to study the behaviour of simple animals in simple environments. For this purpose he developed the "Skinner Box" or "Operant-Conditioning" chamber. This allowed him to take small animals away from most environmental distractions and investigate the laws that govern their behaviour. Skinner found that the consequences of the organism's behaviours guide and motivate its future behaviour. In other words, if the organism receives pleasant

(or beneficial) consequences that behaviour is much more likely to occur at a later date. However, if the behaviour results in unpleasant consequences (or costs) the behaviour is likely to be suppressed.

If the consequence of a behaviour reduces the rate at which that behaviour occurs, then it is said to be a punishment and negative reinforcement has occurred. Negative reinforcement occurs not only with the presentation of an unpleasant event, but can also be the removal of a pleasant circumstance. This type of reinforcement occurs when a child who is naughty has its ice cream removed. On the other hand, the negative reinforcement could be spanking the child.

If a particular consequence increases the rate at which a behaviour occurs then it is said to be a reward and positive reinforcement has occurred. Positive reinforcement not only occurs where the organism is presented with a pleasant situation, but can also result from the removal of an unpleasant circumstance. An example of this is where a rat presses a lever to avoid an electric shock. Skinner called these phenomena operant or instrumental conditioning, because the organism's response operates on the environment and is instrumental in producing the rewards or punishments.

Skinner's theories did not go uncontested. A number of learning theorists, such as Guthrie (1935) and Hull (1943), did not believe that the organisms learned to expect anything during instrumental learning. Instead they proposed that animals learned direct associations between a stimulus and a response without actually "knowing" or anticipating what consequences the response would produce. If an animal did happen to gain some knowledge of (expectancy about) the consequence, that knowledge would not affect its tendency to make the response.

One way of testing this proposition was to condition an animal to respond in a certain way to receive positive reinforcement and to then change the consequences, making them negatively reinforcing. If the animal learned to expect the specific outcome but the outcome has changed, then its tendency to make the instrumental response in the original situation will be reduced. Numerous studies have found this to be the case. For example, Colwill and

Rescorla (1985: Cited in Bootzin, Bower, Zajonc and Hall, 1986) found clear evidence that the animals did learn expectancies during experimental conditioning.

Colwill and Rescorla, placed a number of hungry rats in a small chamber and trained them to make two different responses (pulling a chain and pushing a lever). Each response had a different reward, the chain allowed the rat to have a squirt of sugared water, while the lever released a food pellet. Both the chain and the lever were removed from the cage and the rats were fed on alternate days. Everytime the rat drank the sugared water it was injected with a nausea inducing substance. The rats soon learned to avoid the sugared water. Following this the chain and bar were reintroduced to the cage. The rat still continued to push the lever for food but showed little tendency to pull the chain, which supports the theory that the animals developed expectancies during instrumental conditioning.

The application of operant conditioning to initiate change in human behaviour is known as behaviour modification. Behaviour modification techniques were originally confined to the area of clinical psychology, where it is generally called behaviour therapy. Such therapy has been directed at changing anti-social behaviour, treating anorexia, and removing debilitating fears (phobias).

Behaviour modification techniques have been used successfully with all sorts of people, including psychotics, juvenile delinquents, mental retardates, as well as sophisticated adults. It has been used in many settings including nursery schools, day-care centres, classrooms, houses, mental health clinics, prisons, nursing homes, stores and factories. Behaviour modification has been used on groups of varying sizes, from one individual to entire communities. Davidoff (1976) mentions the use of behaviour modification in stopping temper tantrums in children. He notes a case where a child screams and cries everytime it is put to bed, unless someone stays with the child until it falls asleep. The psychologist consulted on this told the care-givers to put the child to bed then go out of the room and ignore its cries and screams. They did this and within one week the screaming and crying had ceased. The underlying principle here was that with the removal of positive reinforcement (the extra attention), crying no longer had any positive reinforcement value. Therefore, negative reinforcement has taken place, causing the crying to cease.

The behaviours of an entire community have been changed using behaviour modification. Keller (1991) wrote letters to the residents of one part of a street in North Carolina asking them to increase recycling aluminium cans. The people who lived on the street were told that, if they increased recycling, two \$10 gift certificates would go to a homeless shelter. As well as initially setting the residents the goal of increasing the level of recycling, the experimenter regularly gave the residents written feedback about the level of recycling. Included in this letter the experimenter praised residents for their effort. This resulted in an increase in the number of households recycling aluminium cans from 34% to 53%, an increase of 19%. In this case the attainment of the very loose goal "increase recycling" was one positive reinforcer, along with the praise from the researcher. This resulted in an increase in the reinforced behaviour, recycling.

Behaviour modification has been very successful in addressing a number of corporate-based issues including: product quality, absenteeism, quality of work life, and employee occupational health and safety. One area which has received a lot of attention has been changing the behaviours of vehicle drivers. For example Cope, Allred and Morsell (1991) tried to reduce the number of vehicles parked in spaces designated for people with physical disabilities. Cope et al. used an ABABACBA, modified reversal design. This involved the measurement of the baseline (A), followed by the treatment (B). This process is then repeated with the return to baseline (A) and the return of the treatment (B). This repetition happens again with the return to baseline (A) again, but this time a second different treatment (C) is used before the reintroduction of the first treatment (B) and the return to baseline (A). The repetitive nature of this experiment allows the researcher to be much more confident in the assumption that the treatment caused the shown effect.

Using this experimental design, Cope et al. tested the efficacy of ground markings (A), ground markings with a vertical sign (B), and vertical signs (containing a message that concerned citizens were watching the spaces) (C), in stopping vehicles illegally parking there. Illegal parking went from a baseline level of 69% down to 57% during the first intervention period. The return to baseline resulted in a level of illegal parking slightly below that of the

preintervention baseline. The lower level of the undesired behaviour (or higher level of the desired behaviour) seen here in the return to baseline phase, is a fairly common feature of behaviour modification interventions.

The reintroduction of the treatment resulted in an even larger effect than the previous time it was introduced, bringing illegal parking down to 53%. The third introduction of the same treatment resulted in an even bigger effect. During this period illegal parking went down to 34%. This increase in the effectiveness of the same treatment is another fairly common feature of behaviour modification experiments. The lowest level of illegal parking, 27%, was found when the ground signs and vertical sign with the concerned citizens message was used. When the final treatment was removed during the last baseline observation, the level of illegal parking climbed to be just below the preintervention baseline level. This is because when the treatment was removed, so too was the negative reinforcement. This caused the undesired behaviour to increase almost to the baseline level. This unfortunately is a well known feature of behaviour modification. Heward (1987) states that temporary improvement in behaviour is one of the undesirable features of behaviour modification.

The more specific field of vehicle safety has been a very prolific area for behavioural research. For example Van Houten, Malenfant and Rolider (1985), in a multiple baseline ABCA design, attempted to increase the number of drivers yielding to pedestrians. They publicly posted feedback (B) on the percentage of motorists yielding to pedestrians. This was followed by an enforcement programme using warning tickets and feedback fliers (C). The intervention more than doubled the percentage of motorists yielding to pedestrians and on one of the streets the number of near misses involving pedestrians was decreased by more than half. The effects of the treatment were fairly long lasting, with a significant change still being seen when measurement finished nine weeks after the treatment period. This shows that the temporary improvement can last a fairly long time. However, with the withdrawal of the reinforcement a reduction in the desired behaviour will eventually result.

Driver speeding is one area of vehicle safety where behaviour modification has been used extensively. Several studies using behaviour modification have shown that vehicle speeds can be reduced significantly. For example Ragnarsson and Bjorgvinsson (1991), using an ABA single subject reversal design, attempted to reduce vehicle speeding by publicly posting a hypothetical daily percentage of drivers not speeding. They found that this resulted in the average speed being reduced from 69km/hr to 63km/hr. However, the reduction in speed was not permanent, because as soon as the treatment was removed, the average speed climbed to 67 km/hr. This once again shows that the desired behaviour to be more frequent in the return to baseline phase than in the first baseline phase.

This type of study has been replicated many times in Canada and Israel (Ragnarsson and Bjorgvinsson, 1991). Unfortunately, as Heward notes, the results of behaviour modification are often ungeneralisable across settings and even across subjects. This appears to be true in this instance as Roque and Roberts (1989), in an attempt to replicate the results in overseas studies, found that in the U.S. this procedure failed to have any significant effect in reducing vehicle speeding.

However, in Canada a study by Van Houten and Nau (1981) found that this style of behaviour modification was very effective in lowering the average speed, and that it was more cost-effective than police radar surveillance. Another area of vehicle safety that has received a lot of attention from behaviour modification researchers is seatbelt usage.

### **2.3 - Behaviour modification and seatbelts**

Seatbelt usage has been a particularly popular target for behavioural interventions, mainly because of the large costs associated with a failure to wear seatbelts. It has been estimated that the use of a seatbelt reduces the probability of death or serious injury following a vehicle crash by at least 50%. Gray (1988: Cited in Geller, 1990) found that in one branch of the Ford Motor Company the number of employees seriously injured or killed in traffic accidents far exceeded those injured on the job (a 16:1 ratio). When both direct costs (medical care, property damage, etc) and the indirect costs (such as productivity losses, plant disruption,

hiring replacements and training replacements) are considered, an effective seatbelt programme can save thousands of dollars. Thus a great deal of research has been conducted on organisation-based seatbelt promotion programmes.

The pioneering corporation in this field has been DuPont, which implemented a reward/incentive programme that began in April 1980. Since then this organisation has committed at least US\$10,000 each year to a periodic employee incentive programme that keeps 90% of its 800 workers buckled up (Spoonhour, 1981). On a larger scale General Motors ran an incentive/reward programme for their 6,000 employees (Horne and Terry, 1983). Reward opportunities were provided for employees who pledged to buckle up for one year. This increased seatbelt usage from a baseline of 36% up to a 70% usage rate. Three years into the programme, seatbelt usage had stabilised at 60%, so the changes have been fairly permanent.

Rogers, Rogers, Bailey, Runkle and Moore (1988) using a modified multiple baseline design, tried to increase seatbelt usage by Florida state employees through the use of dashboard stickers. They simply put stickers on the dashboards of state-owned vehicles saying that a seatbelt was required and that there may be a reduction in the amount of worker compensation awarded if they had an accident while not wearing a seatbelt. Seatbelt usage increased from an average of 9.7%, to 38% in the intervention phase. This perhaps could be called an incentive/punishment type of behavioural intervention as the subjects were warned that if they did not buckle up and they had a crash, then the level of compensation awarded might be cut. This intervention was fairly successful, but still a level of 38% is only just up to the baseline levels observed by Horne and Terry (1983).

Ludwig and Geller (1991) showed that an increase in one kind of safety behaviour could result in a corresponding increase in other safety behaviours. Ludwig and Geller attempted to increase the level of seatbelt usage by pizza deliverers. Firstly they organised a meeting where the benefits of using a seatbelt were discussed. This was followed by the drivers making a personal commitment to wearing a seatbelt by signing a buckle-up promise card. As well as this, buckle-up reminder signs were placed around the pizza store. They found that not only did seatbelt usage increase but the increase in one safety behaviour was generalised to another which resulted in a significant increase in the use of a turn signal.

Increasing seatbelt use has not only been attempted by organisations, but has also been attempted within the community as a whole. For example, Williams, Thyer, Bailey and Harrison (1989) attempted to increase seatbelt usage through the use of signs and human prompters displaying signs. The research used a multiple baseline design across two different settings. They found seatbelt usage could be increased significantly using the signs, if a period using human prompters preceded this. Seatbelt usage rose from a baseline level of just below 40% to 64% during the intervention. A study by Thyer and Geller (1987) was even less obtrusive, in that all it required was a sticker placed on the dashboard of the car. The experiment used a multiple baseline ABAB design. Baseline usage was found to be around 34%. This rose to 70% with the first intervention period. With the return to baseline, the level of seatbelt usage declined to 41%. The second intervention period resulted in a further increase up to 78%.

Many other types of behavioural interventions have been successfully used to increase seatbelt usage, such as mass media campaigns (Robertson, Kelley, O'Neill, Wixom, Eiswirth and Haddon, 1974), feedback (Grant, 1990), driver education (Bell, Young, Salzberg and West, 1991), laws and enforcement (Hagenzieker, 1991), and pledge cards (Geller and Lehman, 1991). However, one method that has remained relatively unresearched, and yet appears in a great deal of modern cars, is the use of a dashboard reminder light. CD-ROM searches on CAM, Psychlit, Informat, HSELINE, CISDOC, MHIDAS, ERIC, and NIOSHTIC uncovered only four articles testing the effectiveness of the buzzer-light reminder system. In two of the four studies the experimental design was questionable.

## **2.4 - Reminder light**

In a fairly weak study, Robertson and Haddon (1974) visually observed the use/non-use of the seatbelts. Using the registration plate number, they worked out whether the car had originally been fitted with the buzzer-light reminder system. They then related seatbelt use/non-use to the presence/absence of the buzzer-light reminder system. The researchers concluded that the system did not significantly increase seatbelt use. However, even though the study purported to be comparing the seatbelt use of drivers with the buzzer-light reminder system to those with

similar vehicles lacking the device, they failed. This is because Robertson and Haddon had not in any way tested whether the cars that were originally fitted with the device still had one in working order. It is highly likely that a large number of devices had been either disconnected, circumvented or were no longer working for some other reason. Therefore, the study was really comparing vehicles that once had the reminder system with vehicles that did not. This, from an experimental point of view, is definitely not a sound test of the effectiveness of a seatbelt reminder light. This same criticism can be levelled at a later study by Robertson (1975) which used the same experimental method to again conclude that the buzzer-light reminder system was not effective in increasing seatbelt use.

A much more experimentally sound study was conducted by Geller, Casali and Johnson (1980) who compared the different kinds of reminder systems and their effect on seatbelt wearing rates. They compared the two basic categories of reminder systems, limited and unlimited, as well as the different types of presentation (eg. light, buzzer, light and buzzer). An unlimited system operates until the front-seat occupants fasten their seatbelts, while the limited systems only operate for a specific time period (eg. 3-8 sec) regardless of whether the belt is engaged or not.

They found that the unlimited reminder systems were considerably more effective than those of a limited duration. They also found that the use of a buzzer and combined buzzer/light reminder system were considerably more effective than using a light only. Another important finding from that study was that the unlimited buzzer-light reminder systems were more likely to be circumvented than the light or the limited systems.

Berry and Geller (1991) hypothesised that the reason limited reminder systems failed to work was possibly because the other stimuli associated with engine start-up (eg. oil light) compete with or overshadow the seatbelt reminder. However, in a single-subject ABA design they found limited reminders can be effective and encouraged more research in the area of electronic reminder systems.

According to the literature (Berry and Geller, 1991; Geller, Casali and Johnson, 1980; and Robertson, 1975) the more intrusive the system the more likely it will be effective in increasing seatbelt use. However, associated with this increasing

effectiveness is an increase in the chance that the system will be disconnected. One way to stop the systems from being disconnected, noted by the literature (eg. Robertson, 1975), involves choosing to study machines that are not owned by the people who drive them. This decreases the chance that the person will tamper with the system and so the reminder is more likely to be effective in increasing seatbelt use. However, in some forms of research this is not possible.

While research (Berry and Geller, 1991; Geller, Casali and Johnson, 1980; Robertson, 1975) suggests that the use of a light reminder system is both the least likely to work and the least likely to be circumvented, these conclusions are based on the use of a fairly inconspicuous light that continually stays on. The lights are also located in the peripheral vision of the driver.

Baker (1958) calls this reduced ability to detect targets in the peripheral field of vision, "peripheral blindness". Peripheral blindness could partly explain the low effectiveness of the reminder light, as the lights are located in the peripheral vision. Thus, due to "peripheral blindness" and the inconspicuousness of the standard reminder light, the driver may not even be aware of the light. Even if the drivers of the vehicles are initially aware of the reminder light, after a short period habituation may occur and so the subject will again fail to notice the light. One method of increasing the conspicuousness of the reminder light, reducing the effect of "peripheral blindness" and removing habituation is through the use of flashing.

There has been a great deal of research on the use of flashing for attracting attention. For example Thackray and Touchstone (1991) found flashing to be far superior to target shape and colour in attracting attention. Touchstone and Thackray found that flashing targets were unaffected by screen location (unlike either colour or shapes) and less affected by fatigue. Using flashing, the rate of target detection could be improved by up to 82%. Thus flashing would be ideal in attracting the attention of the driver in order to remind them to buckle up.

Flashing may be a good method of attracting attention but it is not good at conveying information. Colour, however, is often used for both attracting attention (although it is not as good as flashing) and conveying information. Christ (1975), in a review of research on colour coding, noted that colour codes

were very good for identification tasks. Macdonald and Cole (1988) in a study evaluating the role of colour in aircraft cockpit displays, found that colour coding resulted in faster responses when the colour was relevant. The use of relevant colours also resulted in fewer errors on almost all tasks. Unfortunately, as Osborne (1987) notes, there has been very little research conducted on the correct colours to use when colour coding. However in deciding which colour to use, one thing we can consider is the state or conditions that colour is already associated with. For example, red is often associated with danger or heat whereas blue is associated with cold. If the appropriateness of the colour is not considered confusion may result and this will sometimes cause the individual to emit the wrong behaviour. An example of this would be if one bathroom hardware company suddenly changed its colour code to blue = hot and red = cold. This would definitely result in a large number of people being burnt in the shower. The reminder light needs to be able to convey to the operator that his failure to use the seatbelt is potentially dangerous. However, the colour should not "cry wolf" and signal that they are exposing themselves to an immediate danger. Thus, according to Morgan, Cook, Chapanis and Lund (1963; cited in Osborne, 1987) the correct colour for this use is orange which they define as "possible danger (but not immediate hazard)".

## 2.5 - Engineering interventions

Although numerous studies have been conducted by the US auto-industry on the effectiveness of various types of engineering interventions, it would appear that only one published study has touched upon the effect of making a seatbelt easier to use on the level of seatbelt usage. One study (Gordon, Kondo and Breedon, 1976) has indirectly tested this by asking subjects whether they would wear a new improved seatbelt, which they had just tested, more often than the poorer designs they had in their own vehicles. A surprising number of the subjects stated that they would wear the new improved design. With the seatbelt design in their own vehicle 47% said they always wore the seatbelt, whereas with the new improved design 67% said they would always wear the belt. Despite this, the level of seatbelt usage in the United States remained virtually the same between 1975-1984 (Reinfurt, St Cyr and Hunter, 1991), even though seatbelt design improved considerably.

One of the earliest engineering interventions used in the US auto-industry was an interlocking device. This made it impossible to start the vehicle without first buckling up. Most vehicles manufactured for the American market in 1974 were fitted with this device. Initially, seatbelt usage rose to nearly 60%, which was more than three times that achieved in vehicles without the device (Robertson, 1975). Unfortunately, within three years seatbelt usage had declined to the same level as in vehicles without the interlocking device (Philips, 1980; Cited in Robertson, 1987). Due to their lack of longevity and the fact that many people complained bitterly about these devices, the requirement to install them was overturned by American congress.

The next engineering intervention that the US National Highway Traffic Safety Administration (NHTSA) tried was the use of passive restraints. Haddon, who was head of the NHTSA, hypothesised that if the occupants of the vehicle were not required to elicit any behaviour, then seatbelt usage would rise. Thus the search for an effective passive restraint began. Passive restraints, unlike ordinary seatbelts, are designed to work without any action being required by the occupant. A vast number of different forms of the passive restraint have been developed, including transparent shields, deployable nets, deployable blankets, restraining arms, cushions, automatic seatbelts and air bags (Johannessen, 1987). Only two basic types of automatic restraints are used, air bags that automatically inflate during crashes and seatbelts that automatically fasten around occupants when they enter the vehicle. The automatic seatbelt was the passive restraint that showed the greatest potential, with the air bag a close second.

With air bags the occupants of the vehicle are not required to perform any act to make the device effective. However, one unfortunate by-product of using air bags was that seatbelt usage actually decreased in vehicles fitted with air bags (Reinfurt, St Cyr and Hunter, 1991). It was hypothesised that this was because the occupants seemed to think that seatbelts were unnecessary due to the protective value of the air bags. This is not the case as the air bags are designed to be supplemental systems, in that they do not protect the vehicle occupants in many crash modes. For example in rollovers and side impacts the air bags do little (except the recently developed side impact air bags designed by Volvo) to protect the occupants.

There are basically three types of automatic seatbelts in the United States. Volkswagon became the first manufacturer to produce automatic seatbelts when it launched the 1975 Rabbit (Reinfurt et al. 1991). The seatbelt consisted of a two point shoulder belt attached to the upper rear of the front door and to a take-up reel located between the front seats. When the door is closed the belt wraps around the occupants of both front seats. Toyota was the next to introduce an automatic seatbelt in their 1981 Cressida. This design consisted of a two-point motorised automatic seatbelt. The shoulder belt moves along a guide rail in the roof and positions itself around the occupant when the door is closed and the ignition is on. Included with this is a manual lap-belt. The third kind of automatic seatbelt has been used extensively by General Motors and Honda. This consists of a three-point non-motorised belt mounted near the upper and lower rear edge of each front door. The belt wraps around the occupant when the door is closed.

Williams, Wells, Lund and Teed (1990) noted that in cars with automatic two-point systems, driver shoulder belt use was substantially higher than that in the same model car with manual three-point belts. In a study aimed at comparing usage rates Williams, Wells, Lund and Teed (1989) found that the use of automatic seatbelts was significantly greater than that of manual belts in comparable cars. They found in Fords, that the use of a seatbelt increased from 52% to 87% in vehicles equipped with automatic seatbelts. For Volkswagon, usage increased from 64% in vehicles with manual belts to 89% in vehicles with automatic belts. All manufacturers studied, except Chrysler, had similar increases. Therefore, there is some evidence that making a seatbelt easier to use will result in a higher level of seatbelt usage. However, there is a significant difference between using a seatbelt that requires no action and using a seatbelt that requires some action to engage it.

## **2.6 - Hypotheses and their rationale**

As it is probably impossible to cheaply create a passive restraining device for the skidders, due partly to the fact that they rarely have doors, making the seatbelt easier to use is the only option available here. The emphasis on ease of use

requires a human factors engineering (or ergonomic) approach rather than the provision of a simple engineering solution. An engineering approach provides a seatbelt, but this may not pay adequate attention to the users.

An extensive literature search, including the previously mentioned CD-ROM data bases did not reveal any studies that had tested whether making the seatbelt easier to use would result in an increase in usage. In fact Woodson (1975) states that he very much doubts whether any study would ever be able to find out if improving the seatbelt design will encourage more people to use a seatbelt. All research found on increasing the level of seatbelt usage has been conducted on passenger vehicles, mostly private cars. Very little research has been conducted using more specialised heavy equipment. In fact, there are no known studies that have attempted to test methods for increasing restraint use. Despite this, the people who drive these machines are also the same people who drive ordinary passenger vehicles. Therefore, these behaviour modification techniques will still be effective in increasing seatbelt usage in forestry machinery.

The installation of the passive restraint system increases the level of seatbelt usage as the occupant is not required to emit any behaviour to activate the system. In fact not wearing the seatbelt requires an action to remove the restraint, or somehow render it inoperative. Therefore, there is a large difference between using an ordinary seatbelt (which requires behaviour to be emitted from the individual) and the use of a passive restraint (which requires behaviour to be emitted to stop using it). This distinction makes it difficult to confidently state that making a seatbelt easier to use will result in an increase in seatbelt use. However, considering this, the feedback from the participants in the Gordon et al. (1976) study, and the comments made by the subjects in this study, it would seem plausible to hypothesise that making the seatbelt easier to use would result in an increase in usage.

### **Hypothesis 1**

*The first installation of the new seatbelt design will increase the level of seatbelt use.*

Although the use of an ordinary non-flashing reminder light has been found to be rather ineffective (Robertson and Haddon, 1974; Robertson, 1975; Geller, Casali and Johnson, 1980; Berry and Geller, 1991), use of the much more effective buzzer-light reminder system would be impossible, given the skidder operators' environment. This is because the operator is required to wear ear muffs due to the large amounts of noise emitted by the skidder's engine and chainsaws working nearby. A flashing light overcomes this particular problem and is much more intrusive than the reminder lights the above studies have tested. This increase in intrusiveness, according to the literature (Berry and Geller, 1991; Geller et al. 1980; Robertson, 1975), will result in an increase in the effectiveness of the system.

## **Hypothesis 2**

*The first installation of the reminder light will increase usage over and above that of the new seatbelt.*

The removal of the new belt will make doing up the seatbelt harder. Therefore, because the behaviour required to turn off the flashing reminder light is harder the light will become more annoying to the operator. This will result in an increase in the level of circumvention.

## **Hypothesis 3**

*The circumvention of the reminder light will increase when the new belt is removed.*

The same reasoning behind hypothesis 1 would also predict that with the removal of the new belt a decrease in seatbelt usage would result. This will still be above baseline because of the effect of the reminder light.

#### Hypothesis 4

*The removal of the new seatbelt will result in a decrease in the use of a seatbelt to a level above that of the baseline.*

The removal of the reminder light will result in a further decrease in seatbelt usage, as the effect of the reminder light will be removed. However, the level of seatbelt usage should decline to a level above that of the baseline. This is a commonly seen feature of behaviour modification interventions. For example the study by Thyer and Geller (1987) found that the return to baseline period was 7% higher than the preintervention baseline. Ragnarsson and Bjorgvinsson (1991) found that with the withdrawal of the treatment the average speeds went up, but they were still below that of the preintervention baseline level. A similar effect would be expected here.

#### Hypothesis 5

*Also removing the reminder light will result in a further decrease in the level of seatbelt usage, but this will still be above the baseline level.*

The same rationale behind hypothesis 1 and hypothesis 2 would mean that these results will be replicated when the treatments are reintroduced.

#### Hypothesis 6

*The refitting of the new belt and the reminder light will result in significant increases in the level of seatbelt use.*

This study attempts to test all the above hypotheses.

## **2.7 - Summary**

The chapter began with a brief history of behaviour modification. This was then followed by examples from the automotive industry. The use of a reminder light was then singled out and all the available literature revised. One main problem with the present reminder light system was discussed, and a potential solution suggested. Relevant literature on flashing and colour coding was discussed, along with the effect of engineering interventions on seatbelt usage. Finally the research hypotheses were discussed along with the rationale behind them.

## CHAPTER 3: METHODOLOGY

### 3.1 - Introduction

This chapter begins with a brief description of the subjects and machinery used in the study. The chapter then covers the experimental design, followed by the types of measures and equipment used to collect the data. The procedure under which the experiment operated is examined. Included in this is the method of data collection. This section also outlines a number of practical considerations and unanticipated problems that forced changes to the procedure, and the nature of these changes.

### 3.2 - Subjects

The subjects in the study were skidder operators. Initially, there were 10 skidder operators in the study, but due to the amount of time needed to travel to all the skidder locations (which ranged from Turangi to the south, some 2 hours from Rotorua, to 50 minutes north of Rotorua) the sample size was lowered to 8. Unfortunately, during the study one of the subjects developed a back problem and stopped driving the skidder. The remaining subjects were 7 skidder operators who worked for either the Forestry Corporation of New Zealand (Waiotapu), Tasman Forestry Limited (Taupo) or Tasman Forestry Limited (Murupara).

It was originally planned to involve skidder operators who were not "contractors" (for a definition of this term see Appendix 1). This was because it was necessary to tell the contractor exactly what was going to be done and why this was being done. This information was withheld from the operator of the skidder, as it was thought that this might influence the results in some way. Unfortunately, shortly after the experiment started, two of the seven contractors became the permanent skidder operator. Due to the expense of wiring up another two skidders and the problem of finding new subjects, the study continued with these two contractors.

As there are many different types of skidders with very different cab designs, only one make of skidder was used. This helped to limit the number of variables. The chosen make started out under the Clark brand name and was then changed to Ranger, which in turn became Valmet and finally VME. Thus a sample of Clark\Ranger\Valmet\VME 666F, 668, F66, F67 and F65 skidders (see Appendix 2 for illustration) were used.

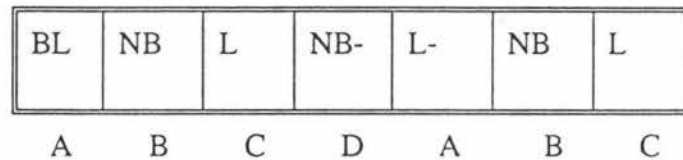
The seatbelt design originally chosen could only be fitted into one model of skidder. Due to an inability to find adequate numbers of this model of skidder, this design could not be used. Therefore, a second seatbelt configuration had to be developed (see Appendix 3 for photograph). This design was based on ideas obtained by talking to a number of skidder operators, an analysis of the available technology and attempting to solve the problems with the standard design. The resulting seatbelt configuration was in fact more "user-friendly" than the previously chosen design. Major design changes involved firstly changing the webbing only system to a retractor type seatbelt, similar to that in all modern cars. The only difference is that the retractor used here was a non-inertia type retractor, and so the locking mechanism was not engaged by quickly pulling out the webbing or being on a steep slope.

The "female" half of the seatbelt was on a stalk (see Appendix 3 for photograph) and was positioned very close to the operators hip. The "male" half of the seatbelt was also positioned near the operators hip, and was held there by a small metal bracket bolted onto the back of the operators seat. This meant that both halves were much easier to grasp than the standard design. Another feature of the new seatbelt was that it allowed one handed operation, unlike the standard design. When the new seatbelt was released the webbing retracted so as to position the belt beside the operators hip once more. This is in contrast to the standard design which fell on the floor when released, forcing the operator to hunt around on the floor the next time it was to be used.

The orange flashing reminder light was mounted on the left side of the skidder's dashboard. This positioned the reminder light in the skidder operator's peripheral vision (see diagram in Appendix 3).

### 3.3 - Experimental design

One group of seven subjects received all the treatments in a typical ABAB single subject design (as shown below). The sequence of events in the intervention are outlined in Figure 3.1.



- BL = Baseline  
 NB = New Belts installed  
 L = Reminder Light installed  
 - = Mentioned Treatment is removed

**Figure 3.1:** *Graphical Representation of the Experimental Design.*

The main features of the seven experimental phases were as follows.

#### [A] Baseline

1. There was an eleven week period of baseline measurements, so that the pre-existing level of seatbelt use could be established.

#### [B] New Seatbelt Design

2. The machines were fitted with the new seatbelt design.

#### [C] Reminder Light

3. Warning or reminder lights were installed in the machines.

#### [D] New Seatbelt Design Withdrawn

4. The new belt is removed from the machines and the old seatbelt is reinstalled.

**[A] Return to Baseline Conditions**

5. The reminder light is removed.

**[B] New Seatbelt Design Reinstalled**

6. The new belt design is returned to the treatment group and stays there permanently, unless the operators find the new belt to be worse than the original.

**[C] Reminder Light Reinstalled**

7. The reminder light is reintroduced.

**Note:** The number of weeks taken for each phase vary for each skidder (except baseline which was 11 weeks long for all of the skidders). Collecting the five data points took from 1 week to 6 weeks. This depended on which crews were working at the time and how many times the measuring equipment broke down.

**3.4 - Measures****3.4.1 - Number of seatbelt closures**

In order to be as unobtrusive as possible it was first proposed that the counter be fully enclosed within the seatbelt. This was so the operators of the skidders would be unaware that seatbelt usage was being monitored. After about four weeks in contact with a number of electronic firms and listening to a lot of rather optimistic promises, it became obvious that this was not going to be possible.

Therefore, it was proposed that a more obtrusive method be used. This involved mounting a switch on the outside of the seatbelts. According to one electronics firm this was supposedly very easy. However, after a number of weeks went by and the only suggestion forthcoming was a switch which would cost \$10,000 to monitor baseline data only, it appeared that this was not going to be possible either. Finally, in the course of discussion a technician came up with an idea which was thought to be unworkable. Rather than give up the idea of measuring seatbelt usage, this method was tried. This involved running the power from the

skidder's ignition through the belt, with one half of the belt being connected to the negative and the other side of the belt to the positive. It was considered to be impractical because of the fact that if both halves of the belt came in contact with anything metal, like the floor of the skidder, it would complete the circuit and/or cause a short circuit. It would then be impossible to tell if the circuit was closed due to the seatbelt falling on the floor or the seatbelt being closed. However, while an electrician was wiring up the skidder for this he came up with the idea of using a magnetic reed switch.

This switch consisted of an open circuit on one side and a magnet on the other. The circuit half of the switch sat on the non-adjustable side of the seatbelt, as it had wires coming off which needed to go down the belt. The magnet was mounted on the other half of the belt, as no wires were required to go down the belt, and thus the adjustability would not be impaired. The circuit was connected to a relay (See Appendix 4 for circuit diagram), which was connected to the skidder's ignition. When the magnet and the open circuit were placed in close proximity (ie. the seatbelt was closed) the magnetic field completed the circuit and 12 volts flowed through (failure to connect the seatbelt did not render the ignition inert). This was registered by a "Husky Hunter" (for a definition of this term see Appendix 1) field computer which was also connected to the relay.

The Husky Hunter is used extensively in the forest industry mainly for collecting data during field observations or various aspects of forestry work, including machinery evaluations and technical comparisons. The Hunter was programmed to act as a data logger which registered every time the status of the circuit changed and at what time this happened. This allowed the researcher to see if the operator of the skidder was just sitting there clocking up a whole lot of seatbelt closures to make it look like the seatbelt was being worn a lot. It also enabled the researcher to distinguish between true seatbelt closures and when the seatbelt had been belted together behind the seat or clicked together and sat upon. To make sure that the Hunter was going the whole time it was in the skidder, it was programmed to make an automatic entry every half hour, recording the time and the date. If any of the automatic entries were missing from the log, this indicated a malfunction.

### 3.4.2 - Number of drags

A number of other pieces of information were also collected from the operator. He was asked to keep a weekly record of hours and days the machine was working, whether he had a person breaking out for him and the number of drags he completed each day. The operator was asked to keep track of the number of drags he completed by pushing a button on a manually operated frequency counter (sheep counter) mounted on the skidder's dashboard. A form (see Appendix 5) was supplied with spaces for all the required information. The operator was asked to fill out this form each day. The contractor (or Foreman) was also asked to ensure that the sheet was filled out each day. While seatbelt usage was being measured, the researcher took note of any dramatic change in the type of work being carried out. Comments made by the operators were also noted, along with the date and the experimental period it related to.

### 3.4.3 - Verifying the number of drags

A small video camera was installed in the machine. This was used as a reliability check to verify the number of drags as reported by the operator. The transmissions from the camera were monitored at the same time they were being recorded. The data from the camera not only doubled as information for a study on operator postures during work in forestry machinery, but was also used to provide additional information about operator seatbelt wearing behaviour.

### 3.4.4 - Questionnaire

After all observational data were collected the operators were also asked to complete a seatbelt evaluation questionnaire (see Appendix 6). This asked the operators to compare the new seatbelt design with the old seatbelt design using a 7 point Likert type scale. The questionnaire also asked the operators why they did not use the seatbelts, what they liked/disliked about the new design, where they thought improvements could be made and how effective they thought the reminder light was.

### 3.5 - Procedure

The operators were told that the researcher was going to be involved in a number of studies, including a study on the number of drags and whether this is affected by the presence of a "breaker out" (for a definition of this term see Appendix 1), operator biomechanics and a study on seatbelts. This was because the researcher did not want to highlight the seatbelt as being of primary importance. As the switch on the seatbelt was noticeable the operator was told that this was the start of a new reminder system that was being installed, and that not all of the parts had arrived yet (which at the time was factually correct). The operator was told that the record of the number of drags was going to be used to calculate the average number of drags per day and how this is affected by having a person breaking out.

The Husky Hunters and relay boxes were housed in the battery boxes of the 4 skidders that had one. In the remaining three skidders, a small ex-army ammunition box was bolted behind the operator's seat. This arrangement was used so as to avoid any of the Hunter's keys being depressed, having the Hunter stolen and to allow the Hunter to be left overnight (both the ammunition boxes and battery boxes were padlocked shut). The five operators who were not contractors could not see into the boxes, so they should not have known what was in there. However, both contractors that later became permanent operators knew, and it would be extremely surprising if none of the other contractors told their operators about the computer in the box.

Only four Husky Hunters were able to be obtained for use in the experiment, which meant the Hunters had to be rotated around the 7 machines. This resulted in each machine being monitored two - three times a week, and thus there were 5 data points for each two week period (except the baseline period where there were four weeks, which resulted in there being 8 data points). A sampling schedule was set that allowed each skidder to be sampled five times a fortnight. Unfortunately, because of the large number of delays due to the supplier of the new seatbelt, the person installing the new seatbelts, the person installing all the electrical equipment, machines moving between forests, machines moving between "compartments" within a forest (for a definition of this term see

Appendix 1), skidders blowing up and being out of operation for a couple of weeks, machines being hidden after being vandalised during the weekend, a lag in the sales of wood which resulted in 6 of the 7 crews being laid off, electrical failures, other people driving the skidder, seatbelts breaking, Hunters breaking down, reed switches coming off, wires breaking, plugs falling out, faults with the Hunter programme, Hunters catching on fire, batteries going flat, seatbelts coming loose and fuses being blown, the schedule was vastly changed. For example during the baseline phase, what started out as being a 4 week period eventually ended up being 11 weeks long. In total, data collection took just under 6 months to complete and required almost 50,000 km in travel.

Using the schedule (which was altered virtually on a daily basis) the Hunters were rotated around the different machines. Repositioning was conducted after the crew had finished work and gone home. This was done so as to eliminate any experimental bias that may have arisen from the operators frequently seeing the researcher. When the Hunter was about to be moved, all the data it had collected were down loaded to a Toshiba laptop computer. The data were then printed out and the number of seatbelt closures was counted.

A belt closure rule was developed to identify "true" seatbelt closure.

*Belt Closure Rule: Any closure which is within 10 second of an opening is not considered to be a "true" closure.*

Using 10 seconds between seatbelt openings and closures was fairly liberal, but this was taken as the *minimum* amount of time between a true opening and closure. Anything faster than 10 seconds was taken to be a sign that the operator had been playing with the belt or, as frequently happened, there was an electrical fault. If the only openings and closures coincided with breaks and knock off time, this was taken to mean that the belt had been connected together and sat on or belted behind the seat. (The openings occur when the machine is turned off because as the power stops flowing through the circuit, the relay opens causing the Hunter to register an opening of the seatbelt. Closures occur because when the ignition is turned on, power flows through the circuit, causing the Hunter to register a seatbelt closure.)

The orange flashing reminder light was connected up to the relay and worked independently from the Hunter data collector as the Hunter was not in the machine on a permanent basis. The reminder light was also controlled by the reed switch on the seatbelt which flashed and continued flashing at 1 second intervals, whenever the machine's ignition was turned on and the seatbelt was not done up. This happened irrespective of whether the operator had completed his drag, was just sitting in the cab with the ignition turned on or was driving around in the bush without the belt done up.

The data collected by the Hunter needed to be related to the number of drags, as the operator is legally required to wear the belt twice for every drag, once when travelling to get the logs and once while transporting the logs to the landing. This means that the number of seatbelt closures should be directly proportional to the number of drags the machine completes. Therefore, in order to calculate seatbelt usage the number of seatbelt closures was divided by two times the number of drags, as recorded by the operator.

$$\text{Percent seatbelt coupling usage} = \frac{\text{Closures} \times 100}{2 \times \text{Drags}}$$

This gave us the percentage of times that the operator engaged the belt when he was legally required to do so. However, as the operator of the skidder may get on and off the machine as many as 7 times per drag, it is entirely possible to wear the seatbelt greater than 100% of the time legally required. For example the operator may wear the belt while pushing down trees or may use the belt when moving to the next log (before the drag has been completed).

The camera was used to verify that the operator was accurately reporting the number of drags he completed. Each camera observation lasted about 2-3 hours and occurred at different times of the day, depending largely on how far the crew were from Rotorua, where the researcher was based. The subjects were told the videoing was being done to look at whole-body vibration in skidder operators. They were also told that the researcher was also interested in seeing how both seatbelts performed, in situ. Therefore, it seems plausible that the operators had

no idea that the researcher was verifying the number of drags recorded. The video recording also made it possible to confirm that the data from the Hunter were accurate.

The camera was initially mounted in the top right hand corner of the skidder's cab, but due to instability and damage to the camera's casing, it had to be mounted on the dashboard of the skidder. This made it impossible for the camera to record the operator pushing the button on the counter. Thus the number of drags, as recorded by the operator, was verified by comparing the number of drags observed by the researcher with the number of drags recorded on the counter during the measurement period. Reading the counter was done unobtrusively as the researcher was required to get into the cab while installing the video camera and to remove it. It was also possible to monitor transcription errors by taking note of the number of drags the operators had counted in the morning and comparing this at a later date with what they had written in the book.

It was originally planned to video each operator once during each observation period, bringing the total number of camera observations to seven per subject. However, due to extensive delays in the delivery of the camera, transmission problems and other technical faults each machine was only able to be videoed twice during the entire experiment. The camera observations occurred once during the baseline period and once during the "New Belt" period of observation. On these occasions the number of drags the operator recorded was compared to the number of drags the camera recorded, to again determine the accuracy with which the number of drags were reported by the operator. The following formula was used to calculate this.

$$\text{Accuracy of drag data} = \frac{\text{Number Recorder by the Operator}}{\text{Number Recorded by the Camera}}$$

### 3.6 - Summary

This chapter has described the subjects involved in the study and the type of data that were collected. The equipment and measures used to obtain the data were also discussed, as was the procedure. In the discussion of the procedure used in the study, a number of problems were highlighted which caused the experimental design to be changed. The changes were not large and in fact did not greatly affect the quality of the data obtained. However, there were a number of other factors that definitely did affect the results, as will be mentioned in the following chapter.

## CHAPTER 4: RESULTS

### 4.1 - Introduction

This chapter presents the results for the seven subjects. Firstly the results of the camera observations are summarised. This is followed by each subject's seatbelt usage data, which are presented in graph form. Accompanying this are the comments made by the operator and any important events (e.g. a dramatic change in work) that occurred while seatbelt usage was being measured. The seatbelt usage data are then combined in a summary graph. The chapter ends with the results of the seatbelt evaluation questionnaire.

### 4.2 - Reliability of collected data

The data obtained through the use of the video camera, indicated that the operators were extremely accurate in reporting the number of drags. For both three hour camera observation periods, all seven operators were 100% accurate in reporting the number of drags. As well, the data obtained during camera observations also showed the Husky Hunter's recordings of seatbelt closures to be 100% accurate (although for two of the camera observation periods the Husky Hunters broke down). A check for faults with the transcription also uncovered no errors.

### 4.3 - Subject 1

#### 4.3.1 - Seatbelt Usage

Figure 4.1 shows the percentage of times that the operator engaged the belt when he was legally required to do so. Each data point contains the data from one day. Due to the problems and practical considerations mentioned in chapter 3, the data points are not necessarily consecutive days.

The mean baseline level for Subject 1 was a very low 7%. With the introduction of the new seatbelt, mean usage increased over five fold to 40%. This was further increased by the introduction of the reminder light to a mean level of 65%. Removal of the new seatbelt more than halved the mean level of seatbelt couplings to 29%. This was reduced further to 26% after the removal of the reminder light. The reintroduction of the new seatbelt resulted in a very substantial increase from 26% to 71%. With the replacement of the reminder light seatbelt usage was increased to 84%.

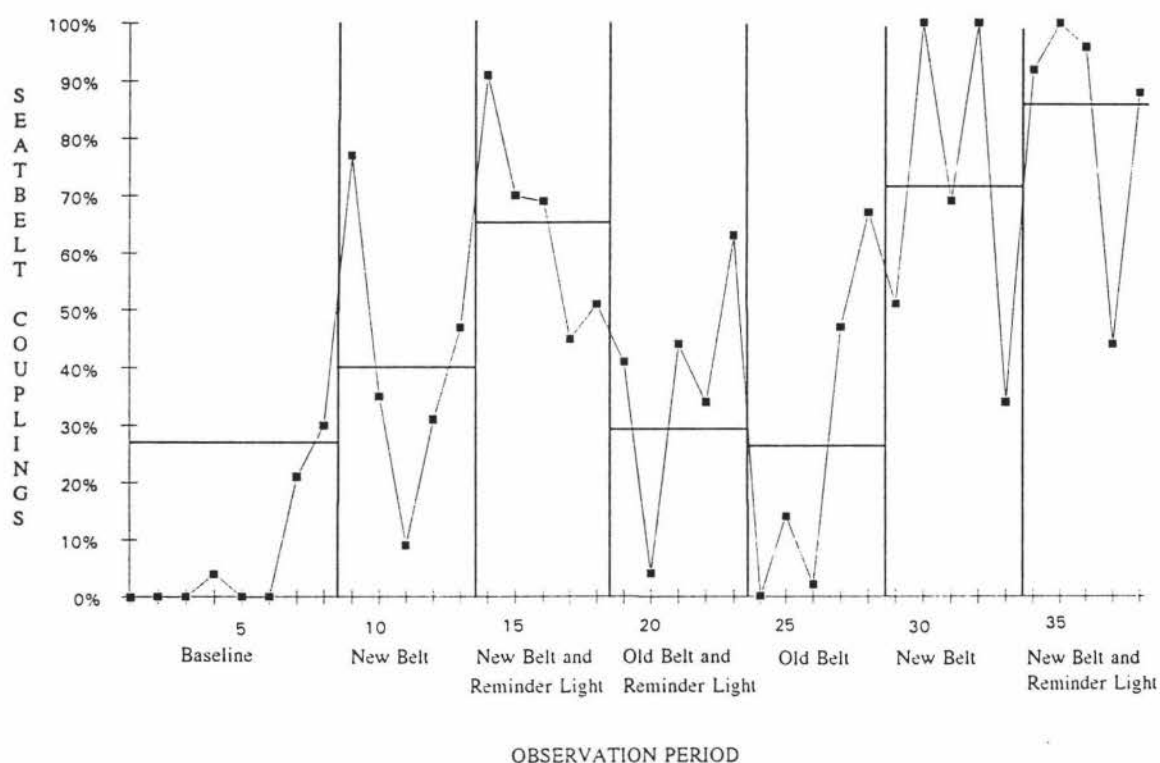


Figure 4.1: Seatbelt Usage - Subject 1

#### 4.3.2 - Operators Comments and Important Events

##### Pre-Baseline Phase:

The researcher first spoke to the skidder operator.

Researcher ... "do you wear your seatbelt often?"

Operator "No never."

Researcher "Why is that?"  
 Operator "Waste too much time finding the bloody thing."  
 Researcher "Would you wear a seatbelt if it was easy to find and put together?"  
 Operator "Might do, if they put us on a steep block."

Baseline Phase:

Fitted the new seatbelt design.

Observation Period 9:

The researcher spoke to the skidder operator.

Researcher "What do you think of the new seatbelt design?"  
 Operator "Not bad, it's better than the other one."

Observation Period 11:

The crew was moved into thinnings, due to a down turn in the sales of wood.

First New Belt + Reminder Light Phase:

Whole crew laid off due to the lag in wood sales.

First New Belt + Reminder Light Phase:

Crew working four day weeks in thinnings.

Observation Period 23:

Crew back at work in clearfell.

Data collection for this Subject began 18/05/93 and was completed by 12/11/93.

In summarising the results it would seem that Subject 1 liked the new seatbelt and thus wore it a great deal more than the standard belt design. Looking at Figure 4.1 and relating the move into thinnings to the level of seatbelt use, this shows that the change in work did not greatly affect the level of seatbelt use. Initially the level of seatbelt usage was reduced both when the crew were moved into thinnings and when they were moved back into clearfell. This could be due to the

first day back into each being settling in periods. In this case installing the new seatbelt increased the Subject's seatbelt usage significantly. The reminder light also significantly increased the level of seatbelt usage.

#### 4.4 - Subject 2

##### 4.4.1 - Seatbelt Usage

Figure 4.2 shows that Subject 2 was unresponsive to all treatments. This Subject never wore the seatbelt. This level of non-usage was constant throughout the experiment, with no closures registered during any observation phase.

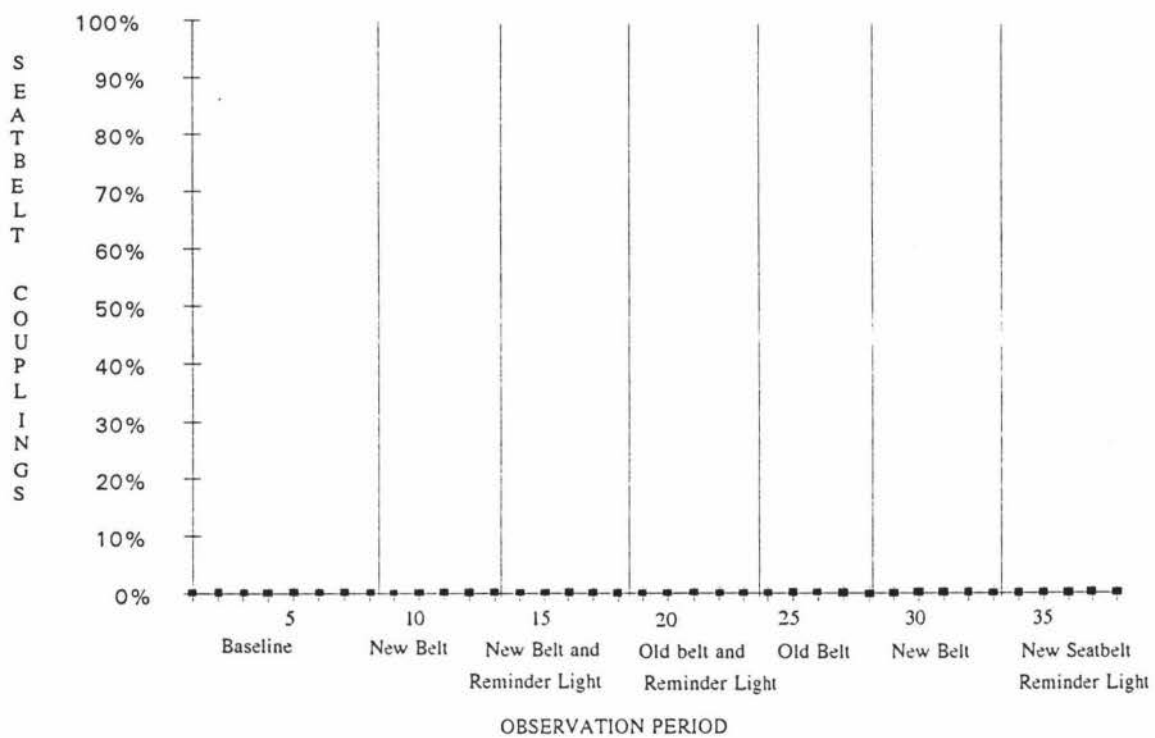


Figure 4.2: Seatbelt Usage - Subject 2

#### 4.4.2 - Operators Comments and Important Events

##### Pre-Baseline Phase:

Before beginning data collection the researcher spoke to the skidder operator.

Researcher "What do you think about the seatbelt in the skidder?"

Operator "Nothing, why?"

Researcher "We are doing some research into seatbelt usage at the moment."

Operator "It's a waste of time, seatbelts are a waste of time. You don't need one in a skidder."

##### Baseline Phase:

Fitted the new seatbelt design.

##### Observation Period 9:

Asked the operator what he thought of the new seatbelt design.

Researcher "How's the new seatbelt design? Have you tried wearing it?"

Operator "Nah, I'm not wearing that bloody thing, its worse than the other one. You need two hands to do the bloody thing up."

Researcher "No you don't, see?" (Researcher shows the operator how to put on the belt one-handed).

Operator "I'm not wearing it anyway. It's not even law, you don't need to wear the bloody thing anyway."

Researcher "Yes it is. The only time you are not legally required to wear a seatbelt is when you are moving to hook on another log. Once you have hooked on all the logs you must wear the belt."

Operator "Oh well, if anyone catches me I'll say I was just moving to hook on another log."

##### Observation Period 14:

Reminder light had been disconnected by the operator. The researcher reconnected it.

Observation Period 15:

Researcher reconnected reminder light, again.

First New Belt Reminder Light Phase:

Researcher reconnected reminder light, again. The reminder light had to be reconnected each day it was required, as the operator kept disconnecting it during all periods of observation when the reminder light was being used.

Data collection started on the 22/05/93 and finished on the 05/11/93.

Subject 2 declined to complete the seatbelt evaluation questionnaire. In summary it would seem that Subject 2 was extremely averse to wearing a seatbelt and did not believe they were of any value at all. It would also appear from his comments that he would go to almost any lengths to flaunt the legal requirement to wear a seatbelt. For example, Subject 2 disconnected the reminder light whenever it was supposed to be on. Therefore in this case neither the reminder light or the new seatbelt design resulted in an increase in seatbelt usage.

## 4.5 - Subject 3

### 4.5.1 - Seatbelt Usage

Figure 4.3 shows the percentage of seatbelt closures when the Subject was legally required to wear the seatbelt. The data points are each one days worth of data, but they are not necessarily consecutive. The mean baseline for Subject 3 was very consistent with an average usage level of 0%. This remained constant despite the installation of the new seatbelt. However, while the new belt was in, the reminder light increased mean seatbelt usage to 26%. With the removal of the new seatbelt the reminder light was not effective. The return to baseline again resulted in the level of seatbelt usage being 0%. Reintroducing the new seatbelt resulted in seatbelt usage rising slightly to a mean level of 5%. However, with the return of the reminder light, seatbelt usage rose substantially to an average of 80%.

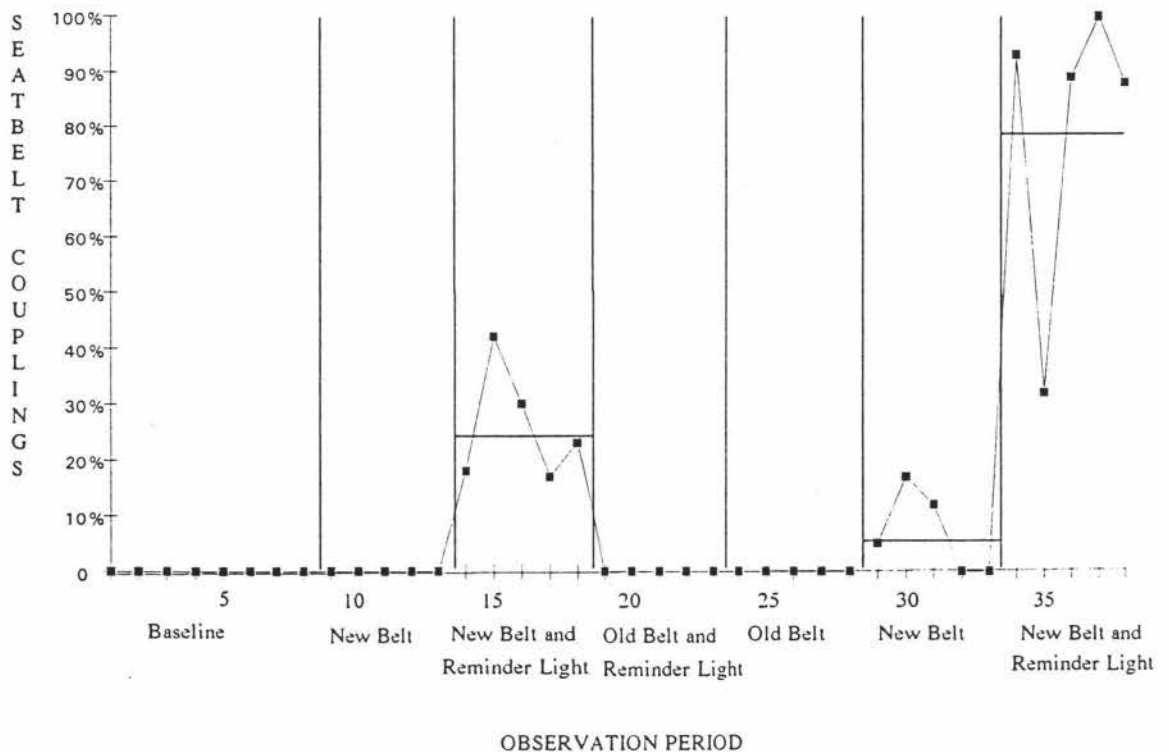


Figure 4.3: Seatbelt Usage - Subject 3

#### 4.5.1 - Operator Comments and Important Events

##### Pre-Baseline Phase:

Spoke to the contractor and driver of the skidder.

- Researcher "Do you ever wear the seatbelt?"
- Contractor "No because it takes too long and I really don't see the value of using it."
- Researcher "What about you?"
- Driver "Yeh all the time."
- Contractor "Nah don't bullshit. You don't have to lie to him, he's from LIRO."
- Driver "Oh, ok. I never wear the stupid thing, it's a waste of time."

##### Pre-Baseline Phase:

Asked contractor if he would mind being in the study.

- Contractor "Ok, but it will be a waste of time as neither of us will wear a belt."

##### Observation Period 1:

Crew shifted into thinnings. Contractor became the permanent skidder operator.

##### Baseline Phase:

Fitted the new seatbelt into the skidder.

##### Observation Period 9:

Asked contractor what he thought about the new design.

- Contractor "It's bloody excellent man, I love the thing. It makes me feel like a part of the machine, instead of some thing bouncing around in it."

##### Observation Period 14:

Met the contractor while collecting the Hunter.

- Researcher "How's the belt going?"
- Contractor "Good man, its bloody excellent."

Researcher "That's good."

Contractor "Yeh, I haven't really been wearing it much because we are doing extremely short drags at the moment so I'm getting on and off the skidder so often. When I get put back into clearfell I'll probably wear it all the time."

#### Observation Period 18:

The researcher rang the contractor to tell him the retractor needed to be taken out.

Contractor "You can't do that, I need it man."

Researcher "I just want to strengthen the spring in the retractor."

Contractor "Nah, it's alright man, don't worry about it."

Researcher "I really want to take it out and strengthen it cause you said that was one of the main problems with it."

Contractor "Oh nah, its good. You just need to ensure that the loop is in line with the retractor."

Researcher "Yeh, but the retractor spring still needs to be a bit more powerful. The guys who are doing it reckon they can get another 25% out of the spring."

Contractor "Ok, but only if it's not for too long cause I need it man. I'd never wear that other thing. When I get my new skidder I'll have to set it up like that too."

#### Old Belt Reminder Light Phase:

During the entire "Old Belt + Reminder Light" phase, the reminder light was disconnected by the operator.

#### Observation Period 25:

Shifted into new block with slightly larger trees on slightly steeper ground.

#### Observation Period 30:

Bumped into the contractor while collecting the Hunter.

Researcher "How's the belt going?"

Contractor "Good man. I haven't been wearing it much in here, cause you are just on and off the machine so often and you have to go so slowly. When I get back into clearfell

I'll probably wear it all the time. When you are finished the study I'll buy all this stuff off you. What you've done with the belt is excellent man, I'll give it to you in writing if you want."

For this Subject data collection began on 03/05/93 and was completed by 13/10/93.

Subject 3 obviously liked the seatbelt and wore it a great deal more than the standard seatbelt design. It would appear that the new seatbelt did slightly increase Subject 3's seatbelt usage by itself. According to the Subject, he would wear the belt much more in clearfell and that the short drags he was doing at the moment had reduced his level of seatbelt use. The reminder light by itself failed to have any effect as the driver kept disconnecting it. This is possibly due to the extra effort required to find the belt and put it on. This Subject may have decided that the extra trouble was not worth it, as the Subject did not disconnect the light when the new seatbelt design was in. However, combining the new seatbelt and the reminder light produced a substantial gain the first time and the second time the average level of seatbelt usage went up dramatically.



#### 4.6.2 - Operator Comments and Important Events

##### Pre-Baseline Phase:

The researcher first contacted the contractor about being in the study.

Researcher	"Does the driver wear the belt at all?"
Contractor	"Not usually, only if he gets into a real dangerous bit."
Researcher	"Why is that?"
Contractor	"It takes too much time to do it up. It's a bloody stupid design, I don't use it either when I drive."

Researcher talks to the skidder operator.

Researcher	"Do you usually wear the seatbelt?"
Driver	"Nah."
Researcher	"Why is that?"
Driver	"Too much stuffing around."

##### Observation Period 1:

The contractor became the permanent skidder driver.

##### Observation Period 4:

The hauler (Appendix 1) that the crew was working with was taken away. The skidder then became the main extraction device, working on country that was far too steep for it to safely operate.

##### Baseline Phase:

Fitted the new seatbelt design.

##### Observation Period 9:

Asked the contractor what he thought of the new seatbelt.

Researcher	"...What do you think of the new seatbelt design?"
Contractor	"Good. It's a hundred times better than the old one".

##### Observation Period 11:

Contractor having trouble using the belt. The locking mechanism was remaining locked up during the morning. Possibly this was due to the cold as it unjammed itself late in the afternoon.

Observation Period 14:

Contractor still having trouble with the locking mechanism in the mornings. This was annoying him as he was unable to pull the belt out.

Observation Period 18:

Rang contractor to tell the him that I needed to take out the new seatbelt design.

Researcher	"Is it ok to take out the new belt? I want to have a look at stopping it accidentally locking up."
Contractor	"Yeh, it's a waste of time at the moment, I can't get the belt to work."
Researcher	"Probably due to the cold freezing the locking device."
Contractor	"Probably."
Researcher	"Well I'll have a look at it anyway."
Contractor	"Right."

For this Subject data collection began on 07/06/93 and was completed by 19/10/93.

Seatbelt usage by this Subject was severely affected by a number of external factors, such as the hauler leaving this crew which forced them to work the skidder on country that was too steep. As well as this there is also the fact that the extreme cold made the retractor lock up. However, from the contractor's comments and the fact that the belt did increase seatbelt usage the second time, it would appear that the contractor did like the new seatbelt design. In this case, ignoring the overly inflated baseline, mean seatbelt usage was increased by installing the new seatbelt design. As well as this, the reminder light had a mild effect on increasing seatbelt usage.

## 4.7 - Subject 5

### 4.7.1 - Seatbelt Usage

The mean baseline level for Subject 5 was a fairly low 11%. This was further decreased to 6% with the installation of the new seatbelt design. The reminder light increased the level of seatbelt usage to over double the baseline level, reaching 28%. Removing the new belt and keeping the reminder light resulted in an increase to 37%. Removing the reminder light resulted in a decrease to 6%. The return of the new seatbelt lowered the mean level of seatbelt usage even further to 2%. This was increased to 12% by reinstalling the reminder light.

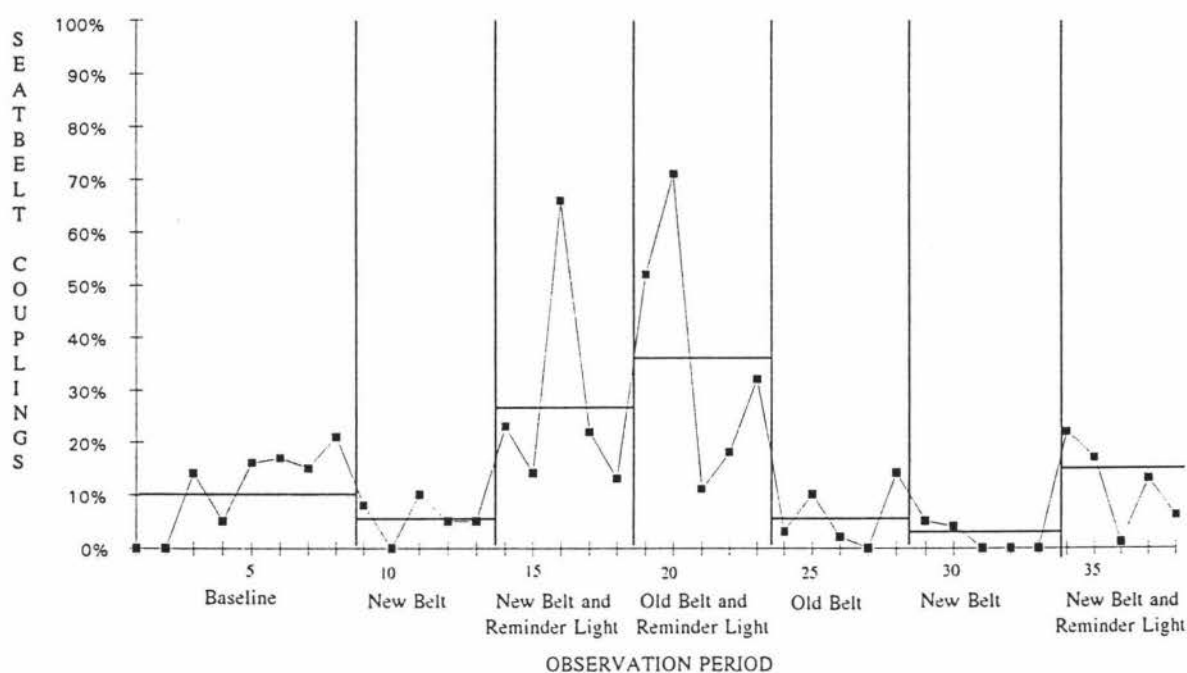


Figure 4.5: Seatbelt Usage - Subject 5

#### 4.7.2 - Operator Comments and Important Events

##### Pre-Baseline Phase:

The researcher spoke to the operator.

Researcher	"Do you wear your seatbelt?"
Operator	"No."
Researcher	"Why not?"
Operator	"Forget."
Researcher	"So do you think the belt design is ok then?"
Operator	"Nah it's pretty useless."

##### Baseline Phase:

Fitted the new seatbelt design.

##### Observation Period 14:

Asked the skidder operator what he thought of the new seatbelt design.

Researcher	"How's the seatbelt going?"
Operator	"Alright, its heaps better than that other heap of crap."

For this Subject data collection began on the 22/05/93 and was completed by 12/11/93.

Subject 5 professed to liking the seatbelt, but the results from measuring seatbelt use indicate that he hardly used the belt at all. One factor that may have contributed to the low level of use is the fact that the operator of this machine was very short in stature and had trouble seeing the logs his skidder was pulling. To see the logs this operator had to get off the seat and stand up a little. Therefore, he would have to undo the belt to complete this, as the retractor would be locked. In other words, using this belt would have been very annoying for this Subject. Using the other belt would also be difficult, but he at least would be able to adjust it so it was slack and thus he would be able to look behind without undoing the belt. Installing the new seatbelt failed to increase usage by this Subject. However, the reminder light did have the effect of increasing usage slightly.

## 4.8 - Subject 6

### 4.8.1 - Seatbelt Usage

The mean baseline level for Subject 6 was the highest in the sample at 60%. Introducing the new seatbelt resulted in no change in the mean level of use. However, when the reminder light was introduced seatbelt usage went down considerably to 0%. This rose minutely to 1% with the removal of the new seatbelt. Removing the reminder light resulted in an increase to 28%, with the old belt. This further increased to 53% when the new seatbelt was reintroduced. Reinstalling the reminder light resulted in a large increase to 74%.

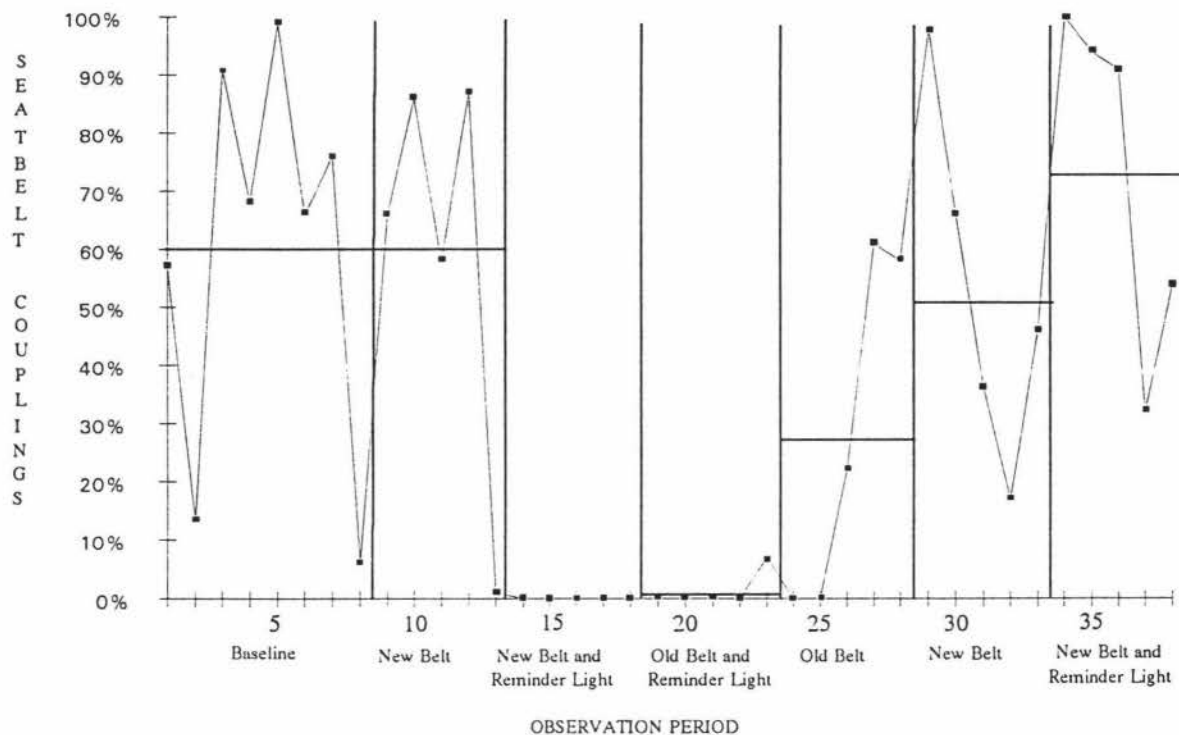


Figure 4.6: Seatbelt Usage - Subject 6

#### 4.8.2 - Operator Comments and Important Events

##### Pre-Baseline Phase:

The researcher first spoke to the skidder operator.

Researcher	"What do you think of the seatbelt in the skidder?"
Operator	"It's good."
Researcher	"Do you wear it much?"
Operator	"Yes, all the time."

##### Baseline Phase:

Fitted the new seatbelt design.

##### Observation Period 9:

Asked the operator what he thought of the new seatbelt design.

Researcher	"How's the new seatbelt design?"
Operator	"Good, much easier to use. You only need one hand, which is bloody good."

##### Observation Period 13:

The crew was put into thinnings.

##### Observation Period 14:

The reminder light was disconnected by the operator during the "New Belt + Reminder Light" phase.

##### First New Belt + Reminder Light Period:

The reminder light was always disconnected during the new belt/reminder light phase.

##### Observation Period 23:

The crew moved back to clearfell.

For this Subject, data collection began 22/05/93 and was finished by 26/10/93.

From what Subject 6 said he appeared to like the new belt design. However, this was not completely obvious from the increase in usage. This is probably due to

the shift into thinnings during the first "New Belt" phase. If the shift into thinnings is related to the graph it can be seen that there is very little seatbelt usage in this treatment phase. From this it would appear that the seatbelt was not used as often because of the fact that they were in thinnings. As well as this the reminder light was constantly disconnected while they were in thinnings. Looking at the second half of the graph, it would appear that the new seatbelt had a positive effect on seatbelt usage, with the reminder light also having a positive effect this time. The high initial baseline could be due to the operator being initially worried about possible repercussions from failing to wear the belt. When the operator realised there would be none, he acted more normally. This is supported by the much lower return to baseline phase. Therefore, disregarding the effect of thinnings it would appear that seatbelt usage can be increased by providing an easier to use seatbelt. The reminder light also increased seatbelt usage when it was paired with the new seatbelt. It is impossible to say exactly what the effect of the light would be on its own because it was only measured while they were in thinnings.

## 4.9 - Subject 7

### 4.9.1 - Seatbelt Usage

The mean baseline level of seatbelt usage for Subject 7 was fairly low at 3%. This increased to 48% with the introduction of the new seatbelt design. A further gain was achieved by installing the reminder light, mean seatbelt usage rose to an average of 74%. Removing the new seatbelt caused the level of seatbelt usage to decline to 0%. This was 0% irrespective of whether the reminder light was in the machine or not. The reintroduction of the new seatbelt caused seatbelt usage to increase substantially to an average of 94%. This was increased slightly to 96% with the introduction of the reminder light.

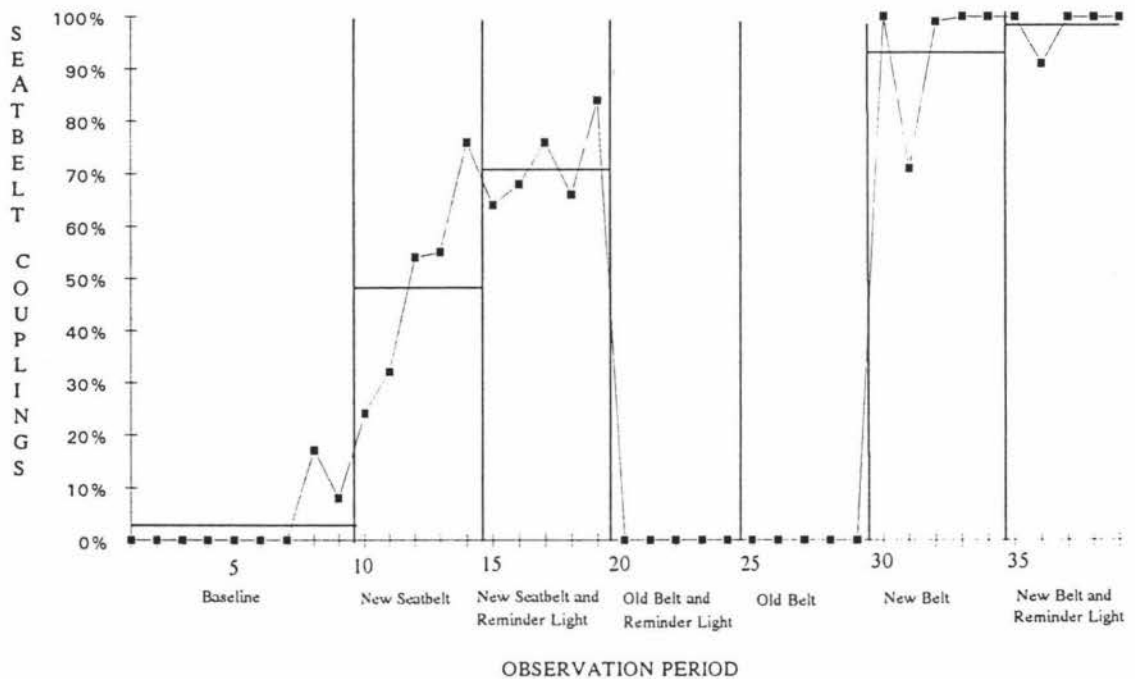


Figure 4.7: Seatbelt Usage - Subject 7

#### 4.9.2 - Operator Comments and Important Events

##### Pre-Baseline Phase:

The researcher spoke to the skidder operator.

Researcher	"What do you think of your seatbelt?"
Operator	"Not much."
Researcher	"Do you wear it?"
Operator	"No."
Researcher	"Why is that?"
Operator	"Waste too much time stuffing around."
Researcher	"Would you wear a belt if it was a lot easier to use?"
Operator	"No, I'd forget."

##### Baseline Phase:

Fitted the new seatbelt design.

##### Observation Period 10:

Asked the operator what he thought of the design.

Researcher	"What do you think of the new seatbelt?"
Operator	"Alright, it's better than the other one."

##### Observation Period 19:

Researcher rang the contractor to tell him the new seatbelt needed to be removed.

Researcher	"I just rang to tell you that I need to remove the new seatbelt."
Contractor	"Oh shit, that's no good. I suppose I'll have to get another one. Where did you get that one from?"
Researcher	"The one I put in?"
Contractor	"Yeh, I want to get another one of those. The set-up you've got is heaps better eh."
Researcher	"I don't want to take it away permanently, I just need to have a look at the spring and see if we can strengthen it."
Contractor	"[Name of the Operator] hasn't complained about it."

Researcher	"Oh ok, but I still want to take it out and get some guys in Auckland to look at it."
Contractor	"Ok, how long will it be out of the skidder?"
Researcher	"I'm not exactly sure, it may take two weeks or so, but I'll get it back to you as soon as I can."
Contractor	"Ok."

For this Subject data collection began 26/05/93 and was finished by 07/11/93.

In summarising the results it would seem that Subject 7 liked the new seatbelt a lot more than the standard seatbelt design. With this Subject, installing the new seatbelt increased the Subject's seatbelt usage considerably. The reminder light also significantly increased seatbelt usage.

#### 4.10 - Mean seatbelt usage for all subjects

Figure 4.8 shows the mean level of seatbelt usage averaged over all seven subjects. The mean baseline level was a fairly low 19%. This was increased to 27% with the introduction of the new seatbelt design. A minute increase of 1% was achieved with the introduction of the reminder light. Removal of the new belt resulted in a decrease to 13%. This declined further to 8% with the removal of the reminder light. Reintroducing the new seatbelt design resulted in seatbelt usage increasing to a respectable 39%. The reminder light boosted the mean seatbelt usage up to 58%.

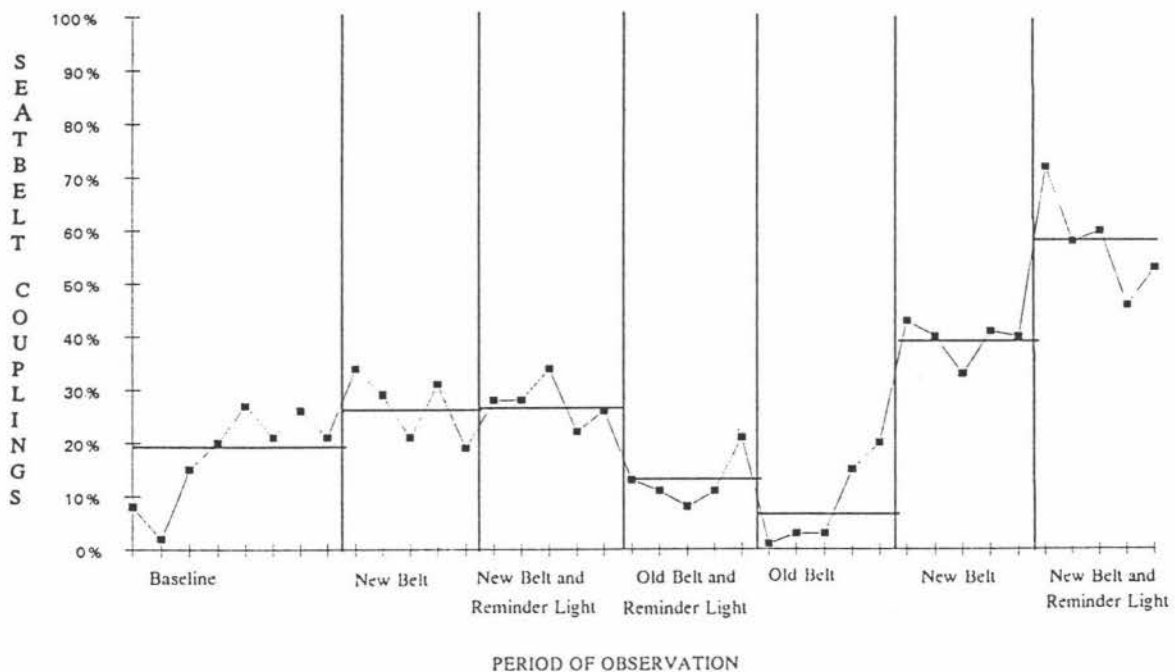


Figure 4.8: Seatbelt Usage - All Subjects

From this we can see that the first two intervention phases resulted in a fairly minor increase in seatbelt usage. This is perhaps partly due to the fact that all the crews were working in thinnings at about this time. Thinnings is very different to clearfell in many respects. Firstly, the operator is on and off the machine many times more than in clearfell, mainly because of the fact that the trees are usually a

lot smaller and so the operator must hook on more logs to make it economically viable. Secondly, in clearfell the entire tree crop in the block is felled and only the useable logs are extracted. However, in thinnings a number of trees are felled and extracted to allow the remaining trees more room in which to grow. Therefore, in thinnings the skidder has to travel down thin tracks, avoiding damaging the remaining trees. These two factors result in the lower seatbelt usage in thinnings.

Another effect noted in Figure 4.8 is the relatively high initial baseline. This is partly due to the operators possibly being initially worried about the repercussions from failing to wear the seatbelt. When they finally realised that there were none they became more relaxed and in the second baseline phase the mean level of seatbelt usage was much lower. As well as this the removal of the hauler from where Subject 4 was operating dramatically affected the mean. The removal of the hauler meant that the skidder had to be used to extract the logs on much steeper ground than it did prior to the hauler leaving. The skidder was working on ground that was too steep for it and so with this increase in danger goes an increase in the desire to wear the seatbelt. Therefore, during this phase the level of seatbelt usage increased dramatically.

The overall trend observed in Figure 4.8 is that the average level of seatbelt usage is increased by installing an easier to use seatbelt and that a reminder light increases this over and above that of the new seatbelt. The combined effect of the two interventions is particularly powerful.

#### 4.11 - Mean seatbelt usage for six subjects

Figure 4.9 shows the overall summary with Subject 2 removed. Subject 2 was removed because the results for this individual were significantly different from all the other subjects, in that no changes were observed during the entire study. Therefore, the researcher thought that the inclusion of Subject 2 would have an unjustifiably large effect on the overall means. Comparing Figure 4.9 with the previous summary shows that, as would be expected, the averages at all periods have been increased. For example in the first "New Belt" treatment, mean seatbelt usage rose from 27% to 31%. The biggest change occurred in the final "New Belt + Reminder Light" treatment period. This changed from an average of 58% to 68%. In this instance, Subject 2 had a large effect on the mean percentage of seatbelt closures. This was the biggest effect Subject 2 had on the mean, all the other effects were between 2% and 7%.

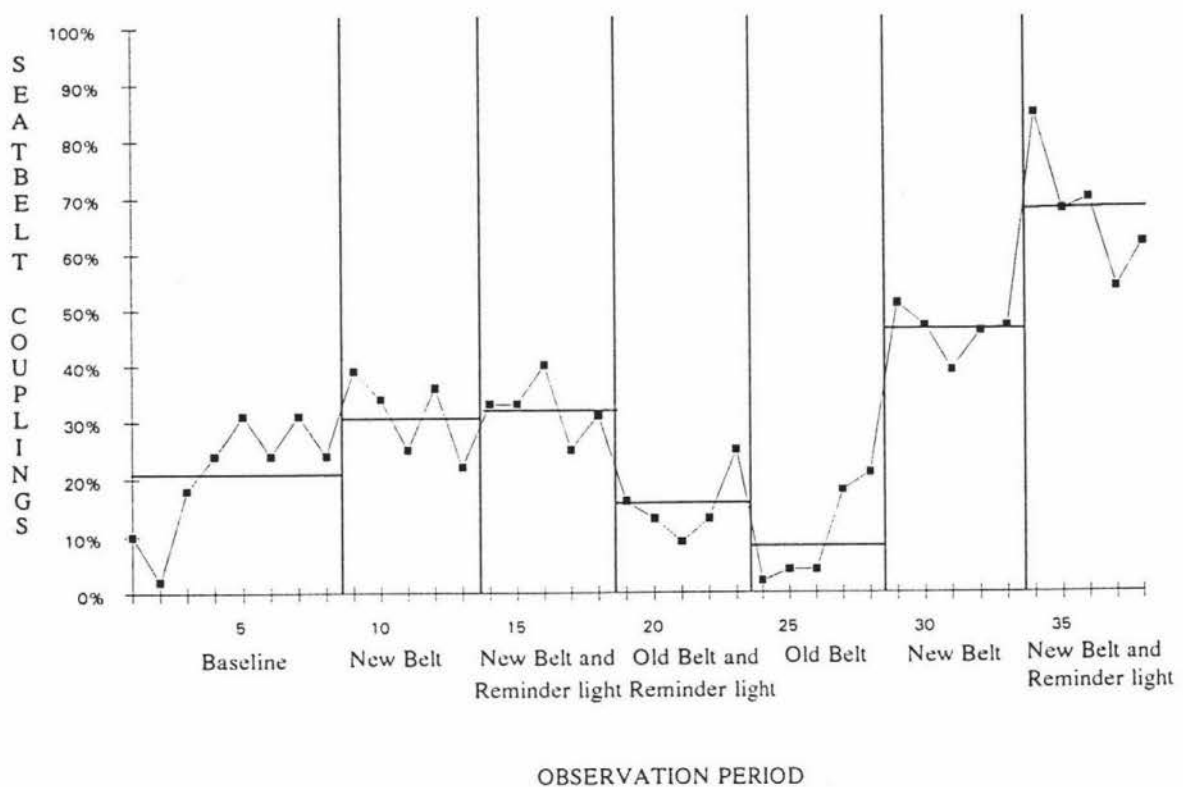
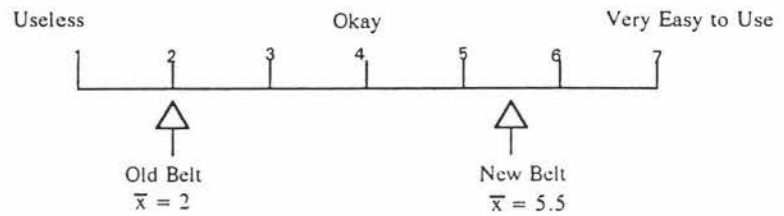


Figure 4.9: Seatbelt Usage - Summary for Six Subjects

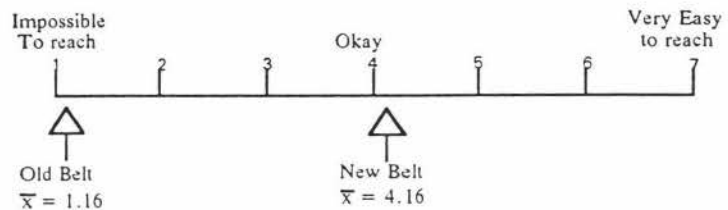
#### 4.12 - Seatbelt evaluation questionnaire

The subjects were asked to compare the two seatbelts on a 7 point Likert type scale. The 6 subjects rated the seatbelts on the following characteristics:

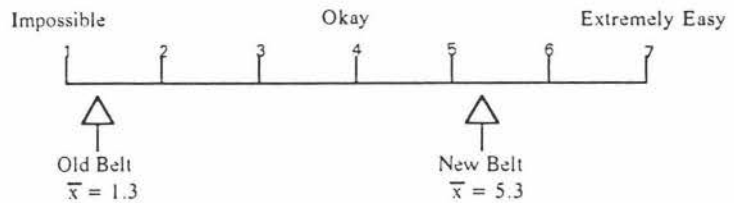
Ease of use, how easy  
is the belt to use?



Presentation, how well is the  
belt presented to you?



Adjustability, how easy  
is the belt to adjust ?



Overall Assessment, rate  
each belt out of seven.

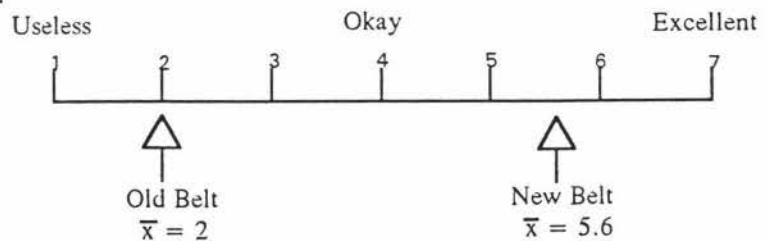


Figure 4.10 - Summary of Seatbelt Evaluation Questionnaire

What do you think of the reminder light ?

$$\bar{x} = 4.3$$

- 1 - Nothing, I disconnected it.
- 2 - Bloody annoying.
- 3 - Hardly noticed it.
- 4 - Reminded me occasionally.
- 5 - Very helpful in reminding me to put on my seatbelt.

The questionnaire results show that the subjects constantly rated the new seatbelt higher than the standard seatbelt design on all measured aspects. They also rated the reminder light as being between very helpful in reminding me to wear the seatbelt and reminded me occasionally. Therefore, they saw the reminder light as being effective in reminding them to wear the seatbelt.

#### 4.13 - Summary

The results presented in this chapter showed that the new seatbelt substantially increased usage by Subject 1, Subject 3, Subject 4, Subject 6 and Subject 7. All the subjects, except for Subject 2, increased seatbelt usage in response to the reminder light. Subject 5 increased seatbelt usage in response to the reminder light only, while Subject 2 failed to use a seatbelt during the entire experiment. The results also showed that environmental factors, such as a shift into thinnings, can have a big impact on the level of seatbelt usage. The last section of the chapter showed that all the subjects liked the seatbelt design and thought that the reminder light was useful as a reminder to put on their seatbelt. These results are discussed further, with special attention to their implications in the next chapter.

## CHAPTER 5: DISCUSSION

### 5.1 - Introduction

Chapter 5 discusses the results presented in the previous chapter. The chapter firstly analyses the results in the context of the hypotheses developed in chapter 2. This is followed by a discussion of particular methodological problems encountered during this study, which have a bearing upon the generalisability of the findings. The discussion then broadens to consider a range of environmental impacts particular to safety research in the forest industry. The chapter finishes with the overall conclusions from this research and the implications for future research.

### 5.2 - Discussion of hypotheses

The changes in mean seatbelt usage can be described in two ways. Firstly in relation to the experimental period preceding it and secondly in terms of absolute percentage points. As the literature in this area (e.g. Ragnarsson and Bjorgvinsson, 1991; Geller et al., 1980) customarily explains the changes in terms of absolute percentage points, this is how it will be approached here.

All subjects, except Subject 2, registered increases in seatbelt usage for at least one of the interventions. Comments made by Subject 2 show that this subject was highly averse to wearing a seatbelt. He stated that he would never wear a seatbelt. This was confirmed by the other results for this subject. Therefore, the data from Subject 2 were treated separately from the rest and Figure 4.9 is used when interpreting overall trends in the data.

Hypothesis 1 stated that the first installation of the new seatbelt design would increase the level of seatbelt use. Figure 4.8 shows this to be the case. The mean percentage of seatbelt use rose 8% with the installation of the new seatbelt. With Subject 2 removed (Figure 4.9) this rise is increased slightly, resulting in a 10% increase in seatbelt usage. However, the individual results show a slightly different picture. Neither Subject 3 or Subject 4 showed any change in seatbelt

usage, while Subject 4 and Subject 5 showed minor decreases. The very large increases shown by Subjects 1 and 7 outweighed these decreases to produce the overall mean increases seen in both Figures 4.8 and 4.9.

Unfortunately, during the phase in which hypothesis 1 was being tested the results were affected by a number of environmental factors, such as the move into thinnings and the removal of Subject 4's hauler. As well as this, there is the fact that the baseline levels had been inflated considerably by the operators' initial anxiety at having a stranger conducting research on their seatbelt. The observed decrease in usage by Subject 5 was mainly due to the fact that this person's small stature made him incompatible with the new seatbelt design. In this case, the new seatbelt was not easier to use, which was a premise of hypothesis 1. Setting aside the data from Subjects 2 and 5, the trend of the results shown in Figure 4.9 supports this hypothesis.

Hypothesis 2 stated that the reminder light would further increase usage of the new seatbelt. Both Figure 4.8 and 4.9 show that the installation of the reminder light only resulted in a 1% increase in seatbelt usage. However, once again the individual results show a slightly different picture. Understandably, the non-cooperative Subject 2 failed to show any change. Surprisingly, Subjects 4 and 6 showed very large decreases in seatbelt usage (31% and 60% respectively), while Subjects 1, 3, 5 and 7 all showed increases between 15-26%. During this phase, seatbelt usage was affected by the same environmental problems noted above. As well, Subject 4 was having a lot of trouble with the seatbelt retractor jamming due to the cold weather. Subject 6 stopped using the seatbelt as soon as his crew was moved into thinnings. The combined results (Figure 4.9) suggest that the reminder light was of very limited effectiveness in increasing seatbelt usage, while the majority of the individual results suggest that the reminder light was very effective in increasing seatbelt usage. These individual results, and the fact that the overall trend was a slight increase, lend some support to hypothesis 2, but this support is moderated by the dramatic effect Subjects 4 and 6 had on the overall results.

Hypothesis 3 stated that circumvention of the reminder light would increase when the new belt was removed. During this phase of the study the reminder light was being circumvented by Subject 2, Subject 3, Subject 6 and Subject 7. Subject 2,

who would not use any seatbelt, always circumvented the reminder light. Subject 6 was also already circumventing the reminder light, so the level of circumvention could not increase for these two subjects. Subject 6 disconnected the reminder light as soon as it was installed the first time. This was probably due mainly to this crew being in thinnings, as the reminder light was not circumvented during its second introduction when they had been moved back into clearfell. As soon as the new belt was removed and the old belt re-installed, both Subject 3 and Subject 7 circumvented the reminder light. The results for both these subjects support hypothesis 3. The results from Subject 1, Subject 4 and Subject 5 provide no support for this hypothesis. Once again the results from Subject 2 can be disregarded and the results from Subject 6 were severely affected by the move into thinnings, and therefore cannot be said to point in either direction. Therefore, the results were inconclusive.

A phenomenon noted in the literature (e.g. Robertson, 1975) is that if the vehicle is not owned by the driver, circumvention is less likely to occur. Out of the five subjects in this study that did not own the vehicle, three circumvented the reminder light at some stage. Of the two that did own the vehicle, only one (Subject 3) actually circumvented the reminder light. The sampling is too small for the drawing of any conclusions, but this question could be taken up in a larger study.

Hypothesis 4 was that the removal of the new seatbelt and the reintroduction of the original seatbelt, would result in a decrease in seatbelt usage, but to a level above that of the initial baseline. Both Figures 4.8 and 4.9 show that with the new seatbelt removed, seatbelt usage did decrease, but not to a level above that of the baseline. Looking at the individual results, Subject 1 decreased to a level above that of the initial baseline. Subjects 3 and 7 showed a decrease in seatbelt usage, but this was to a level below that of the initial baseline. Seatbelt usage for Subjects 4, 5 and 6 did not decrease, and Subject 2 again showed no change.

During this phase of the experiment there were a number of factors that may have affected the results for Subjects 4, 5 and 6. Subject 4 was having trouble with the seatbelt retractor jamming due to the cold conditions. Subject 5 was incompatible with the new seatbelt design as a result of his short stature, and Subject 6 was moved back into clearfell just after the new seatbelt had been removed. Another

factor that may have affected the results was the inflated initial baseline. Therefore, despite the clear overall decrease in seatbelt usage, it is impossible to conclusively accept or reject hypothesis 4 in its entirety.

Hypothesis 5 stated that the removal of the reminder light would result in a further decrease in the use of the re-installed old seatbelt, but that this would also still be above the initial baseline level. Figures 4.8 and 4.9 both show that the removal of the reminder light resulted in a decrease in seatbelt usage, but to a level below the initial baseline. Looking at the individual results, Subject 1, Subject 4 and Subject 5 all decreased their seatbelt usage with the removal of the reminder light, but to a level below the initial baseline. Subjects 2, 3 and 7 did not decrease (as they had already reached 0% usage with the removal of the new seatbelt), whereas usage by Subject 6 actually increased. This, as mentioned earlier, was probably due to the inflated initial baseline level. If the initial baseline level had not been inflated, the result may have been different. This effect, in conjunction with the fact that Subjects 2, 3 and 7 could not decrease any further, and the fact that Subject 6 had just moved back into clearfell, made it very difficult to obtain sufficient data so as to be able to address hypothesis 5.

Hypothesis 6 stated that the refitting of the new belt and the reminder light would both result in significant increases in the level of seatbelt use. Firstly, the graph presenting the overall means (Figure 4.8) shows that mean seatbelt usage rose significantly from 8% to 39%, an increase of 31%. With the higher mean seatbelt usage, the influence of Subject 2 becomes more apparent. Figure 4.9 shows that without Subject 2, mean seatbelt usage rose 36% from 10% to 46%. The individual graphs reveal a similar pattern. As expected, Subject 2 again failed to change at all, while Subject 5 actually recorded a minor decrease in usage from 6% down to 2%. However, Subject 1 (45% increase), Subject 3 (5% increase), Subject 4 (51% increase), Subject 6 (25% increase) and Subject 7 (94% increase) all showed significant increases. Therefore, considering this, the fact that the new seatbelt was incompatible with Subject 5's stature, the fact that Subject 2 failed to change at all and the summary graph, it would appear safe to conclude that the reinstallation of the new seatbelt did result in an increase in seatbelt usage.

With regards to the second installation of the reminder light, Figure 4.8 shows that mean seatbelt usage rose significantly from 39% to 58%, an increase of 19%. As mentioned earlier, with the higher seatbelt usage means, the effect of Subject 2 becomes more noticeable. Therefore, with Subject 2 removed, Figure 4.9 shows a slightly higher increase from 46% to 68%, an increase of 22%. The individual graphs are just as conclusive, with only Subject 2 failing to increase seatbelt usage. Therefore, in this case there appears to be enough evidence to conclusively state that hypothesis 6 is well supported and seatbelt usage is increased both by installing an easier to use seatbelt and through the use of a reminder light.

### 5.3 - Methodological and environmental problems

As was seen in the previous section, for some of the subjects a good measure of control was gained over seatbelt wearing behaviour, resulting in some dramatic individual changes. Most of these changes were also evident when the data from the subjects were combined. These results notwithstanding, there are however a number of limitations with this study. The first and foremost of these was the small sample size. The small sample size meant that any extreme behaviour could unduly affect the overall results. Here the most extreme case was Subject 2, who refused to cooperate. Interestingly, the inclusion of Subject 2's data did not mask the trend, as the same pattern of results was achieved with (Figure 4.8) and without Subject 2 (Figure 4.9). Removal of Subject 5 was considered but could not be justified, as this subject (because of his short stature) only differed from the others with regards to the effect of the new seatbelt. Removing Subject 5 added nothing to the interpretability of the combined results graph, and so a graph with Subject 5 removed was not included.

Looking at the results of hypothesis 2 shows that big decreases in seatbelt usage by Subject 4 and Subject 6 severely affected the overall mean usage in the first "New Belt + Reminder Light" phase (Figure 4.9). In fact these two subjects almost completely hid the increase in seatbelt usage gained by the other subjects through the installation of the reminder light. This was the only intervention phase in which one or two subjects had such a big effect, and as discussed these big effects were mainly due to the environmental conditions. Given the changed

operating conditions, the results were still interpretable. The area in which the small sample size may be an issue is in the generalisability of the results, which is considered later in the discussion.

Another problem is the true baseline level of seatbelt usage. Prior to commencing the study all the subjects, except one, stated that they did not use the seatbelt. The observed baseline level of 21% (Figure 4.9) appears to disagree with this. There is also the fact that in most behaviour modification studies (e.g. Cope et al., 1991; Ragnarsson and Bjorgvinsson, 1991; Thyer and Geller, 1987) the return to baseline levels are above those of the preintervention baseline levels. In this study the second baseline phase was 11% below that of the first (Figure 4.9). This is further evidence that the initial baseline phase was perhaps inflated both by the removal of the "hauler" (for a definition of this term see Appendix 1) from Subject 4, and by the initial anxiety at having someone looking at the seatbelt. This anxiety is perfectly understandable, considering that under the HSE Act (1992) the operator could get fined up to \$25,000 for failing to wear a seatbelt. When the initial worry was over (i.e. during the return to baseline "Old Belt" phase) seatbelt usage settled down to a more normal level. Considering this, the second baseline phase of 10% (Figure 4.9) may be a more accurate measure of the true baseline level. This would significantly affect the argument made for hypothesis 1. It would swing the balance very much in favour of the hypothesis. Looking at the overall graph (Figure 4.9) with a 10% baseline, installing the new belt causes a dramatic increase in the level of seatbelt usage. This would result in a much larger mean increase from 10% to 31%. If the same operation were able to be performed for the individual graphs as well, there would be considerable support for hypothesis 1, especially when the effect of thinnings, Subject 2's consistent lack of response and the untestability of the hypothesis on Subject 5 was taken into account. In this case it would appear that hypothesis 1 could have gained much stronger support.

Conducting behavioural research in this kind of environment involves facing many small and some large insurmountable problems. For example, the distance between skidders is usually great, even within a forest. Kaingaroa Forest is 148,000 hectares in area and quite often there were skidders at both extremes. This made visiting all 7 skidders an extremely time consuming job, which quite

often took over 10 consecutive hours to complete. Because of this it was impossible to use a larger sample size, as the amount of travelling would have increased beyond the capacity of the researcher.

The equipment generally turned out to be adequate, despite the extremely harsh environment of the forest. Although the equipment was generally found to be adequate, data collection still had to be repeated on many occasions. This was mainly caused by the otherwise very hardy Husky Hunters breaking down, the high mortality rate for electrical components, and the large number of times that the wires to the reed switches broke.

Another problem is that it was very hard to control who was driving the machine. Although the regular skidder operator noted down who was driving the machine at the time, this did not solve the problem. It just meant that collected data had to be deleted. However, this procedure only worked if the regular operator recorded who was driving the skidder. While this was probably the case in most instances, there was always the possibility that on the odd occasion the regular operator may have swapped jobs with one of the fallers to give them a short rest. The possibility of such events may account for some of the variability within each subject's data.

Without doubt the majority of the variability would have been contributed by the terrain that the machine was working on. The reason for this is that the subjects appeared to perceive a greater risk of machine rollover and injury while working on steep terrain. This is shown firstly by the fact that Subject 1 mentioned he might wear an easier to use seatbelt if the crew was put on a steep block. This is also supported by the large increase in usage by Subject 4 when the hauler they were working with was removed and they continued working the same area, even though it was considered too steep for the skidder to be working on.

There may also be a problem with the formula "percent seatbelt couplings", as the relationship of required seatbelt use to drags was not as clear as it may seem. The skidders not only dragged the felled trees to a central processing area, they may have completed a number of other tasks as well. The skidder may have been used to push down trees, crush debris on the "cutover" (for a definition of this term see Appendix 1), and sometimes make tracks for other machinery to travel

on. Therefore, although completing drags was the central task that the skidder completed during the majority of the time, it is possible that they may have done other tasks as well. The result of this is that the formula could overestimate the level of seatbelt usage, as they were still required to wear the seatbelt during these operations. It is not expected that this would have affected the results a large amount, as by far the majority of the time would have been spent completing drags. However, it does point out that refinement of the formula should be attempted in future research.

A factor that did have a major impact on the results of this study was the shift into thinnings. The change in work type affected the results dramatically, as is clearly illustrated in Figure 4.9. This graph shows that there was only a minor increase in seatbelt usage with the introduction of the new seatbelt design, and an even smaller increase with the introduction of the reminder light, while the subjects were engaged in thinnings operations. During the second installation of the two interventions, when most of the subjects were back in clearfell, the increases found by installing the new seatbelt design and the reminder light were substantial.

Overall there were a number of problems with the experimental design. While beyond the direct control of the experimenter, their impact on the findings was not so dramatic as to hide the potency of either installing an easier to use seatbelt or introducing an orange flashing reminder light in fostering higher seatbelt use.

#### **5.4 - Generalisability of results**

One of the problems in having to conduct the research on such a small sample of skidder operators, is that they may in some way differ significantly from the population of skidder operators in general. The operators were chosen on the basis of the type of machine only and not for some other reason, such as their present level of seatbelt use. However, as was shown by talking to the skidder operators prior to the measurement of seatbelt usage in this study, six out of the seven operators stated that they did not ever wear a seatbelt.

According to previous research conducted by LIRO (Kirk, 1992) and informal surveys, this appeared to be representative of the level of skidder seatbelt usage in general, irrespective of machine type. Other skidder makes and models have similar seatbelts and no reminder lights. Therefore, it is thought that the results found here could probably be generalised to other makes of skidder.

A further broader question would be do these results generalise to other type of logging machinery? A case can be argued for generalising these results to the operators of "logging tractors" (for a definition of this term see Appendix 1), as they are used to complete much the same work. The only major difference between tractors and skidders is that tractors are used for working on steeper terrain. The seatbelt designs are fairly similar, if not identical to those in skidders. Also, tractors have no warning or reminder light. In view of this it would appear justifiable to conclude that these results could apply to logging tractors. However, other machinery such as loaders do not complete the same type of logging work. Are the results of this study applicable to these types of machinery? The easiest, and most valid method to answer this would involve looking at whether the findings here agree with those of other studies, using different types of machinery.

Dealing with the generalisability of the effect of installing an easier to use seatbelt first. The results from the questionnaire in the Gordon et al. (1976) study, on improving the design of car seatbelts, are in agreement with the results found here. The effect of installing an automatic seatbelt on seatbelt usage (e.g. Williams et al., 1990) also agrees with that found in this study. The fact that the two above mentioned studies were conducted on ordinary everyday motor vehicles, suggests that these results can be generalised. There is a strong case that a more easily used seatbelt will be worn more often.

It is slightly harder to reach a conclusion on the generalisability of the effect shown by the reminder light. The only literature is based on the effectiveness of a non-flashing reminder light. This literature shows that a non-flashing reminder light has the effect of increasing seatbelt usage (e.g. Geller et al., 1980). There is no reason why this effect should not also be seen with the more intrusive flashing light. The literature (Berry and Geller, 1991; Geller et al., 1980) states that the more intrusive the system the more likely it is to have a positive effect on seatbelt

usage. Therefore, as the level of seatbelt use increased here and increased using a much less intrusive system in cars (Geller et al., 1980), it would appear plausible to generalise these results to other types of logging machinery.

## 5.7 - Conclusion

This study has shown that the level of seatbelt usage by skidder drivers can be markedly increased by providing them with an easier to use seatbelt. The addition of a seatbelt reminder light also produced a measurable increase in seatbelt usage. Both interventions are individually capable of producing sizeable increases in mean seatbelt usage, but worked best in combination. In comparing the two interventions, it would appear that the new seatbelt is characterised by a higher level of change in seatbelt usage. The effectiveness of the new seatbelt was not as badly affected by the change to thinnings operations. Also, the new seatbelt on its own produced substantial increases, whereas the reminder light on its own produced a minor increase above the baseline. However, as mentioned earlier, the true efficacy of the reminder light may have been hidden by the fact that most of the crews were in thinnings at the time and the reminder light on its own was not tested in clearfell. Therefore, combining the two interventions should be used for best results. If forced to choose between the two, the improved seatbelt design would be chosen, as the largest and most reliable increases were achieved using this method.

Working within a forestry environment is very hard on both the researcher and the equipment. Moreover, the environment can have a large effect on the level of seatbelt usage and in fact probably reduced the effectiveness of both the reminder light and the new belt.

Despite Woodson (1975) stating he doubted whether any study would find that making a seatbelt easier to use would result in an increase in seatbelt usage, this study has done so. These results are in accordance with comments made by the subjects in the Gordon et al. (1976) study, that they would wear an easier to use seatbelt more often. The finding here also supports the generalisability of the results found using automatic seatbelts (e.g. Williams et al., 1990). Therefore, as

the results of the present study are in agreement with the findings of other similar studies, it is safe to conclude that installing an easier to use seatbelt will, in most cases result in an increase in seatbelt usage.

This study rested upon the use of human factors engineering (or ergonomics) and behaviour modification approaches to increase the use of seatbelts. In general, these two industrial/social approaches (Landy, 1989) were found to be powerful. The success of combining the two approaches should convincingly point out that a combination of the two is desirable. Moreover, it may be impossible to attempt an increase in a behaviour without providing a useable design. For example, it would be very hard to enforce the use of a chainsaw mitt if it was hard to use. The use of high visibility singlets would be hard to encourage if they were cumbersome and uncomfortable. The use of these singlets in New Zealand forestry has not been as widespread as originally hoped, possibly for these very reasons. Enforcing the use of new types of safety equipment tends to be very hard, as the Department of Labour's Inspectors visit so infrequently and when they do visit operators often notice the Inspector before the Inspector notices them. Therefore, if the operator was engaged in any kind of dangerous behaviour he would be able to desist before the Inspector would be able to notice. An increase in motivation to perform the required behaviour may not only come from linking a reward to the behaviour, but can also result from making the device easier to use. Combining the two approaches also combines the two motivations resulting in a much stronger change in behaviour.

Part way through this study, a review of safety programmes was published by Guastello (1993). In this paper Guastello mentions that two of the most effective types of safety intervention programmes are behaviour modification and comprehensive ergonomics. Although this study could only use a single ergonomic intervention (as opposed to a comprehensive one), both this and the behavioural intervention were found to be very useful in reducing potential injury-causing behaviours (failure to wear a seatbelt). The results of this study add weight to Guastello's findings that behaviour modification and ergonomics are very powerful methods for accident prevention.

## 5.6 - Future research

There are four main areas where future research is needed. Firstly there needs to be research conducted on how long the higher level of seatbelt usage achieved here will remain. Methods for both maintaining this higher level and further increasing usage also need to be examined.

Secondly, future research needs to replicate the findings of this study. This should be conducted over a number of environments to add real strength to the conclusions from the present study. The future research should have a high degree of control over the environment. The complete elimination of the chance that someone else may drive the skidder for short periods, keeping the skidders doing the same type of work, and restricting all the skidders to clearfell, are all necessary steps.

Thirdly, research needs to be conducted into why seatbelt usage is lower in thinnings than in clearfell. This study would need to look at the risks perceived by the operators. Do they perceive a lower risk while in thinnings? Is this in fact correct? Future research should also look at ways to correct this misperception (if in fact it is a misperception). Also methods for increasing seatbelt usage in thinnings also need to be researched.

The fourth area where future research needs to be conducted relates to further improvement of the new belt and reminder system. Researchers should firstly look at improving the design of each and then test to see whether these improvements will result in a greater increase in seatbelt usage.

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## APPENDIX 1

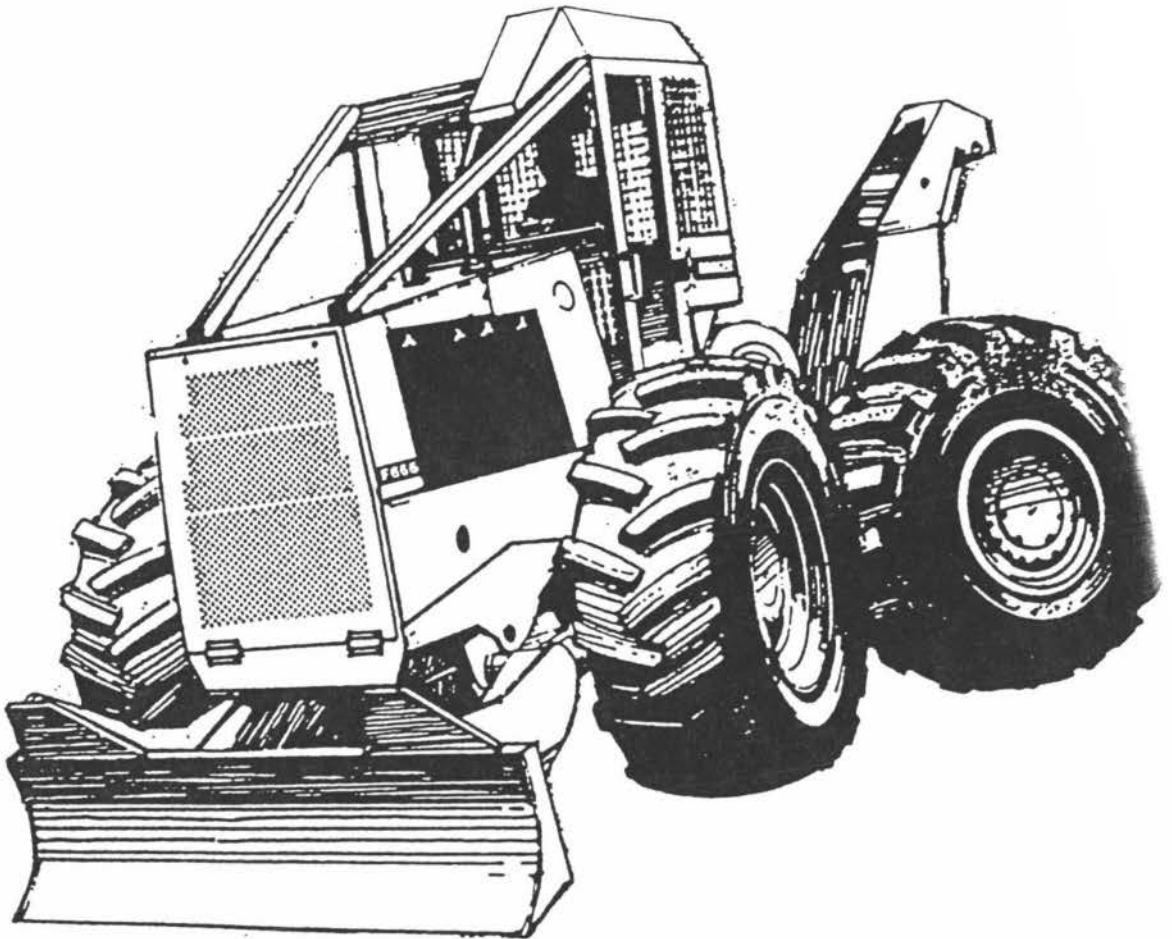
### Logging Terminology

Breaking out	-	Connecting trees or logs to the extraction machinery for transportation to the landing.
Breaker out	-	Person responsible for connecting trees or logs to the extraction machinery
Bush Inspector	-	Inspector employed by the Department of Labour, now called Health and Safety Inspectors.
Chainsaw Mitt	-	A leather glove attached to the front handle of the chainsaw.
Clark	-	Manufacturer of skidders, now owned by VME.
Clearfell	-	To fell and extract an entire stand of trees.
Compartment	-	A numbered sub-division of a forest.
Contractor	-	Owner of the business that fells, extracts and processes the trees. Usually owns most of the machinery, but occasionally rents them.
Drag	-	A log, or a number of logs, skidded or hauled from stump to landing in a cycle.
Faller	-	Chainsaw operator whose job it is to fell the trees.
Ground-based extraction	-	The use of rubber-tyred and tracked machinery for extracting the felled trees. Includes such things as skidders and tractors (haulers are not included in this).
Hauler	-	A machine designed for working on very steep terrain. It is equipped with winches and transports felled trees from where they are felled to the landing.
Hunter	-	Model of Husky field computers used for this project.
Husky	-	Manufacturer of field computers.
Landing	-	A selected or prepared area to which logs are extracted to and sorted, processed, loaded or stockpiled.

Logging	-	The harvesting of timber from the forest.
Log-making	-	Measuring and cutting of tree stems into different size logs.
Operator	-	The person employed by the contractor to use the For example a skidder operator.
Ranger	-	Brand of skidder now owned by VME.
Silviculture	-	The growing and tending of the forest crop.
Skidder	-	A rubber tyred machine designed specifically for extracting trees from where they are felled.
Slash	-	The debris left after logging. Includes such things as bark, branches, broken trees, etc.
Thinnings	-	Felling selected trees in a stand to a special pattern, usually done on trees too small for clearfelling.
Tractor	-	A machine that travels on tracks and is similar in appearance to a bulldozer. Used on terrain too steep for a skidder.
Trimming	-	Removing the branches from a tree or log.
Valmet	-	Make of skidder now owned by VME.
Winch Rope	-	The wire rope on the machine mounted winch that is used to tow the logs behind the machine.

## APPENDIX 2

## SKIDDER

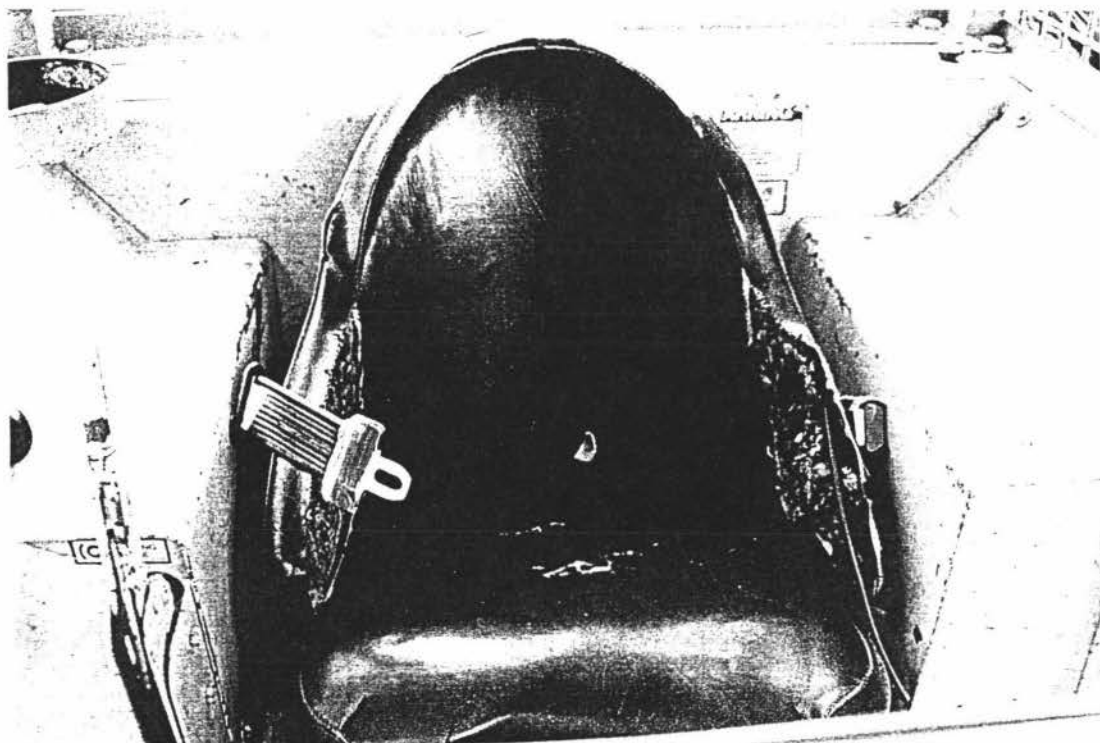


## APPENDIX 3

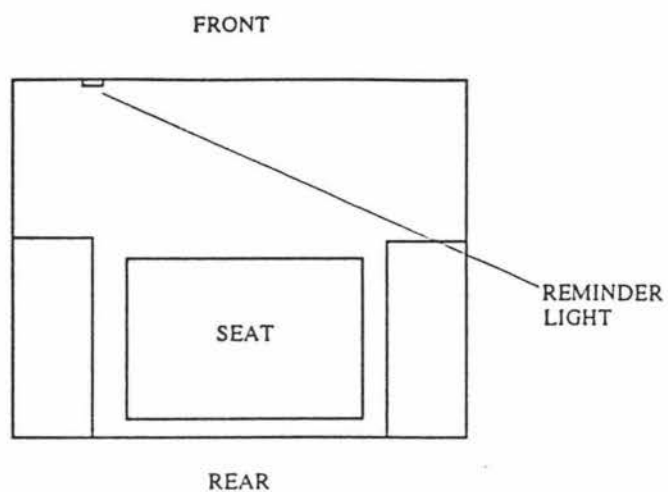
## SEATBELT DESIGNS AND REMINDER LIGHT POSITIONING



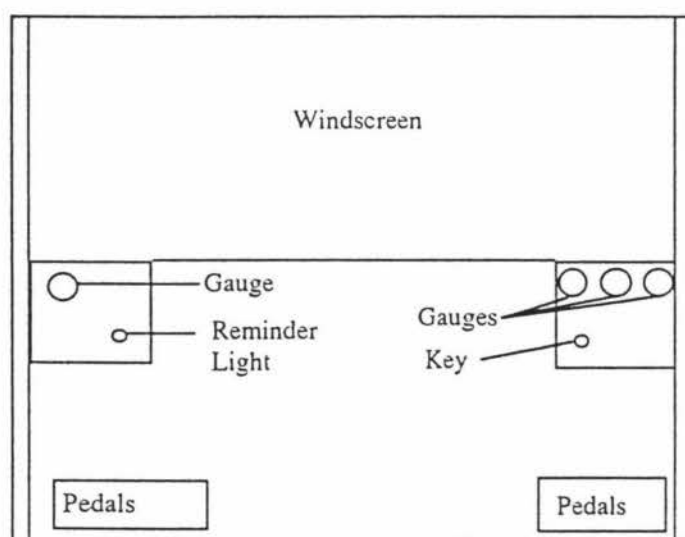
Conventional Seatbelt Design



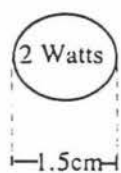
New Seatbelt Design



View from above



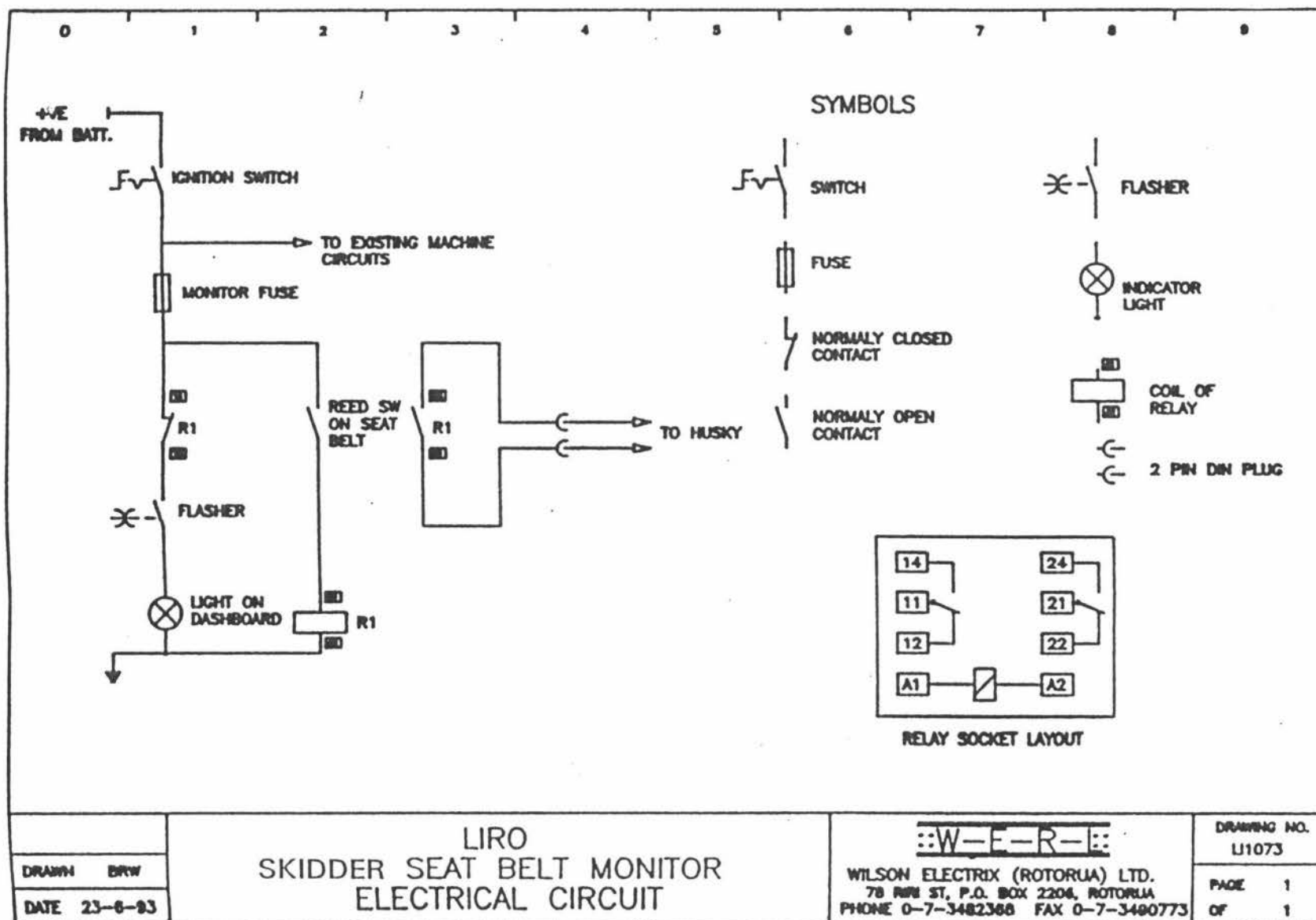
Operator's View



Close-up of Reminder Light

# APPENDIX 4

## CIRCUIT DIAGRAM



## APPENDIX 5

## OPERATOR TIME SHEET

Machine F65  
 Crew No             
 Week Starting             
 Week Ending           

	Names of operators	Hours spent using machine	Number of drags	Breaker out present (most of the time)
Monday 1. 7-11am 2. 11-3pm	  	  	  	Y/N Y/N
Tuesday 1. 7-11am 2. 11-3pm	  	  	  	Y/N Y/N
Wed 1. 7-11am 2. 11-3pm	  	  	  	Y/N Y/N
Thursday 1. 7-11am 2. 11-3pm	  	  	  	Y/N Y/N
Friday 1. 7-11am 2. 11-3pm	  	  	  	Y/N Y/N

## APPENDIX 6

### SEATBELT EVALUATION QUESTIONNAIRE

This is all confidential, this will only be seen by myself.

When, if ever do you not wear the new seatbelt ?

What is the reason for not wearing the seatbelt ?

Please rate both the old belt and the new belt on the following scale

Ease of use, how easy is the belt to use (Circle number).

	Useless				Ok			Very easy to use	
Old Belt	1	2	3	4	5	6	7		
New Belt	1	2	3	4	5	6	7		

Presentation, how well is the belt presented to you.

	Impossible to reach				Ok			Very easy to reach	
Old Belt	1	2	3	4	5	6	7		
New Belt	1	2	3	4	5	6	7		

Adjustability, how easy is the belt to adjust ?

	Impossible				Ok			Extremely easy	
Old Belt	1	2	3	4	5	6	7		
New Belt	1	2	3	4	5	6	7		

Overall Assessment, rate each belt out of 7.

	Useless				Ok		Excellent	
Old Belt	1	2	3	4	5	6	7	
New Belt	1	2	3	4	5	6	7	

What do you like about the new belt ?

What do you dislike about the new belt ?

In what areas, if any would you say the new seatbelt could be improved ?

What did you think of the reminder light ?

1. Nothing I disconnected it
2. Bloody annoying
3. Hardly noticed it
4. Reminded me occasionally
5. Very helpful in reminding me to put the belt on

Any general comments

Thank you for your time.