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**Flight and Duty Times
of Flight Instructors in General Aviation
in New Zealand
- A Study**

A Thesis presented in partial fulfilment
of the requirements for the degree of
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ABSTRACT

Flight Instructors that train pilots in the General Aviation arena are expected to perform to a high level at all times. Flight training is an intense activity during which the Flight Instructor is subject to many factors causing fatigue, both physiological and psychological, many of which may be outside their immediate control. Considerations such as low pay mean that Flight Instructors often work long hours and often have another job which adds to their time at work each day, resulting in a decrease in their time available for sleep. Although considerable research has been done on pilot fatigue in the Air Transport arena, particularly on long-haul pilots, there is a lack of information about fatigue in other areas, particularly where Flight Instructors are concerned, as they are not involved in Air Transport Operations.

This study examines the potential for fatigue in Flight Instructors in the General Aviation industry in New Zealand. To achieve this a Questionnaire and Time Diary were developed, based on previously used materials, and adapted for use in the flight instruction environment. This enabled the flight and duty times of Flight Instructors to be recorded, and subsequent investigation of any preventative strategies or operational countermeasures currently being used to help prevent fatigue. Interviews were also carried out, and compared with the data from the Questionnaire and Time Diary. The results of the research found that despite recorded flight times not exceeding any nominated safe limits, duty times did, especially for Flight Instructors that had secondary employment outside the aviation industry.

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Chapter One

INTRODUCTION

1.1 Background

The purpose of this study was to examine the flight hours and duty times of Flight Instructors working in the general aviation industry in New Zealand. These hours and times are an indication of the extent to which people may be flying while feeling tired or fatigued, and therefore whether their performance may be affected. While there is no legal limit to how many flight or duty hours a Flight Instructor can work in any one day or week, some organisations do restrict the hours that their staff work, in order to minimise the chance of fatigue. However other organisations are not so considerate. There are additional reasons, such as social factors that may make a Flight Instructor more inclined to work long hours, thereby losing sleep time, and becoming more susceptible to fatigue.

1.2 The Organisation of the Thesis

This chapter outlines the purpose and background of the study, and reviews the literature on the subject of fatigue and tiredness. Some of the previous studies conducted in this area are reviewed, and the laws surrounding flight and duty times of pilots are investigated. Chapter Two presents the method used in the research for the thesis and examines subjects, measurement tools, procedures, and sampling method. Chapter Three shows the results of the research, including data analysis, and the findings relating to the various research questions that were investigated. Chapter Four provides a discussion of the results, and highlights the limitations of this study. The final chapter draws conclusions from the study and some recommendations for further research are made.

1.3 A Changing Society

In today's consumer-oriented society, aviation is not the only industry that we

have come to rely on as being available at any time of day or night. Many different types of occupations and industries now rely on around-the-clock operations, including health care, public safety, service and manufacturing industries, military operations, and of course, transportation (Rosekind et al., 1994a). This means that the people working in these industries not only face the potential for loss of sleep, but are also expected to remain at high levels of alertness and accuracy for long periods of time. Unfortunately this often happens at the time of day when their bodies are winding down in preparation for sleep (Dinges, Whitehouse, Carota Orne, & Orne, 1988).

Our technology is continuing to develop and we have become a civilization that is heavily reliant on automation. We have designed machines that are so reliable and safe that it is often the human element that creates the safety risk (Fiorino, 2001). Aircraft have also changed greatly since their creation at the turn of last century. Advances in technology have made many improvements to the basic design. The changes in aerodynamics, engines, avionics, communication and navigation systems mean that today's aircraft bear only a passing resemblance to the original model, and they can take more passengers further, faster, in more comfort, safety and more reliably than ever before. This means that there are now very few places that we cannot travel to by aeroplane.

Despite all the advances in aircraft instrumentation and systems etc., the people that fly these machines have not physically changed. Humans still need regular sleep, the chance to adjust slowly to a new time zone, and their performance will still decrease if they get fatigued (Mann, 1999). Sleep is vital to our performance of any task and losing even one hour of sleep can affect how we feel and perform during the day (Rosekind et al., 1994a). In fact, at present there appears to be no substitute for a good nights sleep (Dinges et al., 1988).

1.4 Fatigue

Tiredness is experienced by all of us almost every day of our lives (Graeber, 1988; Lucas, Mackay, Cowell, & Livingstone, 1997), and may even be seen at times as acceptable and part of getting the task completed (Lucas et al., 1997). However this does not make it safe. The word 'fatigue' has different meanings to different people. We all talk about physical fatigue, mental fatigue, and emotional fatigue covering a wide scope of meanings (Stokes & Kite, 1994). People often use the term 'fatigue' to describe when they feel tired, make mistakes when performing tasks, or get short-tempered (Rosekind et al., 1994a). Another definition is that fatigue is a markedly reduced ability to carry out a task (Gander, 2001). In this study fatigue will be defined simply as a mental state (Edwards, 1990) that entails all the aforementioned feelings.

Pilots have always been acutely aware of the dangers of fatigue, even as far back as 1927 when Charles Lindbergh fell asleep crossing the Atlantic and woke to find himself slowly descending towards the water (Graeber, 1988). Many pilots have also heard the story of the pilot who fell asleep with the autopilot on, only to wake up two hours flying time from land with only one hour of fuel remaining. While this may be just an urban legend, no pilot with any sort of flight experience can deny having had to occasionally struggle with fatigue, or that it affected his/her performance in some way (Printup, 2001).

The National Aeronautics and Space Administration (NASA)¹ Ames Research Centre has done much work on pilot fatigue and its implications for aviation safety, and they created a program to collect systematic, scientific information on fatigue, sleep, performance in flight operations and circadian rhythms (Mann, 1999). In one NASA study, flight crew members were asked how often they felt that fatigue affected their performance during a typical trip. The common response was that crew members did consider that fatigue sometimes affected their performance (Gander, Rosekind, & Gregory, 1998e). One incident related how a pilot who was travelling as a passenger on the flight deck, flew a foreign

registered aircraft for which he was not endorsed around a bad section of weather, while the captain was sleeping (Hayward, 1999). Other long-haul pilots have admitted to nodding off in flight, or arranging for one pilot to nap in the cockpit while the other monitored the flight (Mann, 1999). The fact that this happens, despite regulations in some countries forbidding in-flight rest, means that there is a serious problem. It is not clear from the data currently available just how many of these unplanned naps are happening, and occurring in response to sleep loss and circadian disruption (Rosekind et al., 1994b).

It is now recognized that severe fatigue renders a person unable, as opposed to unwilling, to attain a sufficiently high or safe standard of performance (Gander, 2001). A pilot cannot simply overcome fatigue through motivation or discipline (Mann, 1999). Despite widespread evidence that fatigue occurs frequently enough to be a significant issue in many areas of the aviation industry, it is a difficult issue to deal with as it has many causes, potentially serious consequences, and is difficult to detect reliably and prevent or treat effectively (Mann, 1999). What makes fatigue especially dangerous is that it can often affect people before they are even aware of it, and a fatigued pilot can become quite indifferent to the outcome of a flight, and their operational performance while flying an aircraft (Hayward, 1999).

1.5 Causes of Fatigue

Four main areas that contribute to fatigue are job demands, work organization, human biology and life outside work. Job demands, such as workload and breaks, the duration of shifts, and the type of work can all contribute to fatigue. The time of day that work is taking place, rostering, and work predictability are all areas of work organisation that have an effect on fatigue. Fatigue is also affected by biological factors such as how much sleep a person has had, their body clock, and health and age. Finally, life outside work can have a large impact on fatigue. Things such as the standard of living, commuting to and from work, and family and friends can all make their own mark on our lives, and

¹ For a full list of abbreviations, refer to the Glossary, page 89.

how we feel.

If fatigue is perceived as only being a result of energy expenditure, it is hard to understand why a pilot could get tired doing a task like flying an aircraft. Energy-demanding tasks are easy to study for fatigue effects (Edwards, 1990), but after three or four hours of flying a pilot has generally used little energy, has been comfortably supported in a seated position, and on average, has used little mental energy. Still, the pilot feels more than just sleepy. After a long flight, perhaps exceeding eight hours in length, there is noticeable fatigue and performance can worsen considerably (Edwards, 1990). While it is still possible for a pilot to become physically fatigued, especially during an emergency when some of the mechanical systems fail, it is far more likely for designers to worry about mental, rather than physical overload (Kantowitz & Casper, 1988). It has also been found that a higher task load does not necessarily result in more fatigue (Samel et al., 1997). A Netherlands Aerospace Medical Centre paper said that pilot performance and alertness might be degraded by the effects of cumulative fatigue, night flights and monotony during cruise (Kenney, 1998).

Fatigue is closely interconnected to other problems in that it can be a symptom of them or it can be the cause (Printup, 2001).

1.5.1 Lack of Sleep

The most obvious cause of fatigue is lack of sleep (Brown, 1995; Printup, 2001; Rosekind et al., 1994b). Although there appears to be no comprehensive explanation as to why we sleep, thoughts on this area involve the fact that the brain may need time out to repair itself, and that something that was used up or lost requires replacing. Thus any loss or disturbance to our sleep can affect every aspect of how we function, including an increasing rate of errors, and poor performance (Edwards, 1990).

Our sleep cycle goes through four stages. Firstly approximately ten minutes of REM (rapid eye movement) sleep where the mind is still active (dreaming) and smaller muscles twitch. We then progress through another three stages where

the mind and body gradually slow down, and after about 45-70 minutes we return to REM. We cycle through these stages about five times a night, with the amount of REM sleep increasing in length over successive cycles (Edwards, 1990). Any disruption within a cycle will render it ineffective, and result in a less restful nights sleep (Printup, 2001).

Many different factors appear to affect the amount of sleep disruption a pilot encounters. Most adults accumulate a 5 to 7.5 hour sleep debt during a regular working week, but can make up for this sleep deficit by sleeping in at the weekend (Hayward, 1999). Unfortunately a pilot on a roster with long duty times may not have the chance to recover this lost sleep time. Age can also affect the amount of sleep loss experienced. With normal aging, sleep at night becomes shorter, lighter and more disturbed (Gander, De Nguyen, Rosekind, & Connell, 1993). Some studies have found that long-haul pilots aged 50-60 years old averaged 3.5 times more sleep loss per duty day than those aged 20-30 years (Gander et al., 1998a), or 30-40 years (Gander et al., 1993). The time of day that a pilot works also adds to disruption of sleep, and therefore fatigue. Duty rosters that involve night flying are associated with greater sleep loss than those that do not (Gander et al., 1998d; Samel et al., 1997). Duty periods ending in the morning lead to sleep loss due to the fact that pilots are trying to sleep when their biological time clock is telling them to wake up (Mann, 1999), and when other disturbances such as noise, light, domestic or other social demands are at their highest (Gander et al., 1998c). One Canadian study on Air Traffic Controllers found that while 19% of participants reported frequent difficulty sleeping at night, this figure increased dramatically to 63% during the day (Heslegrave & Rhodes, 1997; cited in Gander, 2001).

1.5.2 Circadian Disruption

Another major cause of fatigue is 'jet lag' (otherwise known as circadian disruption) (Brown, 1995; Edwards, 1990; Rosekind et al., 1994b). While artificial lighting allows us to have light at any time, our bodies are still mainly influenced by the natural light/dark cycle (Costa, 1999). Our bodies have a daily rhythm of temperature rise and fall, reaching a peak around 6pm, and a

low very early in the morning (Edwards, 1990). Other physiological changes that follow this temperature pattern are heart rate rhythms, speed of electroencephalographic (EEG) alpha waves, resistance to illness, resistance to bacteria and virus infection, response to allergens, speed of metabolism of drugs including nicotine and alcohol, sensitivity to pain, grip strength, reaction time, muscle coordination, and various simple mental skills (Edwards, 1990). This pattern of changes is often referred to as our time clock or body clock, and is actually a paired group of nuclei in the base of the hypothalamus, called the suprachiasmatic nuclei (SCN) (Waterhouse, Reilly, & Atkinson, 1997). Travelling across time zones gives a contradictory pattern of environmental time cues to this body clock and 'jet lag' is a temporary dissociation between environment (local time) and body (internal clock) (Waterhouse et al., 1997). A person may be trying to get to sleep when their mind is wide-awake, and conversely they may be trying to stay awake when their mind is asleep (Printup, 2001). Different people suffer differently, but symptoms include fatigue (yet the person can't get to sleep at the new night time), headache, irritability, loss of concentration, and indigestion, loss of appetite and bowel irregularities (Waterhouse et al., 1997). There is even some evidence that as a person gets older, their circadian rhythm shifts to an earlier phase position in the cycle (Gander et al., 1993). Many studies have also suggested that morning-type people have more trouble adapting to shift-work and time zone changes than evening-types (Gander et al., 1998d), thereby making them more susceptible to fatigue. This is probably because their rhythmic rise in body temperature starts up to two hours earlier than for evening-types. They have less of a problem, however, in dealing with early morning activities (Costa, 1999). All these points are of particular concern to long-haul pilots and the physiological challenges for these flight crews are very complicated.

One interesting point to note is that if travel is required across time zones, travel in a westerly direction is preferable to travel in an easterly direction. Under normal circumstances our body clock is being continually reset to a 24-hour length by Zeitgebers (time givers) (Waterhouse et al., 1997). When we travel in a westerly direction, the duration of a day is lengthened, and our body seems to

prefer a delay in its circadian rhythm (referred to as a phase delay) rather than trying to shorten the cycle (phase advance) (Stokes & Kite, 1994). This is most likely due to the fact that our natural body clock actually sets itself to a day of about 25 hours or more in length when not provided with any external time cues. This is called free-running (Edwards, 1990; Stokes & Kite, 1994). Because of this, a westerly direction of travel has been associated with fewer sleep difficulties (Edwards, 1990). One study found that it required 13 days to completely adjust the circadian rhythm after a change of six time zones in a easterly direction, but only 10 days when the same change was made in a westerly direction (Wegmann & Klein, 1985, cited in Costa, 1999). The travel itself has no effects on the circadian rhythm, and this has been confirmed by tests involving flights in a north and south direction, without any time zone changes (Edwards, 1990).

1.5.3 Shift Work

The issue of fatigue is not limited to the aviation industry, as there is usually no distinction between shift work and extended duty hours when comparing fatigue-related issues (Benoff, 2001). In 1994 it was estimated that one in five American workers was involved in shift work, doing some form of altered or non-standard work schedule (Rosekind et al., 1994a). Given societal changes over the past ten years, this number is most likely to have increased, and this increasing number of people must work at times that conflict with their circadian rhythms (Graeber, 1988). These people are exposed to major disruptions in their physiology, social activities and family lives in much the same way that pilots flying long-haul flights are. Shift workers can experience feeling such as fatigue, sleepiness, insomnia, digestive problems, poorer mental agility, and impaired performance, with sleep often being of lesser quantity and quality (Costa, 1999). Eating habits are often disrupted, and the quality of food is likely to decrease. Likewise the intake of stimulants such as coffee, tea, alcohol, and tobacco smoke also tends to increase, all of which has a negative effect on the digestive and cardiovascular functions (Costa, 1999). The major physical changes are as a result of sleep loss and circadian disruptions, just like pilots (Rosekind et al., 1994a). If a person is exposed to these conditions for

extended periods of time, they may start to have permanent and severe sleep problems, and possibly changes in behaviour. These behavioural changes, such as persistent anxiety or depression, often need to be treated with drugs (Costa, 1999).

In the UK it was decided that there needed to be a change in policy for railway safety critical staff, and they developed an approach for scheduling shifts based on assessing different risk factors (Lucas et al., 1997). This method gave fatigue ratings for six aspects of working time patterns, which were then added together to give a 'fatigue index'. If it was too high, this index indicated the need for working times to be changed. A concern was that there could be an inclination to manipulate numbers rather than try and understand the problem of fatigue (Lucas et al., 1997).

1.5.4 Other Causes

Other factors that may cause fatigue are stress, anxiety, and poor health (Printup, 2001). Medication can also contribute to fatigue, and in turn affect motor and mental performance (Edwards, 1990). Also, the fact that pilots often consume more caffeine and snacks but have fewer meals during duty times, especially on long-haul flights, could contribute to their fatigue (Gander et al., 1998d).

Long-haul pilots are not the only members of the aviation industry who face the problem of fatigue. In a survey of Licensed Aircraft Maintenance Engineers (LAMEs) in Australia in September 1998, it was found that these personnel were most likely to refer to issues of pressure, fatigue, coordination and training when describing why occurrences had happened (Hobbs & Williamson, 1998).

1.6 Symptoms of Fatigue

Fatigue can be the symptom of other problems such as hypoxia and dehydration (Printup, 2001), and how much we suffer from fatigue will often depend on our physical and mental health and also vary from task to task

(Edwards, 1990). The symptoms of fatigue are many and varied, and may differ from person to person, and even differ in the same person on different occasions. A pilot may succumb to many symptoms of fatigue while pushing the plane back into the hangar after a long flight, or a long day at work, but fewer symptoms of fatigue may be needed to feel the same way when, for example, doing chores around the house (Edwards, 1990).

Common symptoms include a feeling of indifference to one's performance, increased reaction time, a decreased ability to concentrate on multiple tasks, fixation, short-term memory loss, impaired judgement, impaired decision-making ability, sloppy flying skills, reduced visual perception, loss of initiative, personality changes, and depression (Printup, 2001). In an aircraft cockpit this can lead to many different errors, such as misunderstanding an Air Traffic Control (ATC) clearance, missing an item on a checklist, or inverting frequencies (Fiorino, 2001). It can make a pilot less attentive, more likely to gloss over inferior performance, and show signs of bad judgement. Symptoms such as impaired memory or inability to process information may lead a pilot to find it increasingly difficult to make decisions, and they may have to recheck information several times (Hayward, 1999). Alertness and physical and mental reaction times can be decreased. Bad temper and mood changes can easily block communication and hamper Crew Resource Management (CRM) principles in a two-pilot environment, such as during flight training with a Flight Instructor and student (Hayward, 1999). Inconsistency and unpredictability in completion of tasks, making more errors despite trying harder during a task, being preoccupied with a single task or fixed on a single source of information, and perseverance with unsuccessful solutions, may all signify fatigue (Hayward, 1999).

Where fatigue is due mainly to a lack of sleep it would appear that the body responds by initially allowing decreasing performance on secondary or non-safety critical tasks, such as having an increased reaction time, and reduced task management strategies. It does this to try and protect a high performance standard on primary or safety-critical tasks (Fairclough & Graham, 1999;

Hockey, Wastell & Sauer, 1998). This is through a raising of a person's level of arousal, as initially a sleep deprived person is at a relatively low level. The effect of this stress is to increase their arousal, and therefore their performance (O'Hare & Roscoe, 1990).

1.6.1 Sleepy or Drunk?

Research at NASA Ames Research Institute has shown that a person who is deprived of sleep for 18-20 hours will act and perform as if they have had two or three beers. They behave with a "punchy" attitude, have longer reaction and response times, reduced motor skills, and impaired thinking (Hayward, 1999). The longer they remain awake, the worse these symptoms get. Similar results were found in a University of South Australia study. After 17 hours of wakefulness, there was significant impairment on a hand-eye coordination task, which was equivalent to a blood alcohol content of 0.05% (Benoff, 2001). After 24 hours this had doubled to 0.1%.

1.6.2 Microsleeps

A natural compensation for fatigue and loss of sleep is spontaneous napping, or microsleeps. These are a brief period of loss of awareness and failure to respond to external stimuli (Samel et al., 1997; Rosekind et al., 1994b). It has been found that regardless of training or a pilots professionalism, extreme sleepiness can lead to uncontrolled and spontaneous sleep (Hayward, 1999). One of these during any flight, even as short as one to ten seconds in length, can have extremely serious consequences (Edwards, 1990; Stokes & Kite, 1994). Microsleeps were also found in a study on fatigue symptoms in overnight driving (Summala, Hakkanen, Mikkola, & Sinkkonen, 1999). They were found to be likely to occur in the early morning hours, and it was advised that they should be used as early warning signals of extreme sleepiness.

1.6.3 Differences Between Sexes

There do not appear to be any differences between males and females with regard to how people respond to disruptions in circadian rhythms. However women occupied in work involving irregular shifts or night work do show a

higher incidence of menstrual disorders and fertility problems (Costa, 1999). It is also thought by some that female shift workers may have to endure more demanding living conditions with respect to higher work loads and time pressure associated with additional domestic duties. For example it has been found that women with children show greater sleep problems and consequently have higher cumulative fatigue. Therefore women may be affected differently with respect to adjustment and tolerance to irregular working hours (Costa, 1999).

All of the symptoms previously mentioned have the potential to create careless, and therefore unsafe flying (Hayward, 1999).

1.7 Social Factors That Contribute To Fatigue

Theoretically, pilots have the unquestioned right to declare they are too fatigued to continue a flight safely. However other real-world pressures, such as that placed on them by employers, mean that they do not always do this. As well as looking at eliminating the symptoms of fatigue, we must therefore also realise that there are professional and social factors that help to create an environment where people become susceptible to fatigue (Benoff, 2001). Some factors found during a study of maintenance technicians in Australia, included pressure to increase aircraft utilisation, competition between maintenance organizations, increased financial expectations of technicians, management's pressure to limit the number of employees and its perceived value of high work hours and flexibility (Benoff, 2001). All of these factors could just as easily be applied to any part of the aviation industry, including flight instructing. Of all the factors mentioned, flexible, or irregular hours were found to have the greatest impact on technician fatigue. Flexible rosters can be very beneficial to any organization, however many employers have little knowledge of the impact that this type of system can have on employees and the resulting fatigue that may arise, no matter how enthusiastic the person (Benoff, 2001).

Another social factor that can result in fatigue is the amount of time spent at

work. It has been proven that when people work more than 50 hours per week, both sleep and daily activities begin to adversely compete for the same 24 hours, and a person's decision-making process may be affected. Additionally, the more a person works during night hours, the more sleep that person requires to recover (Benoff, 2001).

Finally, it can just become a simple question of money. People often want more than they really need or can afford, but aviation is not a cheap industry to be involved in. Flight tests, theory exams, and maintaining currency in flight hours and aircraft types can be very expensive. Many kinds of interventions, aimed at compensating for shift and night work inconveniences, have been introduced in recent years, however the main one has been monetary compensation (Costa, 1999), which can have a dangerous masking function. Spending more time at a paying job inevitably ends up cutting into sleep time (Benoff, 2001).

1.8 How Fatigue Negatively Affects Performance

Today many safety critical operations frequently need round-the-clock operations, and fatigue is increasingly recognised as a significant problem for a wide variety of such industries (Lucas et al., 1997). If round-the-clock services are to be provided to long-distance travellers, then circadian rhythms will inevitably be disrupted. This can negatively affect the performance of pilots in two ways. Firstly, it may require flight crews to be on duty during part of the circadian cycle when their performance capacity and alertness are at their lowest, and when fatigue and physiological sleepiness are highest. This is when people are most likely to make mistakes (Gander et al., 1998b).

Secondly, it may require flight crews to try and sleep during parts of their circadian cycle when sleep quality and quantity will be low, and as a result their performance when awake is also lowered (Gander et al., 1998e). It is particularly evident at night, when a decrease in performance has been reported in many different areas of work involving irregular work schedules (Costa, 1999). A higher frequency of errors and accidents was found in train

and bus drivers during this time, and air traffic controllers have described 'night-shift paralysis' as a serious concern. This is where there is a sudden inability to move certain muscles during consciousness, and occurred in about 6% of subjects during one study, and mostly around 5am (Costa, 1999). A study involving measurements of pattern recognition, spatial orientation, reasoning and reaction time found that performance was worse on night shifts than on evening or day shifts (Heslegrave & Rhodes, 1997, cited in Gander, 2001).



Figure 1: View of an aircraft cockpit during night operations.

It has been found that tasks requiring prolonged concentration and quick reaction times are especially susceptible to the effects of too little sleep (Stokes & Kite, 1994). For example, during a flight under Instrument Flight Rules (IFR) where an aircraft may be operated without an external reference, such as while inside cloud, the pilot must continually scan the instrument panel and respond immediately to a variety of cues.



Figure 2: (Left) View outside the aircraft during operations under IFR. (Right) View of the aircraft cockpit instrument panel.

During a flight operated under Visual Flight Rules (VFR), where the aircraft must be operated with external references, the pilot must continually monitor the airspace around the aircraft so as to avoid collisions and keep within their designated airspace. Both of these tasks become very challenging and may be compromised if the pilot is suffering from a lack of sleep (Stokes & Kite, 1994).

Other ways that performance is affected is by a slowing of mental tasks, a loss of motivation and willingness to perform, and in some studies an increase in hostility was reported (Petrie & Dawson, 1997). A progressive deterioration of working memory, sensory acuity and motor speed has also been found (Stokes & Kite, 1994). Fatigue degrades many different cognitive abilities, including vision and perception, memory, performance monitoring, error management, decision-making, motivation and attitudes, communication, and the ability to cooperate (Hayward, 1999). These sorts of symptoms have been noted in field studies of sleep deprivation as well as in some laboratory studies (Petrie & Dawson, 1997). In spite of how a pilot may feel, NASA research has clearly shown that long hours of work with no breaks can steadily and measurably reduce a pilot's performance (Hayward, 1999).

Not only does fatigue affect performance at work but can also have some quite dangerous effects in other areas of our daily lives. For example one study found an association between consecutive midnight shifts worked by Air Traffic Controllers and reports from workers of falling asleep while driving to or from work (Gander, 2001).

1.9 Accidents

There are many documented accidents that can be at least partly attributed to fatigue (Printup, 2001), and studies have shown there is a cause and effect link between pilot fatigue and errors or accidents (Waterhouse et al., 1997). Fatigue has been cited as contributing to the Exxon Valdez and World Prodigy maritime disasters. It was also a factor in the nuclear accidents at Three Mile Island and Bhopal. Additionally, it was found to have affected the decision-

making process of the fatal space shuttle Challenger mission (Printup, 2001; Rosekind et al., 1994a). The possible effects of sleep loss, excessive duty shifts, circadian or daily rhythm effects, and the resulting fatigue, all had a negative impact on the decision to launch the shuttle in spite of concerns about its safety (Hayward, 1999). There have also been numerous other accidents where fatigue is most likely a factor, which involved aircraft that we can more easily identify with. For example American Airlines Flight 1420 which in June 1999 overran the end of a runway, killing 11 people and sustaining numerous injuries among the other 145 passengers and crew; Korean Airlines Flight 801 which had controlled flight into terrain (CFIT) in Guam in 1997, killing 227 people; in August 1993 a Connie Kalitta DC-8 crashed just before landing; a captain of a 707 left a 60-foot-long gouge in the runway at Salt Lake City after trying to manoeuvre his plane while too low to the ground; the crew of a Learjet killed themselves and their passenger while on approach to Gulkana, Alaska; and so the list could go on (Printup, 2001).



Figure 3: An aircraft that overran the end of the runway.

In the United States, the National Transportation Safety Board (NTSB) has found fatigue to be a causal or contributory factor in accidents in every mode of transportation and has issued almost 80 fatigue-related safety recommendations since 1972 (NASA, 1995, cited in Lucas et al., 1997). In the aviation industry the numbers look even worse. As far back as 60 years ago, about 70% of aircraft accidents were thought to have been caused by the human element in aviation. With the increased reliability of today's aircraft, there are some who would support the statement that up to 100% of accidents are now caused by human error (e.g. Hayward, 1999). In 1980 a study

analysed NASA's Aviation Safety Reporting System (ASRS) database for air transport crew error reports that were directly attributed to fatigue. They found that only 3.8% qualified. However it was thought that this relatively small proportion most likely underestimated the frequency of fatigue-related errors, because fatigue was considered to be a personal experience (Graeber, 1988). It had also been suggested that accident reports would tend to under-represent the seriousness of the problem since fatigue was so often inferred from circumstantial evidence (Brown, 1995; Stokes & Kite, 1994). Other factors cited in the ASRS reports, for example inattention and miscommunication, could themselves have resulted from fatigue (Stokes & Kite, 1994). This sort of reporting could have also resulted from the widespread idea that fatigue was not an acceptable excuse for mistakes, because flying when tired is so much a part of the pilot's line of work (Graeber, 1988). The number of incidents in the ASRS database that could be directly attributed to fatigue increased to 21.2% when it included all reports that mentioned factors directly or indirectly related to fatigue (Gander et al., 1998a; Graeber, 1988; Stokes & Kite, 1994). A further sobering thought is that there is no record of how many pilots suffering from fatigue did not have accidents over this time, and so did not get included in any statistics (Stokes & Kite, 1994).

Fatigue is often the cause of pilot error and it is therefore often the final link in the chain of events leading to an accident. It is often the reason that pilots do not make the right decisions or fly as well as they could (Printup, 2001). However, human fatigue does not leave behind any signs and we can only conclude its occurrence from secondary evidence (Brown, 1995). For example, on August 18, 1993, at 1656 eastern daylight time, a military contract flight with a highly experienced crew crashed into level terrain approximately 400 meters west of the runway threshold while attempting to land at the United States (U.S.) Naval Air Station, Guantanamo Bay, Cuba. The aircraft was destroyed by its impact and a subsequent fire, and all crew sustained serious injuries (Hayward, 1999; Rosekind et al., 1996). The crew had been on duty for almost 18 hours at the time of the accident. Based on its research into sleep and circadian rhythms the NASA Ames Fatigue Countermeasures Program

identified four factors to be examined in any accident or incident. These are: 1) acute sleep loss/cumulative sleep debt, 2) continuous hours of wakefulness, 3) time of day/circadian effects, and 4) presence of sleep disorder (Rosekind et al., 1996). Based on the findings from its investigation, the NTSB determined that the probable cause of this accident included impaired judgement, decision-making, and flying abilities of the captain and flight crew due to the effects of fatigue. Additional factors were the inadequacy of the applicable flight and duty time limitations, and the corporate circumstances that led to extended duty time and resultant fatigue of the crew members (Hayward, 1999). This was the first time in a major U.S. aviation accident that the NTSB cited fatigue in the Probable Cause section of the accident report, rather than just as a contributing factor in the Additional Factors section (Hayward, 1999; Printup, 2001; Rosekind et al., 1996).

Any incident or accident is a result of a chain of events and that's why fatigue is so dangerous (Fiorino, 2001), as any small slip has the potential to evolve into something much bigger and much worse. Because of the potential for major loss of life, it is crucial that the extent and impact of fatigue in flight operations be understood. Strategies and countermeasures need to be developed and evaluated to determine which methods will maximise pilot performance and alertness and help to maintain a satisfactory margin of safety (Rosekind et al., 1994a).

1.10 Fatigue Field Studies

1.10.1 Subjective Symptoms in Pilots Reporting High Fatigue Levels

At present there appears to be a lack of basic information on how pilots subjectively experience fatigue and monitor their own levels of tiredness in daily aviation operations. Some studies have suggested that pilots reporting high levels of fatigue may use different sensations to monitor when they are tired. Some important research has been carried out by Petrie and Dawson (1997) in this area, to help identify whether pilots who report high levels of fatigue during a duty use the same types of subjective experiences for monitoring their

tiredness as other pilots. It was found that pilots who reported that they were very fatigued were more likely to notice cognitive disturbance symptoms of fatigue, such as flight planning problems, feeling confused, becoming forgetful, and feeling mentally slow. They were also much more likely to report emotional symptoms, like feeling nervous and irritable. Operationally, these pilots were more likely to use energy planning as a strategy for coping with fatigue during a flight. Unfortunately this study was not able to confirm whether these pilots who were reporting high levels of fatigue were more sensitive to a wider range of symptoms than other pilots, or whether they attributed sensations unrelated to fatigue to their feeling of tiredness.

1.10.2 NASA Ames Research Center

One of the main places of research into fatigue in pilots is the NASA Ames Research Center. In 1980 this organisation held a workshop to look into whether circadian rhythm disruption was of concern. They concluded that there was a safety problem due to transmeridian flying and a potential problem with fatigue in air transport operations (Rosekind et al., 1994a). The NASA Ames Fatigue/Jet Lag Program (now called the Fatigue Countermeasures Program) subsequently developed a research program on flight crew fatigue (Gander et al., 1998a). The program had three goals: to determine the extent of fatigue, sleep loss, and circadian disruption in flight operations; to determine the impact of these factors on flight crew performance; and to develop and evaluate countermeasures to lessen the adverse effects of these factors and to maximise flight crew performance and alertness (Rosekind et al., 1994a). From initial investigations it became clear that, although there was already some potentially applicable information in the scientific literature, it was not readily accessible to the aviation community, regulatory authorities, and the flying public. Also, this research was to be carried out in the cockpit during real flight operations, as information gathered by previous research was primarily based on laboratory studies, and there was no thorough work on the effects of real flight operations on sleep, circadian rhythms, and subjective fatigue, or on the consequences for cockpit performance (Gander et al., 1998a). Unfortunately, although field studies may more precisely imitate conditions encountered in the

real world, they are difficult to conduct because research procedures must not hinder normal standard operating procedures or jeopardize safety. It is also virtually impossible to control all potential causal variables outside the laboratory (Rosekind et al., 1994a).

Initial field studies examining the extent of fatigue, sleep loss, and circadian disruption in flight crew, utilised a combination of self-report and physiological information. The self-report section included a background questionnaire, and a pilot's daily logbook. The background questionnaire collected demographic data and information on flight experience, sleep, nutritional habits, exercise and other lifestyle variables, and general health. It also included some standardised surveys, such as that for personality style. Crew members also documented their daily activities in a logbook. The pilot's daily logbook contained information about flight and duty times, sleep quantity and quality, mood, meals, exercise, physical symptoms, and comments (Rosekind et al., 1994a). Every two hours while awake the crew members rated their subjective fatigue. Disruption of sleep and circadian rhythms were looked at particularly closely, as these are the two major physiological causes of fatigue. Other things that were recorded were subjective fatigue and mood, changes in diet, and reports of physical symptoms (Gander et al., 1998e). Physiological variables that were recorded included core body temperature, heart rate, EEG, electro-oculographic (EOG), and electromyographic (EMG) activity (this information allows a detailed analysis of sleep variables).

NASA conducted studies in three main areas of the aviation industry that are of interest to this thesis: long-haul flights, defined as flights of more than eight hours in duration, short-haul flights with a flight time of less than eight hours, and overnight cargo operations. They investigated the effect that these different operations had on the pilots (Rosekind et al., 1994a), and it was found that pilots on all types of flights could be susceptible to fatigue.

Long-haul pilots were most prone to fatigue through crossing many time zones and having long flight times (Gander et al., 1998d). Long-haul pilots also had to

contend with circadian disruption, and although the time during a layover may be sufficient for an adequate length of sleep, the body has its own physiologically and environmentally preferred time to sleep. Therefore the time available for sleep may in fact be much less than the off-duty time available (Rosekind et al., 1994a). This was also found in a German study that investigated long-haul pilots and their sleep and fatigue. Layovers that involved sleep during the day time generally had pilots sleeping less and the quality of their sleep was reduced (Samel et al., 1997). This would make pilots more vulnerable to fatigue on subsequent duty periods, as they would be starting the flight not fully rested. This was confirmed by fatigue and stress effects being more pronounced during the return journey (Samel et al., 1997). It was also common for pilots to go to bed very soon after returning from extended duty periods, however it did take several days for them to fully recover from the sleep deficits encountered while away (Samel et al., 1997).

Short-haul pilots were most at risk of fatigue through having long duty days, sleep loss as a result of short night-time layovers and shortened sleep episodes due to progressively earlier report times across trips (Mann, 1999), and flying many flight sectors (Gander et al., 1998b). Takeoff and landing are the two phases of flight with the highest workload, so any duty involving multiple takeoff and landings might be expected to have a cumulative effect on the fatigue and performance of short-haul pilots. They also found that during short-haul flights, the flying pilots' heart rate increased during descent and landing, and that this increase was greater under IFR than under VFR conditions.

The pilots flying overnight cargo operations worked less hours per day than daytime short-haul pilots, but their sleep was generally of much shorter duration, and was frequently separated into multiple episodes, instead of one consolidated sleep (Gander et al., 1998c). These frequent awakenings were also found in another study on pilots flying long-haul two-crew night operations (Samel et al., 1997). Duty times ending in the morning, and subsequently trying to sleep while the body is receiving signals to wake up also lead to sleep loss (Mann, 1999). The overnight cargo pilots also reported more negative moods

and greater fatigue on days when they were working, compared to days that they had free of duty (Gander et al., 1998c). In general, circadian disruption and loss of sleep have been found to be the major factors responsible for fatigue during night flights (Samel et al., 1997).

1.10.3 Planned Napping

Some research was also carried out on the effect of planned napping to help reduce sleep loss, and improve levels of performance and alertness, especially during critical phases of flight such as descent and landing (Rosekind et al., 1994b). In this study a Rest Group was allowed a planned 40-minute rest period during the low-workload, cruise portion of the flight, while over water. The limited duration of the nap was important in order to minimise the possibility of crew members entering into deep slow-wave sleep, and thus being prone to sleep inertia should they have to be wakened in an emergency (Gander et al., 1998e). Sleep inertia occurs in the time just after waking up, and results in a measurable decrease in alertness. The Non-Rest Group showed a decrease in performance across flight legs, and within flights, whereas the Rest Group maintained consistent levels of performance. These findings suggest that the planned nap prevented deterioration of vigilance performance, and there was increased physiological alertness following the rest period (Rosekind et al., 1994b). Two potential negative effects of naps were reported. The first, sleep inertia, is the grogginess, disorientation and sleepiness that can accompany awakening from a deep sleep, and this can be associated with initial performance decrement immediately upon waking. Other effects such as a reduction in reaction time, memory ability, and decision-making skills are also common. The duration of the effects of sleep inertia vary from a few minutes to over 30 minutes, and can be affected by duration of deep sleep, the abruptness of awakening, and circadian time of the nap. This can be very dangerous as although the pilot may appear awake, they may not be cognitively awake. There is some evidence that suggests that things such as bright lights, loud noise, physical exercise and washing your face in cold water may minimise the effects of sleep inertia (De Landre, Boag, & Fletcher, 2003). The second negative effect found was that a long nap at certain times of the day could

disrupt the quantity and quality of later sleep periods (Rosekind et al., 1995).

1.10.4 In-flight Activity Breaks

As well as napping, studies were done to assess the effect of brief activity breaks during the flight on alertness and performance. During a flight, flight crews took a brief rest period each hour, involving social interaction and mild exercise. The participants who received this rest break showed improved physiological alertness for at least 15 minutes, and significantly greater alertness for up to 25 minutes after the break, relative to a group of participants who took no break (Neri, Mallis, Oyung, & Dinges, 1999, cited in Mann, 1999).

Research into the areas of fatigue and other related issues such as napping, crew alertness and sleep inertia is currently being coordinated by an international safety group, the Flight Safety Foundation (De Landre et al., 2003). A large group of safety specialists from many different countries are working collectively to develop guidelines for ultra-long range (ULR) flights. These flights can involve duty times of 18-22 hours. The specialists come from many different areas of the aviation industry, including representatives from international airlines, pilots, flight attendants, scientists, civil aviation authorities, and aircraft manufacturers. The aim of this group of specialists is to develop operational guidelines and strategies for ULR flights to gain optimal crew alertness and minimise crew fatigue (De Landre et al., 2003).

Other current research is looking into areas such as examining on-board rest facilities for crew to determine the quality and quantity of sleep obtained, and the feasibility of a video-based automated system for detection of drowsiness on the flight deck (Mann, 1999). Future research is likely to include the effects over months and years of sleep loss and circadian disruption on safety, performance, productivity and health (Rosekind et al., 1994b). Also, much of the initial research was conducted when three person crews were required to operate large aircraft on long-haul flights. With advances in technology most aircraft now only require two people on the flight deck, and this could change some of the findings of past research (Samel et al., 1997). Finally, compared to

long-haul flying only a small number of studies have been done on short-haul commercial flying (Graeber, 1988), and even less on general aviation. The incidence of fatigue in general aviation has not received anywhere near the level of attention that fatigue in commercial aviation has received.

1.11 Preventing Fatigue

The findings from field studies of fatigue in different operations highlight the fact that operational demands vary throughout the aviation industry, as does the way individuals respond to these demands. This makes finding one universal solution to the problems associated with fatigue in aviation very difficult (Gander et al., 1998e). Fatigue is a problem with diverse causes, requiring a multi-faceted and comprehensive yet integrated approach, and it should be evident that no single method can eliminate fatigue as an issue from aviation and other around-the-clock operations (Mann, 1999). Fatigue should also be viewed not just in terms of long hours, but instead as a whole pattern of work and rest (Feyer & Williamson, 1995).

Countermeasures to reduce the potential impact of fatigue in flight operations can be divided into two categories: preventative strategies which are used prior to a duty and during layovers; and operational countermeasures which are used during a duty period and in-flight to help crew members maintain their alertness and performance (Gander et al., 1998a). Of course any method used to prevent fatigue should ideally be convenient, readily available, and have no side effects (Waterhouse et al., 1997).

1.11.1 Duty Time and Scheduling

Given the aviation environment of today, pilots should be able to perform tasks safely and efficiently at all times of the day or night (Graeber, 1988). Unfortunately the most advantageous scheduling of work and rest is not always possible due to the intensity and unpredictability of flight operations (Caldwell, Smythe, Leduc, & Caldwell, 2000), and the universal duty roster is fast approaching the mental and physiological limits of the minimum required crew.

Sound scheduling practices should include scientific information about sleep, fatigue, and circadian rhythms, in addition to other factors, in creating and evaluating flight crew schedules (Mann, 1999). The manner in which different age groups and circadian types of pilots react to sleep loss and fatigue may also need to be taken into consideration (Gander et al., 1993). Any scheduling should also include, if possible, concern about the direction of the flight, and how this affects the length of the day the pilot encounters. It appears that it is easier to move from a morning to evening, or from evening to night shift, as it takes less time for the biological rhythms to move in this direction (Edwards, 1990). Length of duty times also needs to be considered. One German study found that in principle, the flight duty period of the pilots exceeded the standard duty time, as stipulated by law (Samel et al., 1997). Prolonged transfer times between airport and accommodation, and time for hygiene and meals, all reduced the chance of having enough time for adequate sleep.

1.11.2 Naps

Planning to get enough sleep before a trip is the most obvious step in reducing pre-duty fatigue (Printup, 2001). However sleeping during a shift can also be used to good effect. Although this is not approved while in flight in most airlines, studies show that naps can acutely improve alertness and should be taken when a person feels sleepy, bearing in mind that it should also be at an appropriate time. It has been shown that performance does benefit from a nap, no matter when in a long duty it is taken (Dinges et al., 1988), and using earplugs and eye masks can help a person to sleep outside of their normal times. It is important to keep the duration of the nap to within 30-40 minutes, in order to avoid the sleep inertia that is associated with awakening out of a deep sleep (Hayward, 1999). It should be noted that although a nap can improve performance, the beneficial effects are limited, and it does not necessarily improve the mood of the person (Dinges et al., 1988). NASA researchers contend that no nap is too short and that some sleep is better than no sleep (Hayward, 1999). Another finding is that having a nap during the day when feeling sleepy does not appear to diminish the amount of subsequent night time sleep (Stokes & Kite, 1994).

1.11.3 Drugs

Another area in the promotion of alertness that has had much research done on it is the use of drugs. Although various substances have been shown to improve performance at mental tasks, they also often reduce the ability to initiate and sustain sleep, and this may be counterproductive (Waterhouse et al., 1997). The negative side effects of some substances also need to be taken into account (abuse with amphetamines; decision making and psychomotor performance are compromised with caffeine) (Waterhouse et al., 1997).

There is a normal daily rhythm of melatonin secretion, beginning at approximately 2100 hours, and finishing at approximately 0800 hours. The oral administration of this hormone at times outside this has been shown to be able to change the phase of the body clock (Waterhouse et al., 1997), either advancing or delaying it depending on the time of day it is taken. This results in a reduction in the subjective symptoms of jet-lag and can improve sleep. Unfortunately it also has a side effect of lowering body temperature, and there is the possibility of other still unknown side effects (Waterhouse et al., 1997).

Caldwell et al. (2000) performed a study in a simulator using the drug dextroamphetamine sulfate (Dexedrine[®]), a powerful central nervous system stimulant that improves alertness and postpones the need for sleep. They found that subjects administered Dexedrine[®] showed improved aviator performance and alertness during periods of extended wakefulness. In fact the pilots maintained an adequate flight performance for up to 58 hours, without clinically significant side effects. Participants were also aware of the adverse affects of sleep loss on their performance, even though this performance decline was minimal in those who were administered the drug. One interesting side effect that did get mentioned was that those subjects on Dexedrine[®] became much more talkative, with one subject talking almost non-stop during the flight. The simulator console operator (an experienced standardisation instructor pilot) was asked if this subject had become dangerous, but he said that although the subject was annoying, his performance was not dangerous or reckless, other than the fact that he might miss some detail because of his

involvement in conversation. While this is not normally a problem, it could become of concern during certain stages of flight, particularly if something safety critical was missed. The mood of all subjects deteriorated over time, except that those on the placebo reported feeling more angry than those on Dexedrine[®]. The recovery sleep of those on the placebo was deeper as well as less disturbed than those subjects who were on Dexedrine[®]. Although this drug is no replacement for a good nights sleep, its positive effects on alertness could have a marked difference in aviation operations requiring long duty times and sustained vigilance. However, it was also noted that the use of this drug should be strictly controlled, and warned that it is no substitute for restful sleep.

1.11.4 Alcohol, Diet and Nutrition

Alcohol is often considered an aid to sleeping, but NASA studies have shown that this is not the case. One study on short-haul pilots found that they consumed three times more alcohol while away on trips than when they were at home. A drink was used to help the pilots unwind after long days and early start times. In fact alcohol actually disturbs the normal pattern of sleep by suppressing the REM cycle of sleep, so the time spent at rest is not as useful to the body for recuperation (Hayward, 1999).

Similarly coffee is consumed by many people to help them keep alert and awake. While the caffeine in coffee is a stimulant, it is also a diuretic, which results in dehydration, and this along with the fact that it also has withdrawal symptoms can lead to fatigue (Printup, 2001). It also initiates an insulin reaction that may leave the pilot with a minor case of low blood sugar after the initial energy rush (Benoff, 2001).

The diet of a pilot is often not nutritionally balanced, with a large intake of snack foods and carbonated drinks. However, when no alternative is available this food can help to stave off or even reverse the effects of hypoglycemia, which can cause fatigue. Of course in the long term a healthy diet is much more preferable, and pilots can help by packing their own meals or buying alternative foods to chocolate bars and chips (Printup, 2001).

1.11.5 Exercise

Some pilots have found that exercise helps them cope better with fatigue, although the research on this matter seems divided. In 1976 Lubin, Hord, Tracy, & Johnson (cited in Angus, Heslegrave & Myles, 1985) found that moderate and regular exercise did have a positive result on the effect of sleep deprivation. However in a later study, Angus et al. (1985) found that there was no difference between an exercise group and non-exercise group, in terms of their ability to perform tasks demanding vigilance or complex cognitive skills, or in their subjective states. More recently though, another study that focused more on the physiological symptoms of circadian disruption found that there was a phase-advance shift of one of the circadian factors and sleep-wake patterns following outdoor exercise, both of which helped to hasten resynchronisation of the body clock to a new time zone (Shiota, Sudou & Ohshima, 1996). Caution should be taken, though, with the timing of any workout, and it should be completed in plenty of time for rehydration of the body prior to reporting for duty.

1.11.6 Other Methods

There are several other methods that have been tested with regards to preventing circadian disruption on long-haul flights, and thereby reducing fatigue. These include the use of bright lights (Waterhouse et al., 1997), based on the observation that bright light in the morning advances the body clock, while bright light in the evening delays it. Changes to aircraft or cockpit design have been investigated, however since the operation of the aircraft does not contribute critically to task and workload this would not improve the situation regarding fatigue (Samel et al., 1997). Methods such as exposure to cold air or noise have been found to be virtually ineffective to promoting alertness and reducing the perception of fatigue (Caldwell et al., 2000). Dehydration can hasten the onset of fatigue, and as the cockpit of an aircraft often has very low humidity (particularly in larger passenger aircraft) pilots should ensure that they take in plenty of fluids to prevent this (Printup, 2001).

1.11.7 Education

Of course the success of any operational fatigue countermeasure ultimately depends on individual flight crewmembers. Mark R. Rosekind, president and chief scientist of a California-based scientific consultancy, believes that people are very poor at assessing how alert they are. "If you ask someone 'how are you feeling?' they'll say 'fine'. A person suffering [from] fatigue, like a victim of hypoxia, is often unaware there is a problem, and if someone thinks they are ok, they are not going to implement any strategy [aimed at reducing fatigue]" (Fiorino, 2001, p83). Education about fatigue and its effects could help eliminate this problem.

In 1995 NASA and the NTSB compiled a fatigue-related resource directory, which aimed to provide transportation-industry members with current, accessible information on the topic of fatigue (Lucas et al., 1997). Recognising the importance of education as a key preventive strategy, not only for flight crews but for everyone involved in aviation, the NASA Fatigue Countermeasures Program also developed an education and training module on alertness management in flight operations (Rosekind, Gander, Connell, & Co, 1999). It is intended to be implemented as a live presentation by a trained individual, and is in three parts. Firstly, it addresses fatigue factors in flight operations, with basic information on sleep, sleepiness, circadian rhythms, and how these physiological factors are affected by flight operations. Secondly it looks at some general misconceptions that people have, and why they are incorrect. Finally participants are given some recommendations for alertness management strategies in flight operations (Rosekind et al., 1999).

Education about fatigue can provide pilots with a basis for assessing the feasibility and effectiveness of different strategies in relation to their specific operational and personal needs (Gander et al., 1998e). Admitting to fatigue has often been associated with negative connotations, such as laziness or lack of motivation, but recognising that it has physiological causes should help to dispel these myths.

Some airlines, such as Delta Air Lines, Airborne Express, and UPS, have made a start on trying to reduce fatigue, by introducing certain educational procedures like alertness management programs (Fiorino, 2001), while others, like British Airways, Air New Zealand, Qantas, and Finnair, have already started to implement cockpit napping (Fiorino, 2001).

1.12 Rules On Maximum Flight and Duty Times

Most jurisdictions throughout the world have regulations that limit the amount of hours that a driver of a heavy vehicle can do. These regulations commonly include a limitation on the maximum number of hours that can be driven per day, and week, and rules relating to required rest periods. Some countries limit actual driving hours behind the wheel, while others limit working hours, which may include time for loading, unloading, paperwork, etc. (Haworth, 1995).

Similarly, most Civil Aviation Authorities (CAA) impose Flight and Duty Time restrictions on Air Transport flights (these are flights carrying fare-paying passengers). These procedures do not work alone, but go alongside other sections in the rules that clearly identify the inadvisability of pre-flight fatigue for air transport flights. This is a general rule that all pilots should apply to themselves to make sure that they do not start a duty or flight with an undesirable existing level of fatigue, and its associated performance decline (Hayward, 1999).

For example, in New Zealand, Civil Aviation Rule (CAR) Part 135, which governs Air Operations for Helicopters and Small Aeroplanes (aeroplanes that have a passenger seating configuration of nine seats or less, excluding any required crew member seat, or a Maximum Certified Take Off Weight (MCTOW) of 5 700 kg or less) has a section dealing specifically with Fatigue of Flight Crew, namely Subpart K. This section prescribes flight time limitations and other rules to minimise fatigue in flight crewmembers engaged in air operations. The operator of an airline is required to establish a scheme that regulates flight and duty times of pilots, and that takes into account many

different factors, including the type of operation:

135.803 Operator responsibilities

(a) Each holder of an air operator certificate shall not cause or permit an aircraft to perform an air operation unless—

(1) a scheme has been established for the regulation of flight and duty times for every person flying in that aircraft as a flight crew member; and

(2) the scheme addresses the following factors for air transport operations where appropriate to the operator's type of operation:

- (i) rest periods prior to flight;
- (ii) acclimatisation;
- (iii) time zones;
- (iv) night operations;
- (v) maximum number of sectors;
- (vi) single pilot operations;
- (vii) two pilot operations;
- (viii) two pilots plus additional flight crew members;
- (ix) flight crew members' qualifications;
- (x) mixed duties;
- (xi) dead-head transportation;
- (xii) reserve or standby periods;
- (xiii) flight duty period;
- (xiv) in-flight relief;
- (xv) type of operation;
- (xvi) cumulative duty time;
- (xvii) cumulative flight time;
- (xviii) discretionary increases in flight time limitations or flight duty limitations or both;
- (xix) circadian rhythm;
- (xx) days off;
- (xxi) record-keeping; and

Most notable of these factors is that New Zealand operators are required to take into account circadian rhythm, night operations, maximum number of sectors, changing time zones, and rest periods prior to a flight.

The operator is also required to ensure that pilots who are operating the aircraft are not fatigued:

135.803 Operator responsibilities

(b) The operator of an aircraft performing an air operation shall not cause or permit any person to fly in the aircraft as a flight crew member if the operator knows or has reason to believe that the person is suffering from, or, having regard to the circumstances of the flight to be undertaken, is likely to suffer from, such fatigue while they are so flying as may endanger the safety of the aircraft or its occupants.

As well as the operator, the pilot is also given the responsibility of removing themselves from the flight deck if they feel that they may endanger the safety of the flight:

135.805 Flight crew responsibilities

(a) A person shall not act as a flight crew member of an aircraft performing an air operation if that person knows or suspects that they are suffering from, or, having regard to the circumstances of the flight to be undertaken, are likely to suffer from, such fatigue as may endanger the safety of the aircraft or its occupants.

Pilots are also expected to ensure that they remain inside the flight and duty time limits:

(b) A flight crew member shall not perform other hire or reward flight duties while employed, engaged, or contracted by an air operator when such duties and flying in addition to that in air operations will exceed the flight and duty time limitations prescribed in the scheme required by 135.803(a)(1) relating to that flight crew member.

(c) A person shall not act as a flight crew member of an aircraft performing an air operation unless that person has ensured that the limitations prescribed in the scheme required by 135.803(a)(1) relating to that person are not exceeded.

Finally, exceptions to these limits may be made in special circumstances, for example an emergency medical flight:

(d) Notwithstanding paragraph (c), the flight and duty time scheme limitations shall not apply where the flight is one which ought to be made in the interests of safety or health of any person, in such cases it is the responsibility of the pilot-in-command to be satisfied that the safety of the flight will not be endangered by reason of any flight crew member exceeding the applicable flight time limitations.

There are almost identical sections in CAR Part 125, Air Operations Medium Aeroplanes (aeroplanes having a seating configuration of 10 to 30 seats, excluding any required flight crew member seat, or a payload capacity of 3410kg or less and a MCTOW of greater than 5700 kg, or performing a Single Engine IFR passenger operation), and CAR Part 121, Air Operations Large Aeroplanes (aeroplanes having a seating configuration of more than 30 seats, excluding any required flight crew member seat, or a payload capacity of more than 3410kg).



Figure 4: Example of Medium-Sized Aircraft (Beechcraft 1900D).

There is also another document, Advisory Circular 119 -2 that deals with fatigue of flight crew, for both small, medium, and large airlines. This states specific numbers with regard to flight and duty times, length of meal breaks, length of rest periods between shifts, etc, within which these airlines have to operate

Similarly, Part 48 of the Australian Civil Aviation Orders (CAO) deals with flight time limitations in aerial work, charter, and regular public transport service operations. Section 48.0 (1.4) plainly identifies the inadvisability of pre-flight fatigue for pilots, and the resulting safety implications. Section 48.1 (1.2) states that any time on duty or standby must be preceded by nine or ten hours of rest (depending on the time of day that this rest period is taken). Section 48.1 (1.3) sets a daily duty time limit of 11 hours, and finally section 48.1 (1.14 and 1.15) sets maximum limits for duty times over one year, and over 30 days.

1.13 Flight Instructors in General Aviation

At present the flight and duty time limitations placed on pilots operating in the Air Transport sector of the aviation industry are not mandatory for private operations or flight training. This does not mean that there has not been concern or awareness from within the industry about fatigue among general aviation pilots. Every person training for a pilot licence not only has to pass flight tests, but also has to pass written theory exams. Human Factors is one of the subjects that prospective pilots have to study, and it is during this paper that most trainee pilots learn about acronyms such as "I'M SAFE" (or a variation on this). This lists some areas that pilots should check themselves on, before being considered safe to go flying. The "F" in "SAFE" stands for fatigue, and reminds all pilots that they should check whether they feel they have had enough sleep, or rest, to perform the flight safely. This applies to Flight Instructors just as much as any other pilot. It is considered that education about this topic will make pilots more aware of when they may be fatigued, even though some researchers believe that someone suffering from fatigue may not realise it (Fiorino, 2001).

A literature search revealed only one study in this particular domain and this was done 60 years ago (Dougherty, 1943). Because of the wartime increase in the military forces, there was an increase in the training schedules of student pilots. Unfortunately the supply of trained Flight Instructors could not keep pace with the increasing number of students, so existing personnel were required to work longer hours. This study looked at the effects of this increase in flying time on the Flight Instructors in the Army Air Force. Twenty randomly chosen participants reported weekly for questioning and a physical check-up, and records were kept of weekly flying hours. Among other things, it was found that more stress occurred when people were night flying as well as day flying, and that the Instructors' subjective symptoms of fatigue included tiredness, particularly in the afternoon, less patience with students, increased irritability towards students, friends and wives, less concern with the progress of the students, and decrease in mental alertness. Researchers also noted that the

younger participants were slightly less affected than older ones, and significantly 17 of the 20 instructors needed an additional one to two hours of sleep per night to work efficiently. Whilst these long hours of work were only a temporary measure, it was concluded that if such a demanding schedule was to continue indefinitely, without sufficient daily rest periods, that it would lead to a deterioration in the health and efficiency of the Flight Instructors.

1.14 International Laws

I contacted several overseas aviation authorities, including the FAA (Federal Aviation Administration), the U.S. regulatory aviation authority, and the United Kingdom (UK) CAA. At present neither of these bodies impose any restrictions on flight and duty times for Flight Instructors in general aviation, only air transport operations. It was noted that in the UK it is apparently usual for the individual flying schools to set flight and duty time limits for their own staff (M. Marsh, personal communication, September 23, 2002). Some authorities, such as the European Joint Aviation Authority (JAA), in their regulations regarding Flight Crew Licencing, do require Flight Training Organisations to have an Operations and Training Manual. Included in this document, the organisation must state the maximum duty hours for Flight Instructors and students, and these figures must be acceptable to the National Authority granting the approval for the Flight Training Organisation to operate (F. Woods, personal communication, September 12, 2002).

1.15 The New Zealand General Aviation Environment

In New Zealand, like many other countries, some flight training organisations take their cue from the airlines and voluntarily impose flight and duty time restrictions on their staff. However, in my experience there are also many other training organisations where Flight Instructors are not looked after so well, and where staff are at an increased risk of suffering from fatigue. This seems more common for Flight Instructors who are not in full time employment.

The New Zealand CAA puts out a quarterly Aviation Safety Summary Report, and in this it reports on incidents and accidents in New Zealand airspace. An accident is an occurrence that is associated with the operation of an aircraft and takes place between the time any person boards the aircraft with the intention of flight and such time as all such persons have disembarked and the engine or any propellers or rotors come to rest. It involves occurrences such as any time a person is seriously or fatally injured, the aircraft sustains damage or structural failure, or the aircraft is missing or completely inaccessible. An incident is any occurrence, other than an accident, that is associated with the operation of an aircraft and affects or could affect the safety of operation. In 2002 there were 35 accidents involving fixed wing aircraft with a MCTOW of 5670kg, out of a total of 93 accidents. Of the total number of accidents in all categories, 11 were fatal accidents, involving 22 fatalities. Although causes have only been assigned for 29% of all accidents during 2002, many accidents could potentially have been as a result of fatigue. Although it is difficult without a full definition of the categories, active failure factors such as 'Inappropriate Strategy' (six cases) and 'State Change Not Detected – Information' (three cases), and task/environment error factors such as 'Inadequate Checking' (one case) and 'Risk Misperception' (one case) could all describe symptoms of fatigue. In this same time period, there were 3361 incidents, all of which could have become accidents.

According to New Zealand CAA statistics there are currently 1310 pilots who hold a Commercial Pilots Licence for Aeroplanes, with an active Class 1 medical. Potentially all of these pilots could also hold a Flight Instructors Rating. In contrast to this there are only 1008 pilots who hold an Air Transport Pilots Licence for Aeroplanes, with an active Class 1 medical. This means that there is the possibility that more pilots are trying to get into the air transport industry than are currently employed in it. This leads to strong competition among pilots.

Employers know that flight instructing is most often used to help the instructor build the necessary number of flight hours, in order to move on to an airline.

Therefore, they consider that because a Flight Instructor is not usually considering a long-term commitment to the organisation, and that they are in fact doing the Flight Instructor a favour by giving them the flight hours that they want, there is no reason to pay them well. Because of this it is not surprising that many pilots do not consider flight instructing as their final career choice. This means that Flight Instructors, especially ones with only a part-time flying position, often have other jobs for financial reasons, and this can lead to fatigue through long days of work, and usually not enough sleep. This problem can be compounded if the secondary employment is a night job, or one that has late hours, such as working in a bar, restaurant, or service station.

1.16 Defining the Research Problem

The study completed for this thesis was based mainly on three other studies that had previously investigated fatigue.

Firstly, an Australian study by Feyer and Williamson (1995) investigated fatigue in long-haul drivers. This was a two-stage study, with the first stage involving gathering information about a range of strategies that might be helpful in reducing driver fatigue. A questionnaire was designed to obtain information about fatigue from drivers. The questionnaire included details of the driver's driving experience, details of current employment and working conditions, as well as details of their last trip and their last working week. Drivers were also asked about their experiences of fatigue including the effects of fatigue on their driving, factors that contributed to their fatigue and how they dealt with the problem. The questionnaire was designed to be self-administered, and interviews were conducted at truck stops. Population-based stratification of the sample was not possible, and consequently the sampling strategy adopted was to survey the industry as widely as possible in order to include as many views as possible. Among other things, this study found that the majority of drivers believed that fatigue was a problem in the industry, but not with themselves personally. However most drivers reported that their driving was adversely affected by fatigue. There were also differences in the fatigue experienced by

drivers in different sectors of the industry. Finally, the timing of rest and work was very important, not just the length of duty time. The second stage of this research involved an on-road evaluation of some of the strategies found in stage one. In this part drivers were required to provide detailed diaries of their work and rest schedules in the week before each evaluated trip, and also complete questionnaires regarding subjective assessments of their fatigue levels.

Secondly, in the aviation field, Petrie and Dawson (1997) did a study on 188 pilots flying international routes with Air New Zealand. As part of the study participants were asked to complete a 29-item symptom checklist on how much they noticed a variety of experiences or symptoms when they were fatigued. Each item was rated for frequency on a Likert scale ranging from 1 (never) to 5 (always). The results of this study showed that the symptoms most frequently noticed by this group of long-haul international pilots when they were fatigued on duty, fell into five main factors. These were sleepiness, cognitive dysfunction, emotional disturbance, boredom, and physical effects (Petrie & Dawson, 1997). The pilots were also asked about any coping strategies they used, both before and during a duty. It was found that the most common pre-flight strategy to prevent fatigue was napping and conserving energy, and that during the flight the coping strategies could once again be grouped into five main factors: planning energy use, active coping, mental withdrawal, communicating with other crew, and coffee drinking.

Finally, the NASA studies mentioned earlier used a combination of self-report and physiological information (Gander et al., 1998a). Their self-report documents were used as a basis for the information gathering papers in this study.

There have been many studies in the area of fatigue involving subjective ratings of tiredness and performance, almost all involving a questionnaire and some form of daily log or diary of how time was spent and particularly sleep duration, as well as recorded physiological data. In addition to those studies mentioned

above, a German study by Samel et al. (1997) involved these same type of information gathering documents, as well as physiological measures (EEG, EOG and ECG) recorded by small portable computers (Oxford Medilog 9000) attached to a belt.

Aviation human factors measurement can generally be placed into one of four groups: flight performance, non-flight performance, physiological, and subjective (Meister, 1999). Because this study is investigating flight and duty times, and the potential for fatigue, rather than the results of fatigue itself, flight and non-flight performance measures were not considered appropriate. For the same reason, as well as due to a lack of accessible equipment, it was not feasible for this study to try and obtain physiological measurements. Subjective measures, then, were suitable for this study, and despite the reservations some researchers have about their validity and reliability, they have always been, and still are, an essential part of aviation human factors measurement (Meister, 1999).

Based on this information I chose to conduct a non-experimental descriptive study involving a self-administered questionnaire, and a seven-day Time Diary. The advantage of using a questionnaire is that they are relatively cheap to develop, provide adequate anonymity for the participant, there is less bias by the researcher, and they are consistent and uniform to administer and analyse. In addition to the written information, interviews were conducted with Flight Instructors not directly involved in the written study, to see what their perception and experience of working other jobs, while Flight Instructing, had been.

I chose to investigate fatigue in General Aviation, and particularly in Flight Instructing, because as a Flight Instructor, I am familiar with this area, and there was an apparent lack of investigation and research into fatigue in this area of the aviation industry. The hours I used as Flight and Duty Time limits are based on those stated in CAR Part 125, used by the three Air New Zealand Link airlines, namely Eagle Airways Ltd, Mt Cook Airways and Air Nelson Ltd. Pilots flying medium sized aeroplanes for these airlines have many flight and duty

time limits that they must adhere to, as stated in Advisory Circular 119-2. This covers everything from how many hours they can work in a 24-hour period, to the maximum amount of flying they can do in a year. The main limits that apply to this study are that they are not allowed to exceed 11 hours duty per day, or 8 hours flight time per day, except in special circumstances to complete disrupted schedules. These are the same limits applied to pilots flying VFR Air Transport Operations in small aircraft. Pilots must also not work more than 50 hours of duty, and fly for not more than 35 hours in the last 7 days.

Normal sleep length varies from person to person, and there is no one best length of sleep for all pilots (Edwards, 1990). However studies have shown that the average amount of sleep varies from approximately six to ten hours (Edwards, 1990), so a central value of 8 hours was considered to best represent the variety of participants. Hence, in this study 8 hours of sleep per night is used as a benchmark for getting adequate rest.

Through the tools mentioned above, the specific research questions that I aim to answer are:

- (a) Is there evidence in the Time Diary of long flight times on any day (combined flight time of more than eight hours)?
- (b) Is there evidence in the Time Diary of a long duty time on any day (work at aviation job and any other employment of more than eleven hours)?
- (c) Is there evidence in the Time Diary of long flight times over a week (combined flight time of more than 35 hours)?
- (d) Is there evidence in the Time Diary of long duty times over a week (work at aviation job and any other employment of more than 50 duty hours)?
- (e) Is there evidence in the Time Diary of lack of sufficient sleep during any night (sleep of less than eight hours), and how does this compare to the

anecdotal evidence from the interviews?

- (f) Is there evidence from the Time Diary that participants are flying when tired, and how does this compare to the anecdotal evidence from the interviews?
- (g) Is there evidence from the Time Diary that participants feel that their performance is affected when flying, and how does this compare to the anecdotal evidence from the interviews?
- (h) How (if at all) do participants prepare for or handle long duty and flying days?
- (i) Do Flight Instructors who consider Flight Instructing as their 'final career choice' complete significantly more Flight and Duty Times than other Flight Instructors?
- (j) What type of Flight Instructor is most at risk of fatigue?

Chapter Two

METHOD

2.1 Subjects

The sample for the study consisted of 18 participants who completed the Questionnaire and Time Diary. A further 21 people were approached regarding being interviewed, and all of them agreed to participate in this research.

The sample of Flight Instructors who completed the Questionnaire and Time Diary was made up of six female and twelve male participants aged between 22 and 49 years old.

2.2 Apparatus/Measurement Tools

The survey materials consisted of several different documents. An Information Sheet, a Questionnaire, a Time Diary, including an Introduction to the Time Diary, and an Interview Sheet.

2.2.1 Information Sheet

The Information Sheet (see Appendix A) covered the nature and purpose of the study, what was required of the potential participant, how the information they provided would be used, what would happen to the information they gave, and how confidentiality and anonymity would be protected. It also listed the rights of the participants, including the right to not answer any question or participate in the study. It included a paragraph regarding how this project had been reviewed and approved by the Massey University Regional Human Ethics Committee, and contact details of someone the participant could get in touch with if they had any concerns about the conduct of this research. Participants were also given the chance to include their name and postal address if they wished to receive a copy of the findings of the study. This was on a separate sheet so that any identifying information was not kept with the returned Questionnaires or Time Diaries.

2.2.2 Questionnaire

The Questionnaire (see Appendix B) was designed to gather mostly demographic data: age; gender; when the participant started learning to fly; when the participant became a qualified Flight Instructor and what flight instructor qualifications they currently held; whether they flew with full-time or casual students; what tasks they had to complete in their present flying employment; average hours per day and week spent in flight instruction (both airborne and ground); other tertiary qualifications they may have held; recreational activities they were involved in; any employment they may have had in other areas outside aviation (nature of the job, as well as whether it was full-time, part-time, or casual employment); and finally the role that Flight Instructing played in their career. It was considered that information about these areas of the participants and their work may have been able to give a profile of the type of Flight Instructor that was at risk of becoming fatigued. The questions all had fixed alternative answers, with mutually exclusive categories.

They were also asked to rate how often on an all-points anchored five point Likert scale certain events occurred. For example:

To what extent do you miss meals or eat at irregular intervals due to flying?

Very Often Often Occasionally Almost Never Never

The events that the participants were questioned on were:

1. To what extent were meals missed or interrupted due to flying?
2. To what extent did participants fly when feeling tired or sleepy?
3. To what extent did participants get an early night if they knew that the following day was going to involve long duty hours?
4. To what extent did participants plan their day to include meal breaks and rest periods?
5. To what extent did participants feel that they became forgetful when tired?

After self-testing the Questionnaire, a pilot study was done on two subjects who had been briefed about the purpose of this research, to get an initial reaction to the wording of the questions. It was found that in some questions, the wording was a little ambiguous, and two questions did not have categories that covered all possible answers. After amending these problems the questionnaire was trialed with a further four subjects who had not been given any previous information regarding this study, and none of these subjects had any problems with completing all the questions correctly.

2.2.3 Time Diary

The Introduction to the Time Diary (see Appendix C) contained instructions on how this document was to be filled out. The Time Diary itself (see Appendix D) covered seven consecutive days, and participants were asked to note how their time was spent every half an hour, both at work, and outside of work, at home or socialising. Although the pilots daily logbook in the NASA studies got participants to rate their subjective fatigue every 2 hours, this was deemed impractical in this study, as many flights were calculated to be shorter than this length of time. Therefore participants were asked at the time they conducted any flight, to rate on a scale of 1 to 5 if they felt tired:

- 1 = not at all tired*
- 2 = a little tired*
- 3 = somewhat tired*
- 4 = very tired*
- 5 = extremely tired*

They were also asked if they felt that their performance was affected:

- 1 = not at all*
- 2 = a little*
- 3 = somewhat*
- 4 = very*
- 5 = severely*

Finally they were asked if they felt that the week during which they had been

completing the Time Diary had been an average one, and if not, to give a reason why.

The Time Diary also underwent testing during a pilot study. It was found that the layout of the page was quite important, as some people missed ticking boxes for what they were doing for the full 24 hours each day. It was found that having a complete 24 hours in view for each day, rather than having to turn pages, mostly eliminated this problem. Another problem was that some test subjects were unsure when to complete the sections dealing with if they felt tired, and did they feel that their performance was affected. Despite the instructions at the start of the Time Diary some people filled in these sections at all times of the day, not just when they were flying in an aircraft. A definite division including bold lines and additional shading of the sections dealing with time at work versus time outside of work, helped with the understanding of how to complete this section accurately.

2.2.4 Interviews

The Interviewer used the Interview Sheet during all interviews. This was to ensure that every interview followed the same set format (see Appendix E). All participants received the same information prior to the interview, regarding what the study was for, and what the interview subject was. By following the set format, the questions that were asked and the order in which they were asked remained the same for each interviewee. This was to help minimise interviewer bias, especially since the interviewer already knew some of the participants. The number of questions was kept small (only nine questions) to keep the length of time that the interview took to a manageable time frame (three minutes). This was done to also help with encouraging people to participate in the interviews, as most Flight Instructors are fairly busy people, and the smaller the time involved, the more chance that people would agree to participate.

The questions involved two main areas: any other employment outside of aviation, and areas regarding fatigue, including possible loss of sleep, flying when tired, and performance being affected. The Interviewees were questioned

about whether or not they had any other employment while they were part-time or full-time Flight Instructing. If they did, they were asked what industry the job or jobs were in, and how long they had worked at another job in addition to their aviation employment. They were also questioned about if they felt they had lost sleep due to working more than one job. Finally they were asked about whether they could recall ever doing airborne flight instruction while they were tired, and whether they felt that this had affected their performance in any way.

2.3 Procedures and Sampling Method

2.3.1 Questionnaire and Time Diary

Sixty-one flight training organizations from around New Zealand were contacted. These were organizations that had advertised in two large aviation publications (New Zealand Aviation News, and Pacific Wings), as well as those listed in the Telecom White Pages Telephone Directory on the Internet. The organizations represented a cross-section of the flight training industry; i.e. flight training institutions that were New Zealand Qualifications Authority approved and whose students were eligible to get full-funding for their training, as well as Aero Clubs whose main students were casual fliers, usually with other jobs.

The resulting sample was by no means randomized, however it was not possible to obtain a full list of all flight training organizations throughout New Zealand. As in the Australian study by Feyer and Williamson (1995), it was attempted to survey the industry as widely as possible in order to include as many different views as possible.

Only the Chief Flying Instructor (CFI) at each organization was contacted. This was to protect the privacy of the employees who were to become participants in this study, and ensure their anonymity. The CFI was given a brief overview of the background of this research, and what this study required of both them and their staff. The CFI would only be required to pass the information to their staff, but the Flight Instructors would need to take approximately five minutes to complete the Questionnaire, and approximately five minutes each day, for

seven consecutive days, to complete the Time Diary.

2.3.2 Information Packages

I sent Information Packages, containing an Information Sheet introducing the study, a Questionnaire, a Time Diary, and a self-addressed postage-paid envelope, to the organisations that agreed to pass the information on to their staff. I sent 133 Information Packages to 22 organisations from around New Zealand, between 13th October 2002 and 31st October 2002. For a list of participating organizations, see Appendix F.

The targeted subjects were any Flight Instructors working part-time or full-time for these flight training organizations. The CFI asked Flight Instructors if they wished to participate in the study, and consent was implied by the Flight Instructor posting back the completed Questionnaire and Time Diary in the postage-paid envelope. The participants also had the option of including a name and return address, if they wished to receive a copy of the analysis of the information, and the results of the study.

The initial contact call to the CFI was followed, approximately two weeks later, by another reminder call. This was to check that the Information Packages had arrived, and that they had received enough copies for all their staff. It was also a chance to prompt the CFI to remind their staff about the study, and the importance of the data that they could provide.

2.3.3 Interviews

Convenience sampling provided most of the people who were approached regarding being interviewed. This included people who were not currently flight instructing and who had moved on to other areas of the aviation industry. These particular participants worked for Air Transport Operators such as Eagle Airways, Air Nelson, Mt Cook Airlines, and Air New Zealand. Other participants were Flight Instructors currently working at various flight training organisations based at Ardmore Airfield in Auckland. Ardmore Airfield was chosen as it had a large number of Flight Training Organisations in a small geographical area, as

well as being close in proximity to the Interviewer. The CFI's of these organizations were asked if they would mind their staff being included in interviews at the same time that they were approached about the written study. Any staff who wanted to be interviewed were then given contact details for the Interviewer.

The interviews were held between 13th January 2003 and 11th May 2003, and were conducted both in person by the Interviewer, as well as over the phone, as not all participants resided in Auckland. As some of the interviews were done by phone there was no equipment with which to record them, so all interviews were recorded in full in writing only. Given the low number of questions asked, and the relatively limited range of answers that could be provided by the participant, this was seen as feasible, while still being able to maintain accuracy during the recording.

Chapter Three

RESULTS

3.1 Data Analysis

Much of the data was evaluated by using descriptive statistics for calculating percentages, mean values and standard deviations. A correlation coefficient was used to examine the extent of linear association, between Actual and Average Daily Flight Instructing Hours, Actual and Average Weekly Flight Instructing Hours (both for participants who thought that their recorded week had been an average one, and those who considered that it had not been an average one), Tiredness and Performance, Hours of Sleep and Tiredness, Flight Number and Tiredness, Length of Flight and Tiredness, and finally Time of Day of Flight and Tiredness. A Likert scale was used for gathering the data regarding participants' feelings on fatigue and some related issues. Regression analysis was used to calculate how much of a participant's tiredness, or level of performance could be predicted by certain variables. Finally, a thematic analysis of comments made during the interviews was carried out.

3.2 Questionnaire

Between 28th November 2002 and 2nd February 2003 I received 18 Questionnaires and Time Diaries from all over New Zealand. The following collates the responses to the 14 questions contained in the Questionnaire.

There were six female and twelve male participants aged between 22 and 49 years old, with an average age of 31.7 years old, and a standard deviation of 8.5 years. The average age of the female participants was 28 years old, with a standard deviation of 10.4 years, however the average for male participants was 33.5 years old, with a standard deviation of 7.2 years (Figure 5).

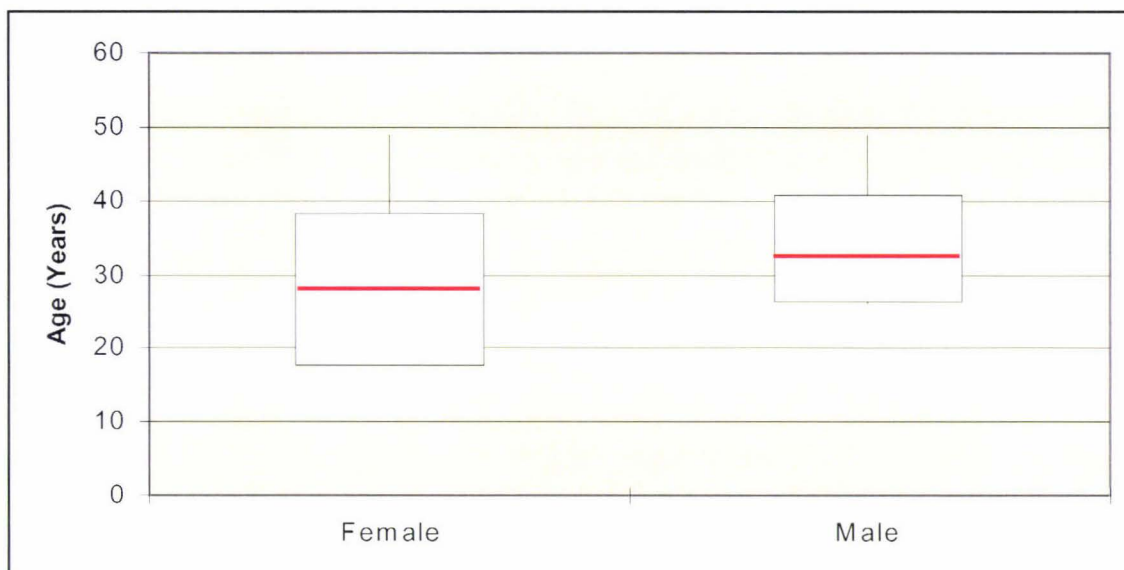


Figure 5: Comparison of Ages of Male and Female Participants. The red line through the box indicates the mean value, with the box extending one standard deviation either side of the mean. The single extended line indicates the upper and lower range of values.

The participants started learning to fly between 1971 and 2001, and qualified for their Flight Instructor Ratings between 1982 and 2002.

Two of the participants (Figure 6) had C-Category Flight Instructor Ratings and were still flight instructing under the direct supervision of a Flight Instructor who held at least a B-Category Flight Instructor Rating. CAA requires newly qualified flight instructors to be checked this way for the first 6 months or 100 hours of flight instructing, whichever takes longest. There were four participants who had C-Category Flight Instructor Ratings but were out of direct supervision. There were ten participants who were more experienced and held B-Category Flight Instructor Ratings, of which two also had D-Category Flight Instructor Ratings. A D-Category Flight Instructor Rating allows the holder to do Biennial Flight Reviews as long as they work for an airline in a training role, conduct aircraft type ratings, and give instrument flight instruction. Finally two participants had A-Category Flight Instructor Ratings, the most advanced qualification for Flight Instructors.

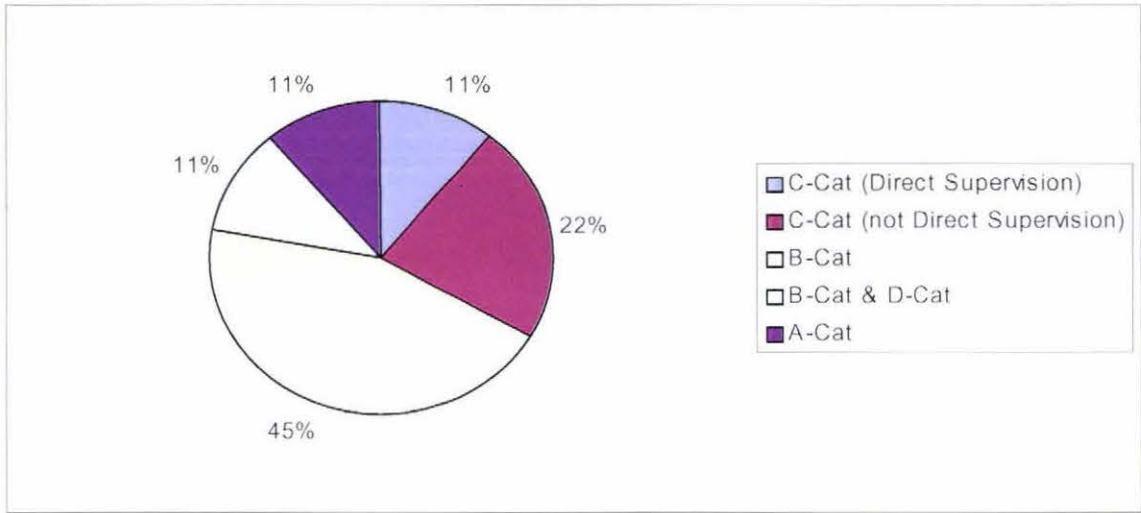


Figure 6: Distribution of Flight Instructor Ratings of Participants

Most of the participants had a mixture of Night Instructor Ratings, Multi-Engine Instructor Ratings, Aerobatics Instructor Ratings, and IFR Instructor privileges (Table 1). There were three participants who held no additional instructor ratings, and these were the three most recently qualified flight instructors. Of these three, one had gained their flight instructor rating in 2001 and was just out of direct supervision, but the other two, who had only gained their flight instructor ratings last year, were still under direct supervision. It would be normal for such new flight instructors to not hold any additional instructor ratings or privileges, until they had gained a little more experience.

Participant Number																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Night		Y	Y	Y	Y	Y		Y		Y		Y	Y	Y	Y	Y	Y	Y
Multi-Engine		Y	Y		Y			Y		Y		Y			Y	Y	Y	
Aerobatics		Y	Y	Y		Y					Y	Y					Y	Y
IFR			Y		Y					Y		Y			Y		Y	
Testing					Y	Y											Y	

Table 1: Instructor Ratings and Privileges held by Participants

Most participants flew with both full-time and casual students, with some

participants also flying with private owners, industry personnel, staff, overseas pilots for foreign licence validation, and tourists.

All participants had a wide range of duties in their current aviation employment, with an average of seven different areas of responsibility. These duties included airborne Flight Instruction, ground briefings/debriefings, staff supervision, student solo flight supervision, theory lectures, other paperwork, staff training, reception/administration, flight examining, air transport operations, foreign language interpretation, management, event planning and operations, accounts/budgeting, maintenance controller, quality assurance, airfield operations, and safety.

There were large differences in the amount of flying that the participants stated they flew on average per day ², with a minimum of 0.5 hours, and a maximum of 8 hours (Figure 7). The average was 4.4 hours per day, with a standard deviation of 1.8 hours. None of the participants recorded average daily flight times that would exceed the nominated maximum of 8 hours per day, however two of the participants were at the limit of this daily flight time, and more than two hours per day higher than any other participant. These two participants were male Flight Instructors, aged 28 and 33 years old, with B-Category Flight Instructor Ratings, as well as most of the other instructing endorsements, such as Night, Multi-Engine, and IFR. One of them also had an Aerobatics Instructor Rating. They both flew with full time students, had tertiary qualifications and had no other employment outside aviation. Both participants also had more than the average number of duties and responsibilities at their aviation job.

² Participant 8 was excluded from any data analysis involving Average Daily or Weekly Flight Instructing Time as they chose not to answer this question.

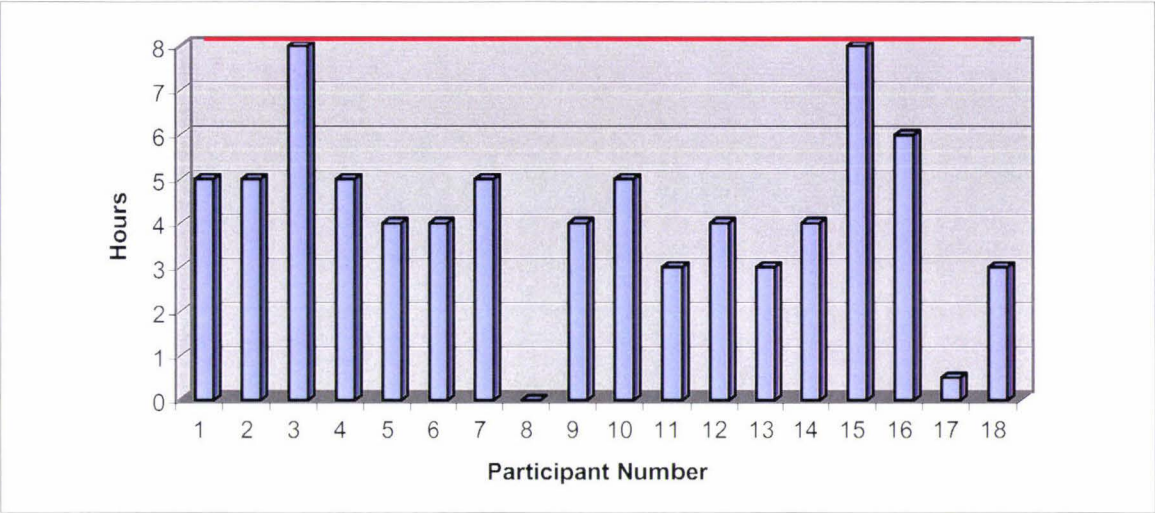


Figure 7: Average Flight Instructing Hours Per Day

A similar result was found with the average hours per week that the participants spent flight instructing, with a minimum of 2.5 hours and a maximum of 45 hours (Figure 8). The average was 23.4 flying hours per week, with a standard deviation of 9.2 hours. Only two of the participants exceeded the nominated maximum of 35 hours flying per week, and it is interesting to note that it was the same two participants that were at the limit of the nominated maximum Flight Instructing Hours per day.

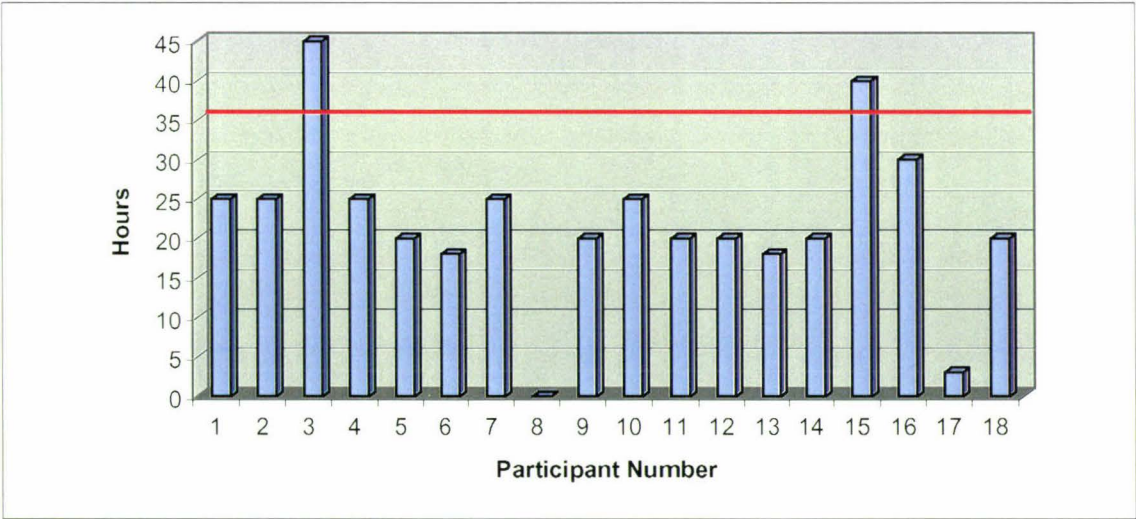


Figure 8: Average Flight Instructing Hours Per Week

Twelve of the participants had completed some form of tertiary qualification, with nine participants completing a Bachelor Degree (one also completing a Masters Degree with Honours), two participants completing Certificates or Trade Certificates, and one participant completing a Master Scuba Diver Qualification.

Only two participants indicated that they were not involved in any recreational activities. Of the recreational activities that the other participants were involved in, only one participant included a passive activity (TV, and internet). The others were involved in a wide range of indoor and outdoor sports, including fishing, golf, boating, touch rugby, running/walking/tramping, gym, surfing, hunting, diving, horse riding, volleyball, cycling/mountain biking, kayaking, hockey, indoor netball, gardening, and basketball.

Only four of the participants had other employment, of which one had a full-time position, two had part-time positions, and one had casual employment outside aviation. The type of work that participants were involved in was varied, with administration, waitressing, managerial, and temp office work being the secondary employment that these four participants had.

Eight participants saw flight instructing as a “stepping-stone” to a commercial airline job, five saw it as a final career choice. The rest had other more personal views about their position, including moving to instructing on larger aircraft, moving to a job outside aviation, becoming a flying academic or air safety investigator, seeing flight instructing as a desired part of their career development, or just being undecided about what their next step in aviation was going to be.

When participants were questioned about the extent to which they felt that they missed meals or ate at irregular intervals due to flying, the average answer was 2.4 (Often) on a Likert scale of 1 (Very Often) to 5 (Never), with a standard deviation of 1.04 (Figure 9).

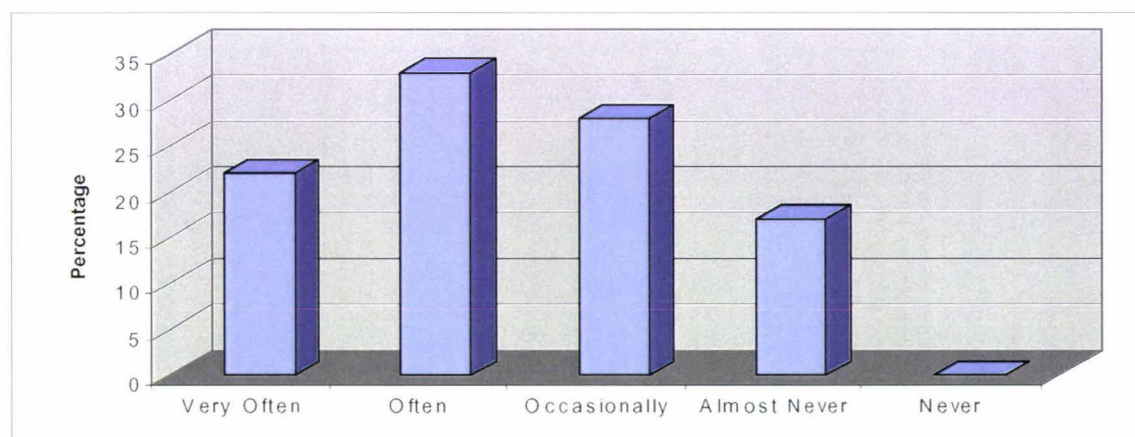


Figure 9: Extent of Missed Meals

The extent of flying when tired or sleepy was fairly consistent over most participants, with a mean of 3 (Occasionally), and standard deviation of 0.59 (Figure 10).

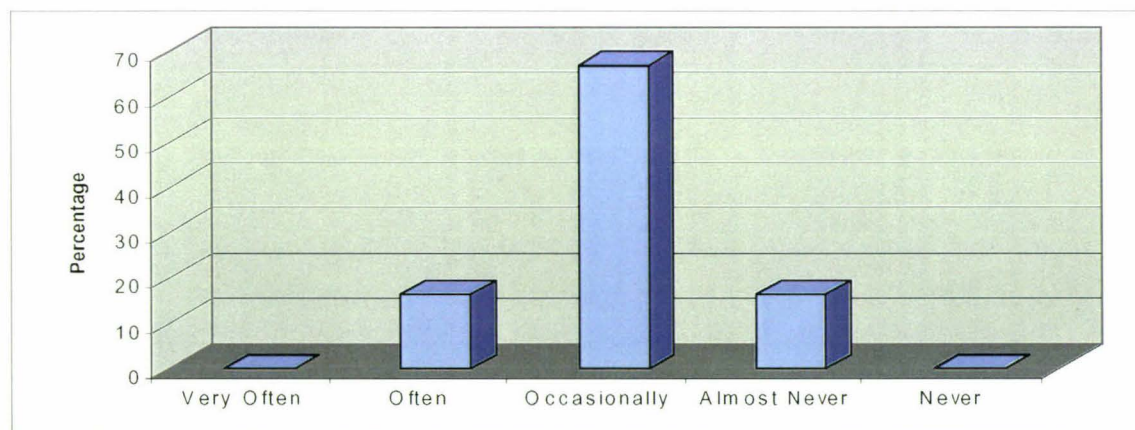


Figure 10: Extent of Flying When Tired

Participants were also fairly consistent with the extent of ensuring they had an early night prior to a long working day, with a mean of 2.6 (between 2 (Often) and 3 (Occasionally)), and standard deviation of 0.78 (Figure 11).

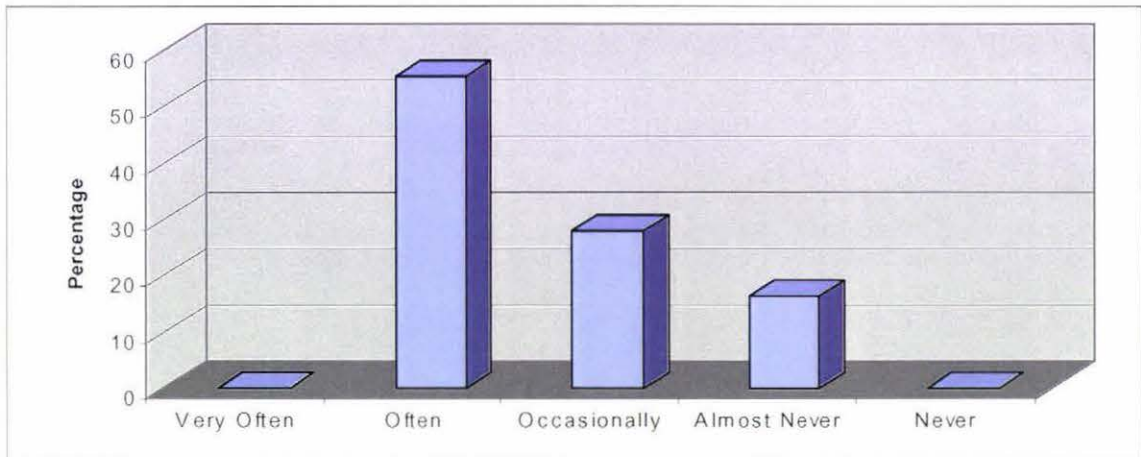


Figure 11: Extent of Having An Early Night

The extent that participants planned their day to include meal breaks and rest periods had a mean of 3.1 (Occasionally), and standard deviation of 0.90 (Figure 12).

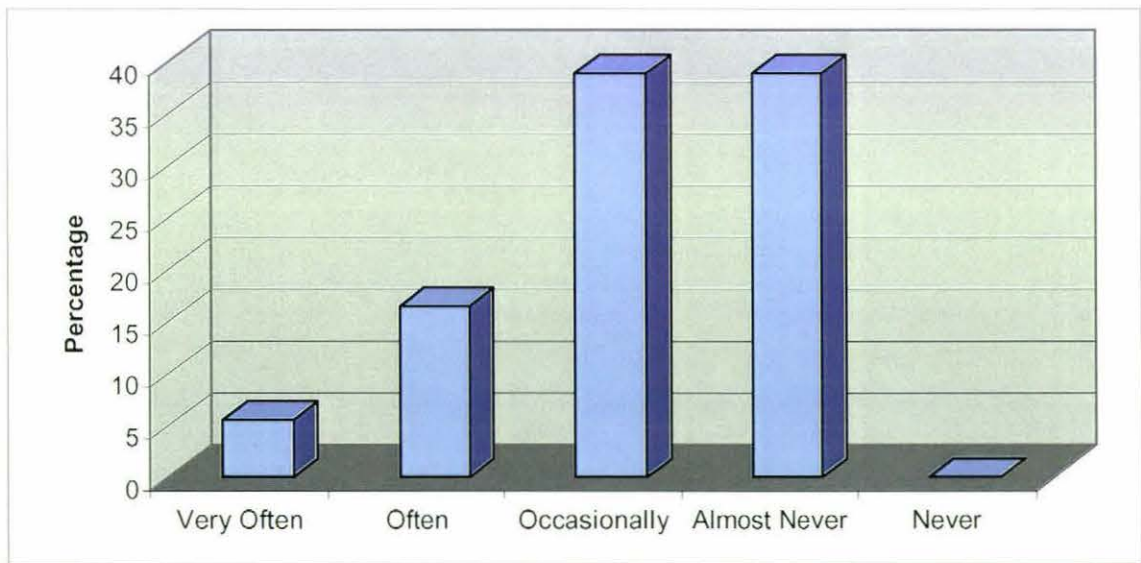


Figure 12: Extent of Planning Breaks

Finally the extent to which participants felt that they became forgetful when tired had a mean of 3.2 (Occasionally), and standard deviation of 0.92 (Figure 13).

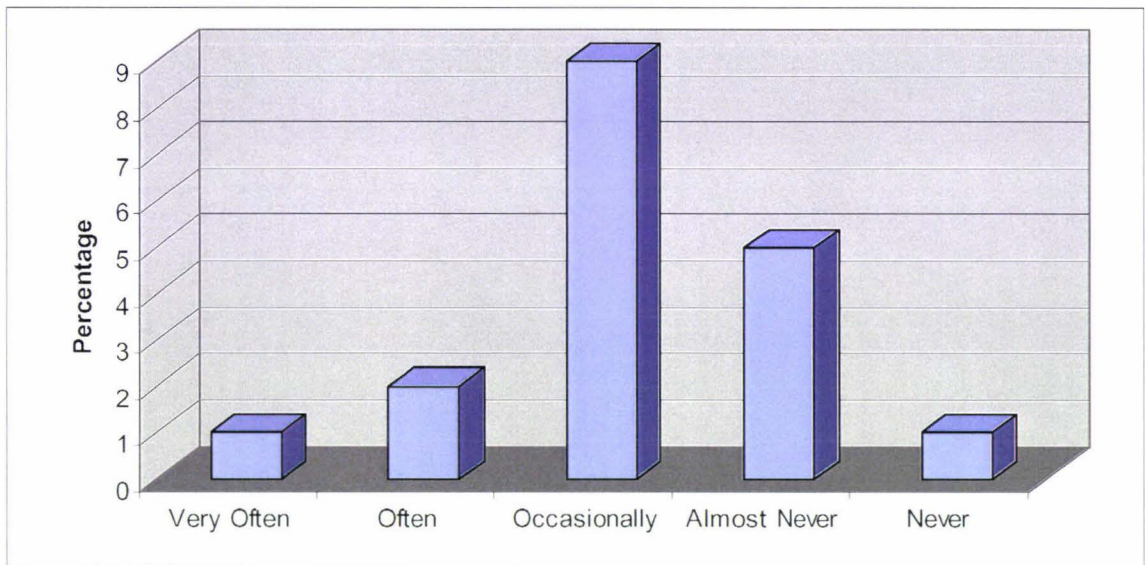


Figure 13: Extent of Becoming Forgetful

3.3 Time Diary

A comparison was made between the Average Daily Flight Instructing Hours (as given in the Questionnaire) and the Actual (observed) Daily Flight Instructing Hours (as given in the Time Diary) (Figure 14) ³. The correlation coefficient between the two data sets was 0.37 (df =16, ns).

³ Participant 4 was excluded from Time Diary analysis, as the copy that was sent to them was incomplete, therefore the data that they returned was also incomplete.

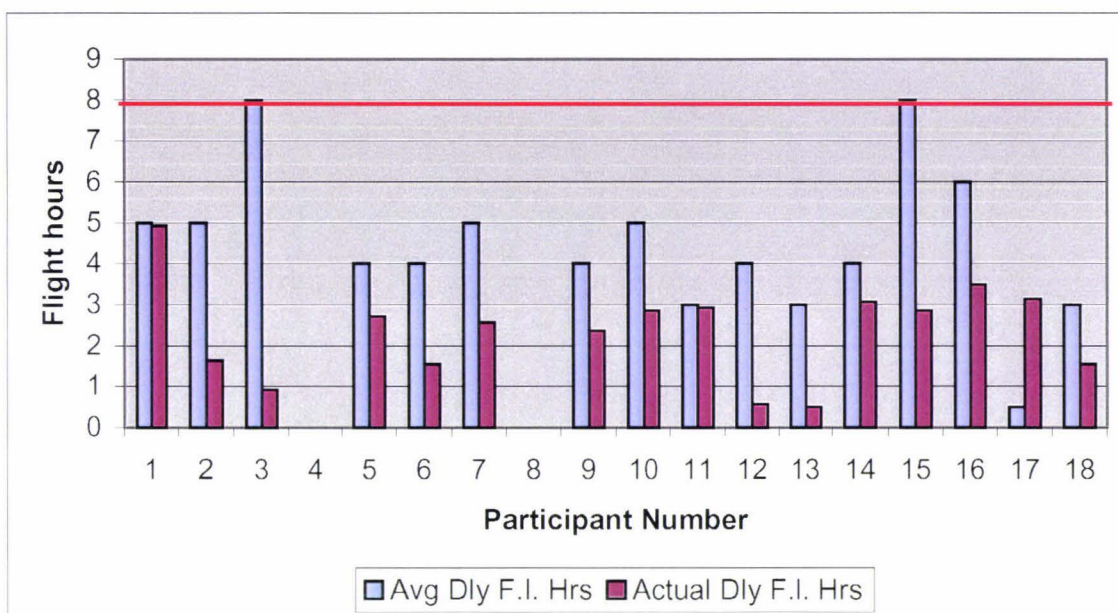


Figure 14: Average and Actual Daily Flight Instructing Hours

A comparison of the two samples (Figure 15) showed that while both Average and Actual Daily Flight Instructing hours had a minimum of 0 hours, the Average days had a maximum of 8 hours, and a mean of 3.97 hours (Standard deviation = 2.27), while the Actual days had a maximum of only 4.9 hours, and a mean of 2.09 hours (standard deviation = 1.34). None of the recorded days had flight hours exceeding the nominated daily maximum of 8 hours.

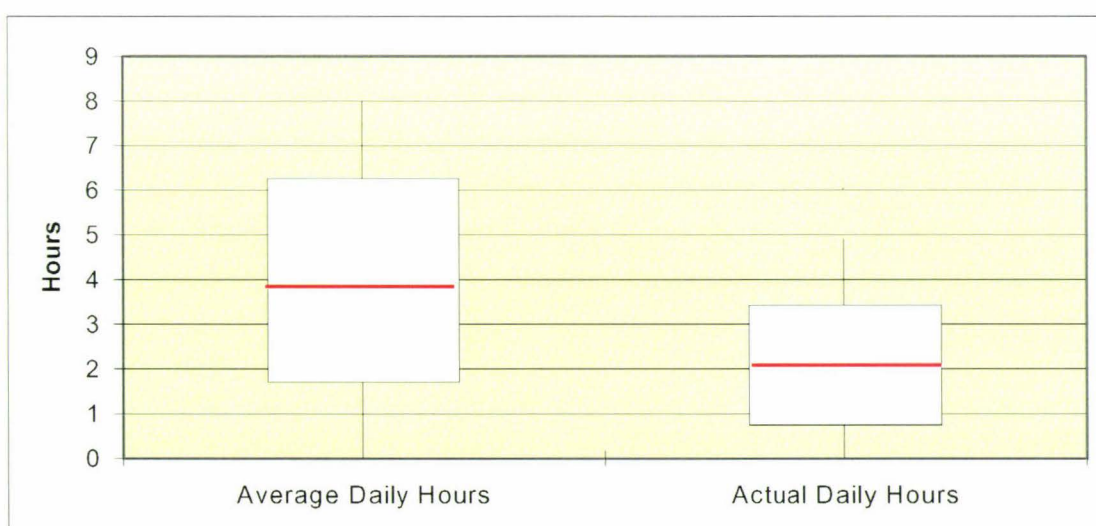


Figure 15: Comparison of Average and Actual Daily Flight Instructing Hours.

A Paired *t*-test indicated a significant difference between the two samples ($t =$

3.71, $p < 0.01$).

The Daily Flight Time during the week that the Time Diary was completed, had a minimum value of 0 hours, a maximum of 7.5 hours, a mean of 1.66 hours, and a standard deviation of 1.90 hours. Of the 63 days that recorded some time spent flying, none had daily flight times that exceeded the nominated maximum of 8 hours (Figure 16).

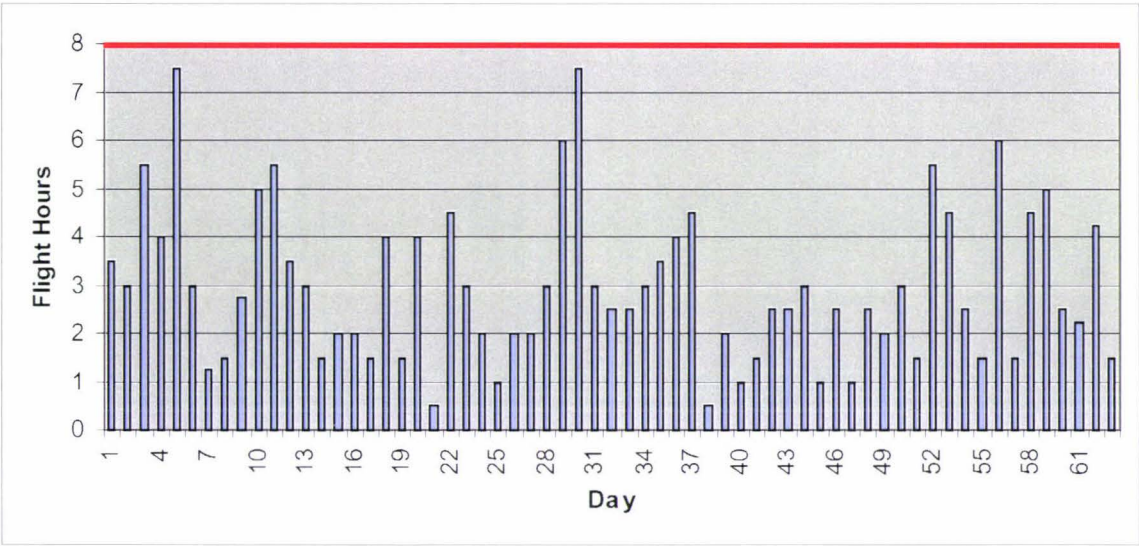


Figure 16: Actual Daily Flight Time

Many days (45.3%) recorded in the Time Diary did not involve any flying (Figure 17), but on the days when flying did occur, the majority only involved 1 or 2 flights (71.9%).

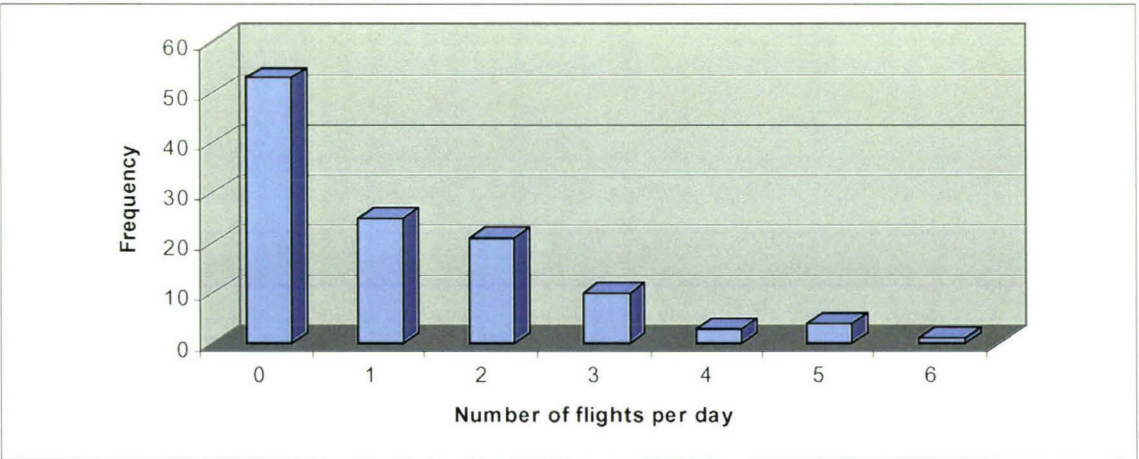


Figure 17: Frequency of Number of Flights Per Day

With regards to whether the participant felt that the week during which he/she had completed the Time Diary was an average one or not⁴, 35% of participants who answered this question felt that it had been an average week, while the other 65% felt that it had not. The main reason given for the week not being an average or usual one was the weather being unsuitable for flying to be completed. Other reasons included the type of flying that the students were completing (solo cross-country navigation flights where no Flight Instructor was required), or that the students were away on exam study break. Some participants were involved in other duties to the exclusion of their flying, e.g. one participant was preparing to host the Alpine Regional Rally, and had a lot of organisation and paperwork to complete prior to this event. Another participant was just starting a new job and was required to spend time learning the standard operating procedures and documents at their new place of employment. Finally the week that some Flight Instructors chose to complete the Time Diary included public holidays, so the participant was not at their aviation employment as much as usual.

Comparing the Average Weekly Flight Instructing Hours with the Actual Weekly Flight Instructing Hours for participants who stated that they thought that the Time Diary did represent an average week (Figure 18), the correlation coefficient was -0.246 (df = 4, ns).

⁴ The data from only 16 participants was used in the weekly analyses, as one participant had not answered the final question regarding whether or not they felt that the week during which the Time Diary had been completed was an average one or not.

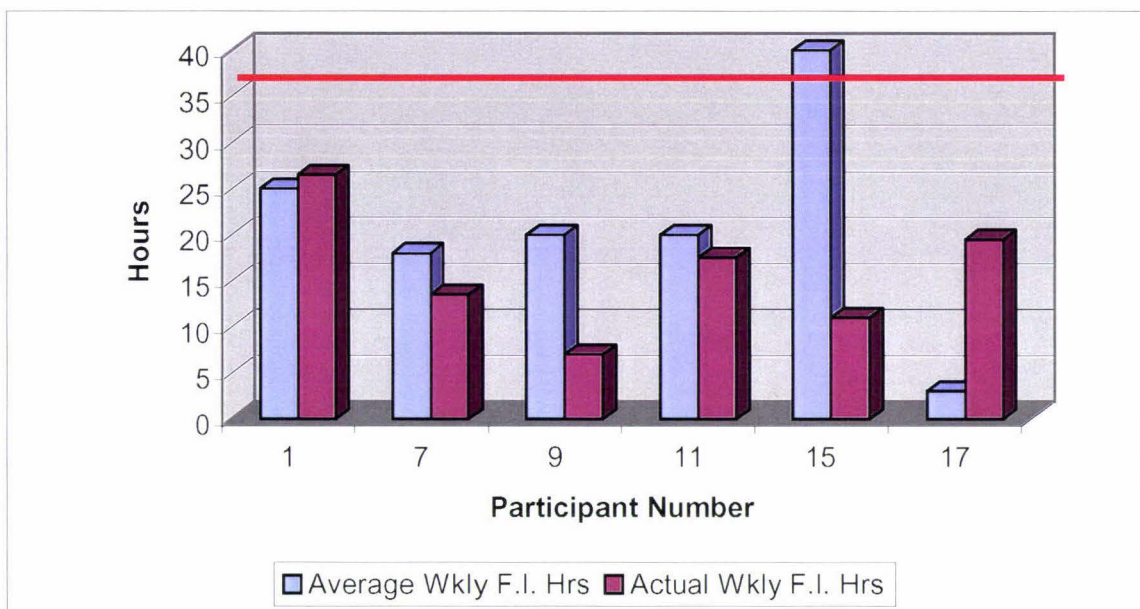


Figure 18: Average and Actual Weekly Flight Instructing Hours (Average Week)

When looking at the two samples (Figure 19), the Average Weekly Flight Instructing Hours had a minimum of 3 hours, a maximum of 40 hours, and a mean of 21 hours (standard deviation = 11.93), while the Actual Weekly Flight Instructing Hours had a minimum of 7 hours, a maximum of 26.5 hours, and a mean of 15.83 hours (standard deviation = 6.88).

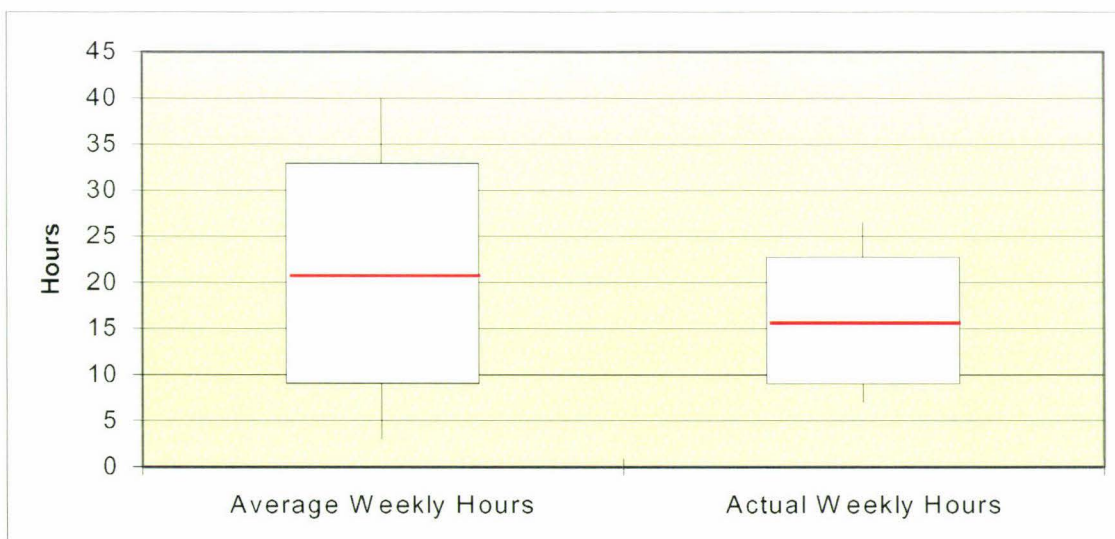


Figure 19: Comparison of Average and Actual Weekly Flight Instructing Hours (Average Week).

A Paired *t*-test indicated no significance between the means of the two samples ($t = 0.834$, ns).

For those participants who did not think that the Time Diary represented an average week, a comparison of the Average Weekly Flight Instructing Hours with the Actual Weekly Flight Instructing Hours (Figure 20) gave a correlation coefficient of 0.10 (df = 8, ns).

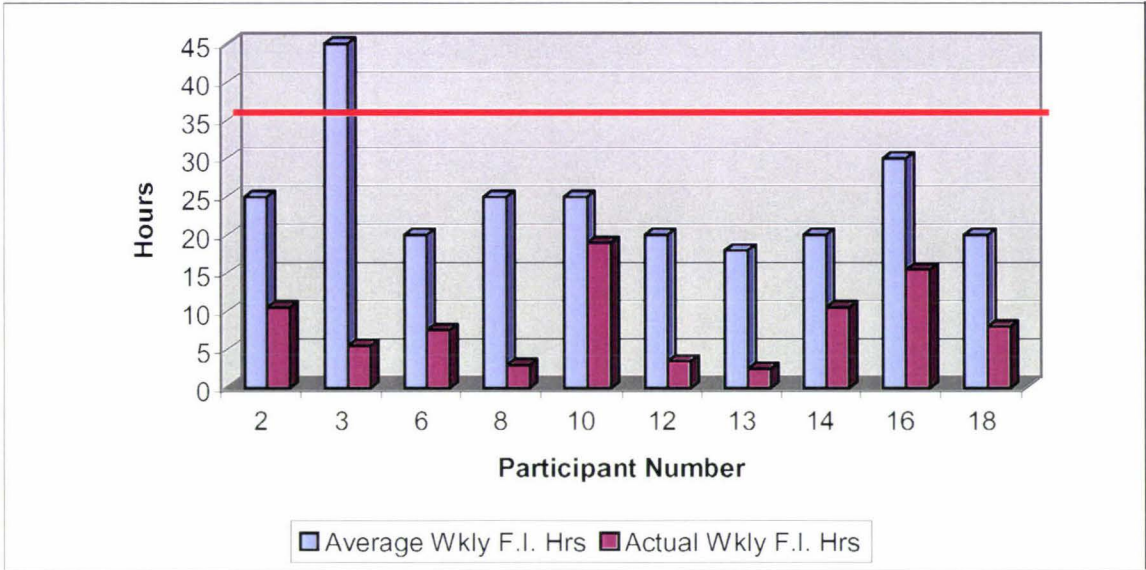


Figure 20: Average and Actual Weekly Flight Instructing Hours (Non-Average Week)

When comparing the two samples (Figure 21), the Average Weekly Flight Instructing Hours had a minimum of 18 hours, a maximum of 45 hours, and a mean of 24.8 hours (standard deviation = 7.98), while the Actual Weekly Flight Instructing Hours had a minimum of 2.5 hours, a maximum of 19 hours, and a mean of 8.55 hours (standard deviation = 5.46). A Paired *t*-test indicated a significant difference in the means of the two samples (*t* = 5.58, *p* < 0.01)

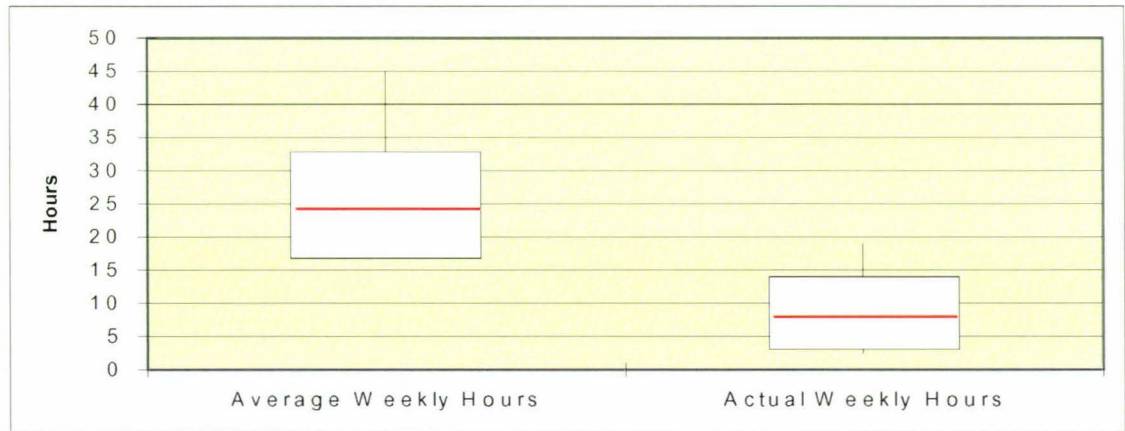


Figure 21: Comparison of Average and Actual Weekly Flight Instructing Hrs (Non-Average Week).

When analysing the flights that were completed during the week that the Time Diary was being filled out (Figure 22), a significant majority of the flights (59.5%) were of only 1 hour in duration, with 84.5% of flights being 1.5 hours or less in duration.

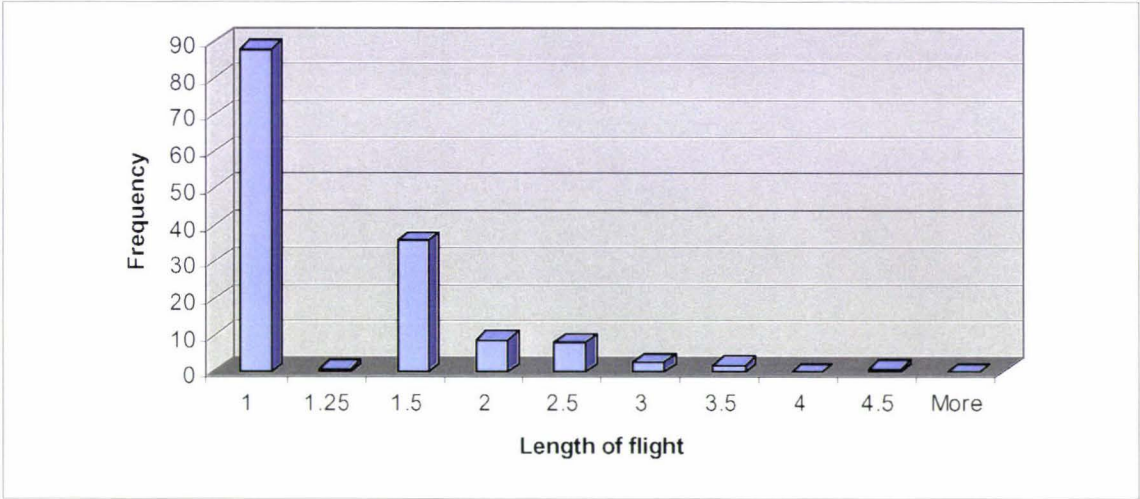


Figure 22: Frequency of Length of Actual Flight Times

The Daily Duty Time (Figures 23 and 24) recorded by each participant during the week that the Time Diary was completed, had a minimum of 0 hours (the gaps that are in the graph), a maximum of 15.5 hours, a mean of 6.8 hours, and a standard deviation of 4.31 hours.

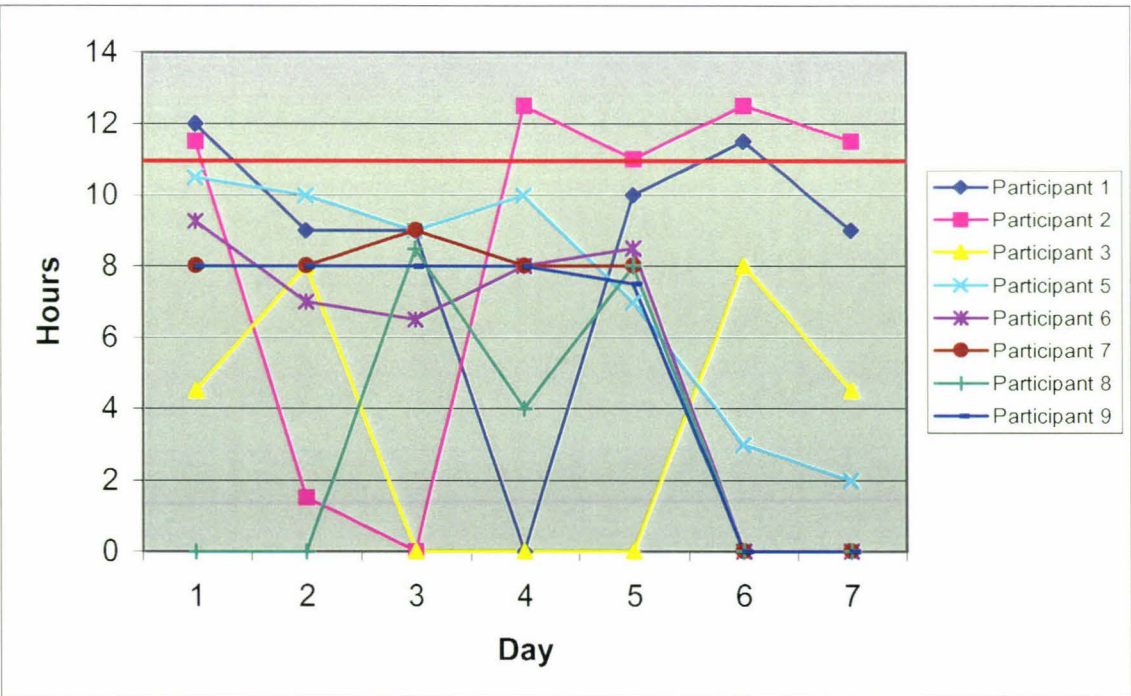


Figure 23: Actual Daily Duty Time (Participants 1 – 9)

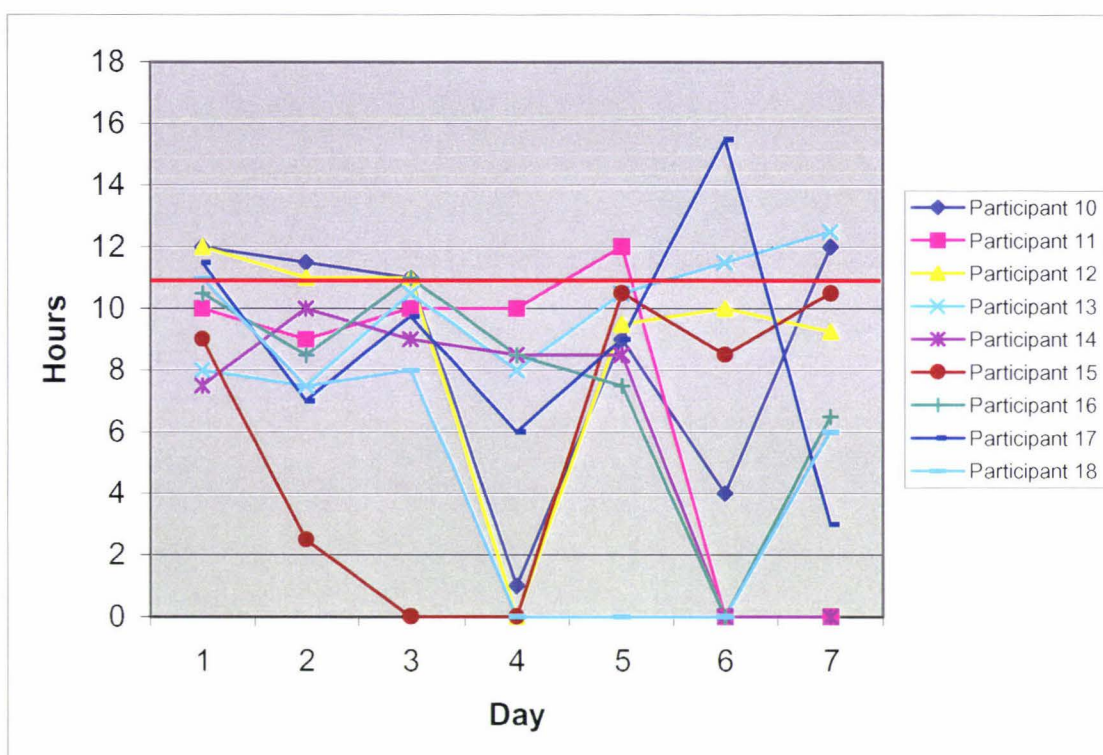


Figure 24: Actual Daily Duty Time (Participants 10 – 18)

Of the 119 days recorded, 12.6% exceeded 11 hours Duty Time, the nominated daily maximum. This involved seven of the 17 participants who contributed data to this section of the analysis. Only one of them was female, and they were aged between 23 and 45 years old, with five of them in a six year range of 26 to 32 years old. The majority of them were B-Category Flight Instructors, with two C-Category Flight Instructors out of direct supervision, and one A-Category Flight Instructor. Only one participant did not have any other instructing endorsements. The remaining Flight Instructors had a mixture of Night, Multi-Engine, Aerobatics and IFR Instructing, with the A-Category Flight Instructor also having Flight Examining privileges. They flew with a mixture of full-time, casual and other types of students. Four participants had nine areas of duties and responsibilities (more than the average of seven), while one had the average, and two had just below average (six areas). Four participants had tertiary qualifications, and three had other employment (one casual, one part-time, and one full-time). There was a relatively even spread of people who considered Flight Instructing to be a final career choice, people who saw it as a 'stepping stone' to the airlines, and people who had other views.

Only 6 of the 119 days recorded by the participants had time spent at other employment, apart from Flight Instructing. On these days, the amount of Daily Duty Time, in addition to other work (Figure 25), had a minimum value of 9 hours, a maximum of 13 hours, a mean of 11.21 hours, and a standard deviation of 1.42 hours. It is significant that a third of the 6 days exceeded the nominated maximum of 11 hours Duty Time on any given day. These two participants were also in the group of seven that exceeded the Daily Duty Time. It is also significant that no participant had other employment as well as any duty time at their aviation job, more than once during the week that they recorded the time diary.

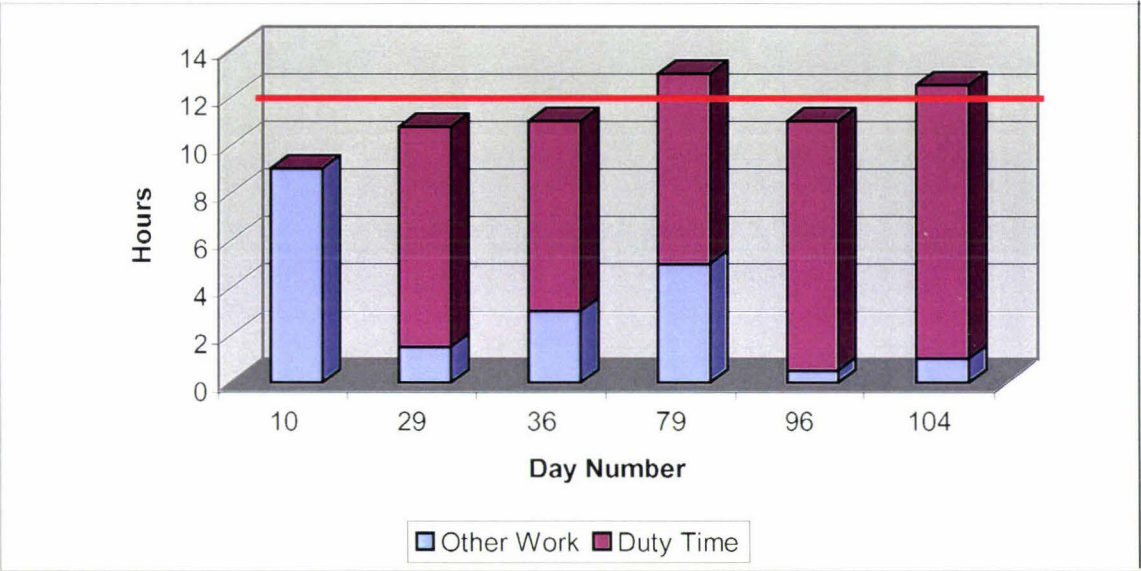


Figure 25: Actual Daily Duty Time + Other Work

Most, but not all participants took lunch or other breaks at some time during their duty. There was a minimum of no time spent at breaks, a maximum of 2 hours, a mean of 0.61 hour, and a standard deviation of 0.57 hour. Of 93 days involving duty time, nearly one third (32.3%) had no meal or drink breaks.

The Weekly Duty Time (Figure 26) during the week that the Time Diary was completed, had a minimum value of 20.5 hours, a maximum of 68.5 hours, a mean of 47.75 hours, and a standard deviation of 13.98 hours.

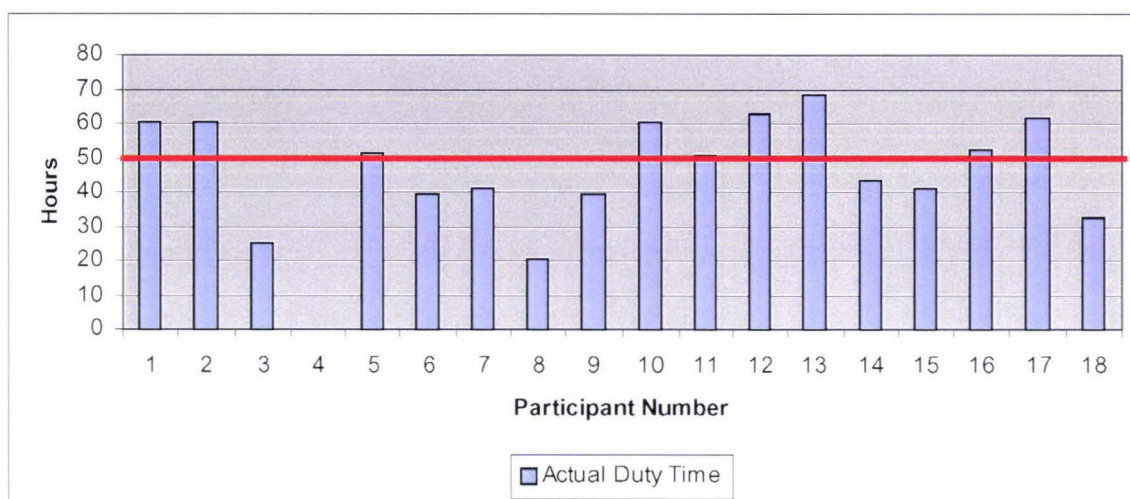


Figure 26: Actual Weekly Duty Time

Of the 17 participants, 9 of them (53%) exceeded the nominated maximum of 50 hours Weekly Duty Time. All of the seven participants who exceeded the nominated maximum Daily Duty Time on any day, also exceeded the Weekly Duty Time Limit. In addition, there were two other participants who joined this group. They were one male and one female, aged 27 and 24 years old respectively. They were both B-Category Flight Instructors, with a mixture of flight instructing endorsements. Both flew with full-time students, although the male participant also flew with casual students. They had an average number of areas of duties and responsibilities (seven) in their aviation employment, both considered Flight Instructing a 'stepping-stone' to the airlines, however the male participant also had a tertiary qualification.

The participants who considered Flight Instructing as a final career choice were investigated to see whether they completed more flying or duty time compared to other participants who were not considering remaining in Flight Instruction long term. Participants Number 4, 6, 7, 12 and 17 were the ones that considered Flight Instructing to be a final career choice, and it would appear that they did not complete significantly more flying or duty time than any other participant (Figure 27). This was confirmed by an Independent Samples *t*-test, conducted on both Actual Weekly Flight Instructing Time ($t = 1.128$, ns), and Actual Weekly Duty Time ($t = 0.475$, ns), where equal variances were not

assumed.

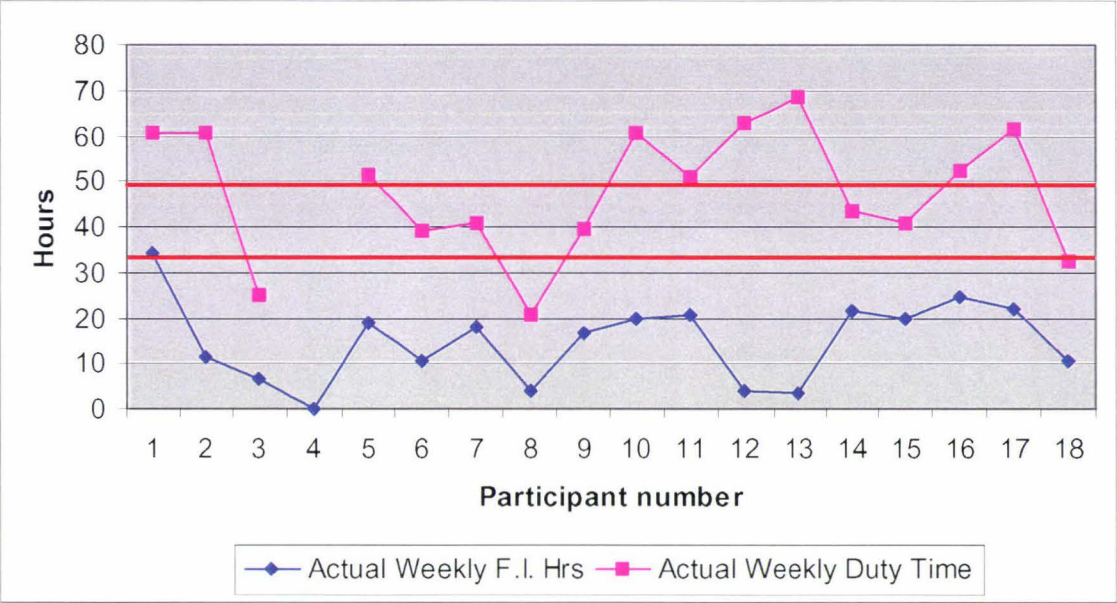


Figure 27: Actual Weekly Flight Instructing Hours and Duty Times. The red lines indicate the nominated maximum Weekly Flight Time (35 Hours) and Weekly Duty Time (50 Hours).

Participant 4 had no actual data, as the copy of the Time Diary that was sent to them was incomplete, therefore the data they returned was also incomplete.

The amount of sleep that was recorded by each participant during the seven days that they completed the Time Diary (Figure 28) had a minimum of 5 hours of sleep, a maximum of 12 hours of sleep, a mean of 8.66 hours per night, and a standard deviation of 1.49 hours. There were 28 nights out of 117 (23.9%) where the recorded sleep was less than 8 hours, the amount that was considered necessary for an adequate nights rest in this study.

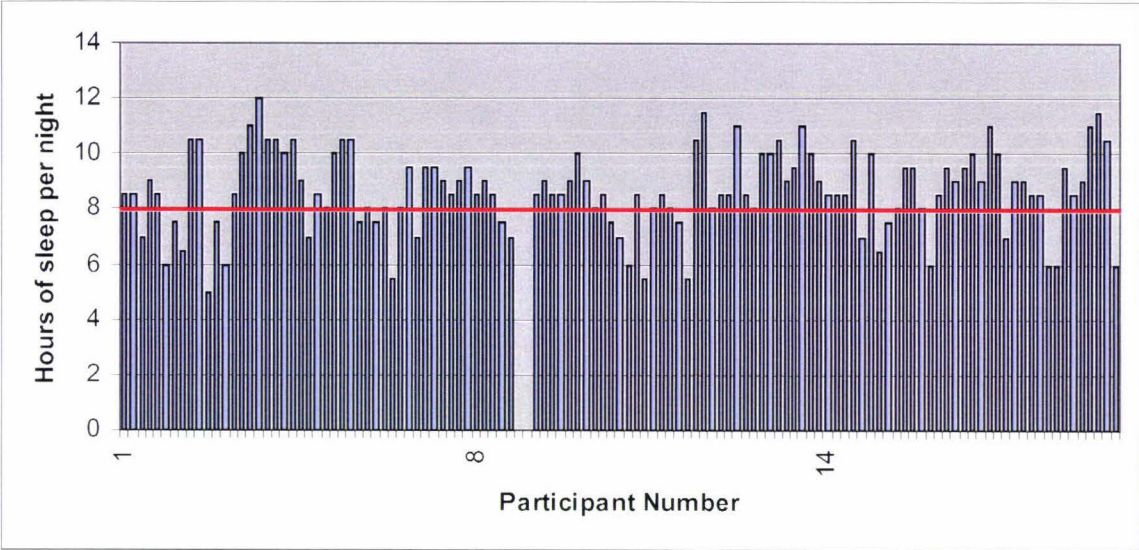


Figure 28: Nightly Hours of Sleep During Study Week

A look at the frequency of different amounts of sleep (Figure 29) shows quite a strong Normal distribution about the mean.

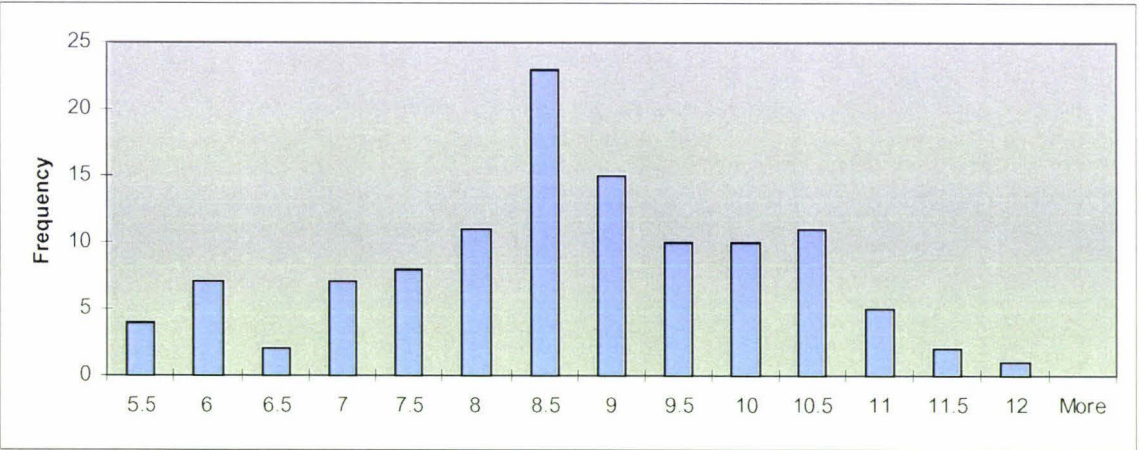


Figure 29: Frequency of Hours of Sleep Per Night

A number of variables were explored to try and explain how tired the participants felt during flights (on a 5 point Likert scale, where 1 = not at all tired, 3 = somewhat tired, and 5 = extremely tired). Most relationships that were investigated showed very little in the way of correlation. The correlation between how many hours of sleep the participant had the night before a flight and how tired they felt during the flight had a coefficient of -0.03 ($df = 60$, ns). There was a correlation coefficient of 0.03 ($df = 148$, ns) between which number

flight this was for the day (ie. first, second, third, etc), and how tired the participant felt during the flight. The correlation coefficient was -0.04 (df = 145, ns) between how long the flight was and how tired the participant felt during the flight. However, the correlation between what time of the day the flight took place and how tired the participant felt was significant (r = 0.20, df = 141, p < 0.02). In other words, the later in the day the flight occurred, the more tired the participant felt.

Although the scatterplot (Figure 30) does not clearly show a reasonable linear relationship, a regression showed that 4% of Tiredness is explained by the Time of Day that the flight took place (r squared = 0.04; F(1,141) = 5.81, p < 0.02). This indicates that the later in the day a flight started, the more tired the participant was likely to feel.

The regression equation is:

Tiredness = 1.38 + 0.0005 Time of Day

(1)

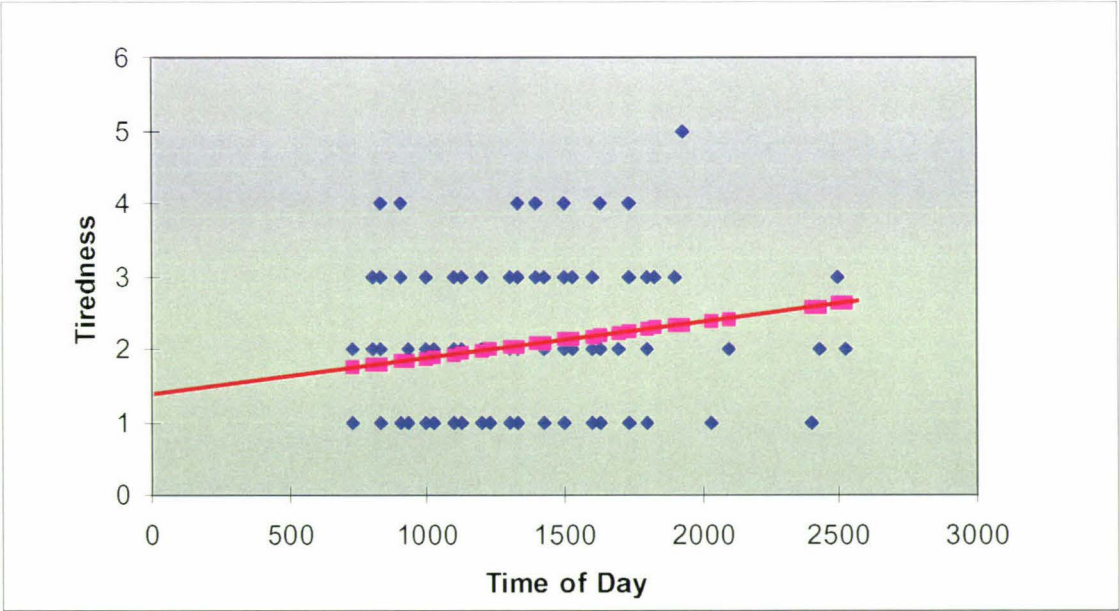


Figure 30: Scatterplot of Time of Day Versus Tiredness, where 1 = not at all tired, and 5 = extremely tired. The red line plots the regression equation.

The residuals from the regression do appear fairly constant along the line when plotted (Figure 31).

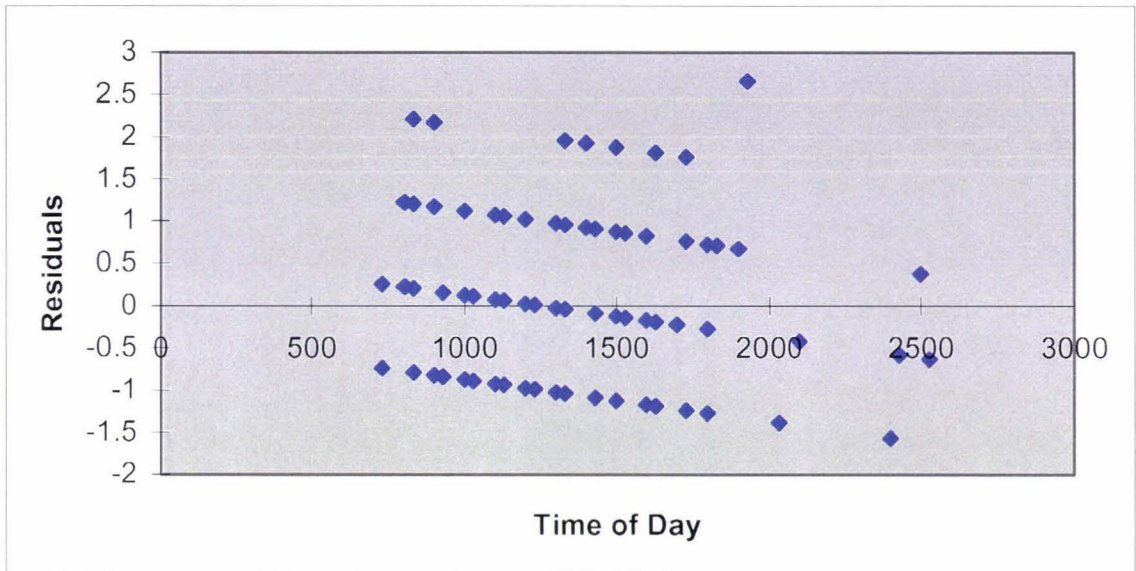


Figure 31: Plot of Residuals from Regression of Time of Day on Tiredness

When investigating the link between how tired the participants felt during a flight and if they felt that their performance was affected (once again a 5 point Likert scale where 1 = not at all affected, 3 = somewhat affected, and 5 = severely affected), there was a strong correlation ($r = 0.74$). This is confirmed by the scatterplot (Figure 32) in which a reasonable linear relationship is apparent. A regression showed that 48% of Performance is explained by the variable Tiredness ($r^2 = 0.48$; $F(1,145) = 133.53$, $p < 0.01$). In other words, the more tired the participants felt, the more they felt that their performance was affected.

The regression equation is:

$$\text{Performance} = 0.45 + 0.52 \text{ Tiredness} \quad (2)$$

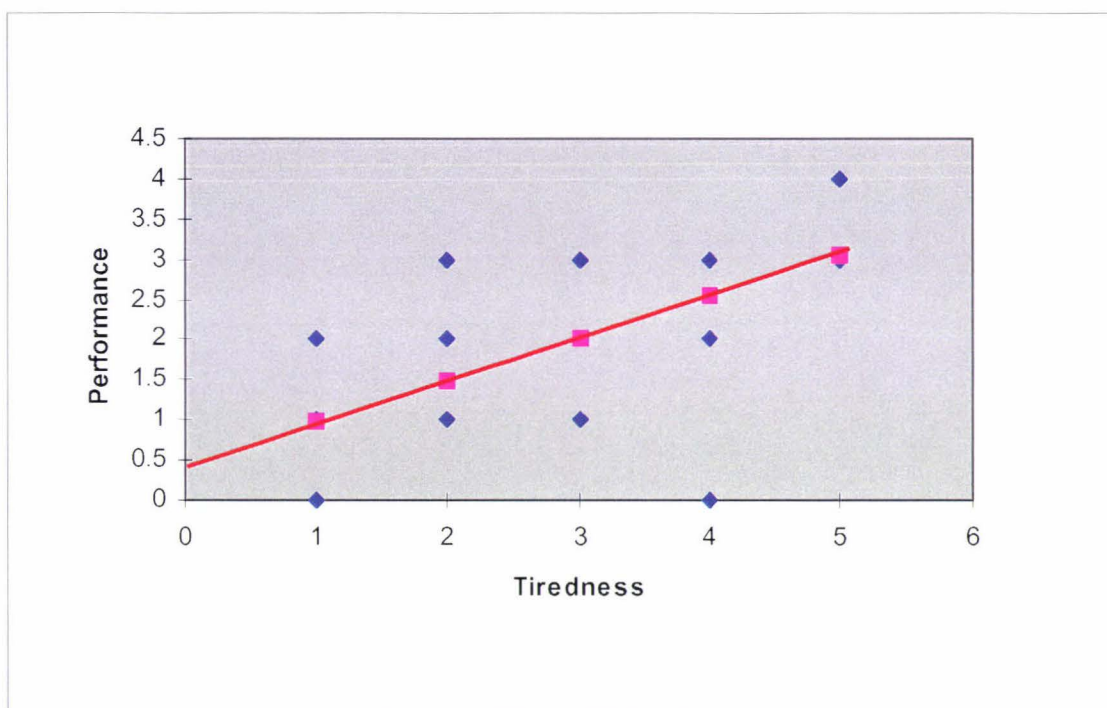


Figure 32: Scatterplot of Tiredness versus Performance, where 1 = not at all tired, or performance not affected at all, and 5 = extremely tired, or performance severely affected. The red line plots the regression equation.

A plot of the residuals (Figure 33) shows that, given the low numbers of participants, they do appear fairly constant along the line.

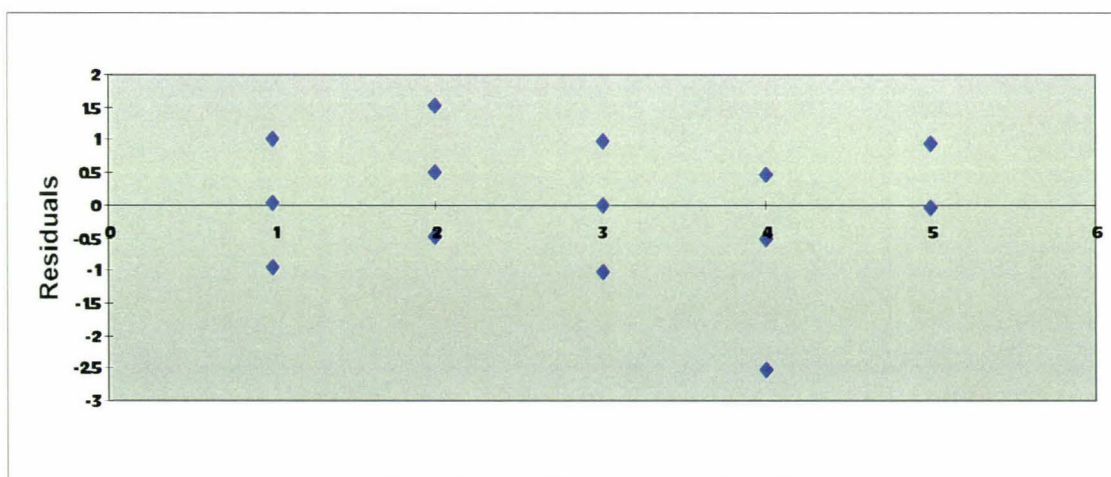


Figure 33: Plot of Residuals from Regression of Tiredness on Performance

To confirm whether this sample correlation can be applied to the population, the null hypothesis is tested, i.e. there is no correlation between Tiredness and Performance among the population.

$$H_0: \rho = 0$$

With $r = 0.74$, and degrees of freedom $= n - 2, = 145$, at the 5% significance level, the test statistic must fall in the range -1.984 to 1.984 in order to not reject the null hypothesis.

$$\begin{aligned} s_r &= \sqrt{(1 - r^2 / n - 2)} \\ &= \sqrt{(1 - 0.5476 / 146 - 2)} \\ &= 0.045 \end{aligned}$$

$$\begin{aligned} t &= r - \rho / s_r \\ &= 0.74 - 0 / 0.045 \\ &= 13.214 \end{aligned}$$

As the test statistic, t , falls outside the required range we can reject the null hypothesis, and conclude that a linear relationship exists between Tiredness and Performance in the population.

There are some assumptions in using regression. Firstly it assumes that there is a linear relationship between the variables. Secondly, it assumes that there is stability in the relationship, so that we can predict things outside the range of values of the independent variable that we have got. Thirdly, it assumes that the variance of the residuals remains constant along the line (homoscedasticity). Finally, it assumes reversibility (the relationships for increases in variables are the same as for decreases).

3.4 Interviews

Most of the people interviewed had employment, other than Flight Instructing, at some stage of their flying career (Figure 34). The vast majority of Interviewees had other employment while working as a part-time Flight Instructor. While 14.3% had no other employment, 42.9% had one other job, 28.6% had two other jobs, and 14.2% had three other jobs. Nearly half of the Interviewees did not have other employment while working as a full-time Flight Instructor

(47.6%), while 42.9% had one other job, and 9.5% had two other jobs.

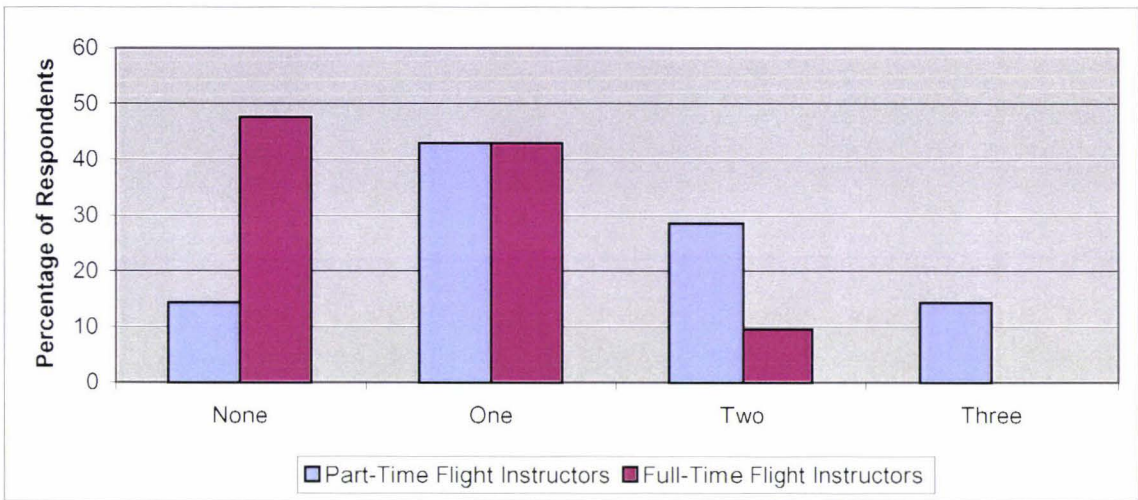


Figure 34: Number of Other Jobs Held by Part-Time and Full-Time Flight Instructors

Of those Interviewees who at some time worked more than one job, 63% thought that they lost sleep due to working more than one job.

The length of time that respondents had been working at another job while also Flight Instructing (either part-time or full-time) had a minimum of 1 month, a maximum of 66 months, a mean of 24 months, and a standard deviation of 17.7 months.

Almost all of the people interviewed could recall at some time doing airborne Flight Instructing while they felt tired (95.2%), and 66.7% also gave some form of affirmative reply when asked whether they thought their performance, while flight instructing, was affected in any way due to feeling tired or fatigued. From the comments that the interviewees made, it was clear that these Flight Instructors knew that they were fatigued, that their performance was affected, and even how their performance was affected, yet they still elected to complete these flights. Remarks such as “I think you tend to compensate with an increased scan rate” (Interview #1), “You tend to let other peoples’ mistakes go on for a bit longer that they should” (Interview #4), “More in the choice of words, and stumbling when trying to explain something” (Interview #16), and “I probably shortened the lesson as you’re tired and just want to get back on the

ground; I probably short-changed the student as you don't put the full effort into the lesson that you should do" (Interview #20) show that the Flight Instructors were aware of their performance decrement. Other explanations like "especially on cross country flights, when you end up not really paying full attention to the flight" (Interview # 3), and "having no breaks, like working at weekends, really catches up with you the following week" (Interview #13) show that these Flight Instructors were aware of their situation. Several Flight Instructors also described their performance as being not 100% on the ball, but some also stressed that they did not consider that they were unsafe, in spite of their decline in performance: "I don't think I was unsafe, but I definitely wasn't as on the ball as usual" (Interview #9), "I might have been a bit grumpier but not unsafe" (Interview #15).

Chapter Four

DISCUSSION

4.1 Introduction

This chapter discusses the findings of the study and the implications of these findings for Flight Instructors. The study set out to examine the effects of flight hours and duty times on Flight Instructors in the general aviation industry in New Zealand, and whether or not there was evidence of fatigue in this area. There has been considerable research into fatigue in some areas of the aviation industry. For example the NASA research into the effect of fatigue on pilots on long-haul flights, short-haul flights and overnight cargo operations (Rosekind et al., 1994a). This study investigated the potential for fatigue in an area where there had been no appreciable amount of research.

Having received the Questionnaires and Time Diaries from participants, I proceeded to compare the hours worked and flown by the participants, with the maximum flight and duty time limitations placed on pilots flying for medium sized air transport operators around New Zealand. Although these limits pertained to pilots flying aircraft larger than the average flight instructor would operate, it provided a guide to legally acceptable working hours when dealing with paying passengers and public safety. Therefore it was considered it would be suitable to apply these limitations to Flight Instructors training paying



Figure 35: Examples of common single-engine aircraft used for flight training. Left: Piper PA28-161 Cherokee Warrior; Right: Cessna 172 Skyhawk.

students.



Figure 36: Example of a twin-engine aircraft used for flight training: Piper PA44-180 Turbo Seminole

I compared the qualitative information that I received from people during the interviews, with the numerical data from the Questionnaire and Time Diary, to ascertain whether I could verify my findings, given the small numbers involved in the Questionnaire and Time Diary research.

4.2 Participants

Unfortunately, it was decided by some CFI's that their staff would be too busy to participate in this study. Regrettably these were the very people that I was most interested in obtaining information from, as it was thought that they were the type of Flight Instructor most likely to be working long duty hours and logging greater flight times, and therefore at a higher risk of getting fatigued.

Although there were only a small number of respondents to the survey, they covered a good spread of Flight Instructors across the general aviation spectrum. There was a wide range of ages of both male and female Flight Instructors, from young newly qualified Flight Instructors, to those older people in a more senior role as CFI. This was reflected in the range of three decades that participants started learning to fly (1971-2001), and the twenty year range in participants receiving their Flight Instructor Ratings (1982-2002). The average age of females in the study was slightly younger than their male

counterparts, and this is most likely due to aviation still being a relatively new choice of career for females. The majority of older Flight Instructors in the industry, such as the CFIs, tend to be male. The participants also had a full range of Flight Instructor Ratings, covering all levels of experience, and all types of flight instruction. The students that the participants flew with also came from many different types of people training to fly, from casual weekend fliers, to those training for a career in the aviation industry themselves. The responsibilities and duties of the participants also covered many diverse areas, from basic briefings, flights, and debriefings, to lecturing, and the more managerial roles of accounts/budgeting, maintenance controller, quality assurance, airfield operations, and safety.

Two thirds of the participants had also completed some form of tertiary qualification, in addition to their flying training. This confirms what appears to be an increasing trend for aviation personnel to be not just qualified pilots, but to also have a wider knowledge base that can be used to their advantage as they progress through their career, usually into management areas. It also gives the pilot another qualification to fall back on, in case they are unable to continue active flying due to loss of their aviation medical certificate.

The vast majority of participants were also quite physically active outside their flying, with most activities that people were involved in being outdoor recreational and sporting activities. This is very common among pilots, as they have to maintain good general health not just in order to retain their aviation medical certificate, but also to be able to physically handle the challenges of manoeuvring an aircraft, and the stressors that this places on the human body. If pilots are not in good general health they will be more susceptible to the rigors of flying, and it is suggested that keeping physically fit will help the body cope better with fatigue (Hayward, 1999).

4.3 Daily Flight Time

The first of the research questions involved looking for any evidence of long

daily flight times, i.e. combined flight time of more than 8 hours in one day. The maximum daily flight hour limit used in this study was 8 hours, the same as used by pilots flying under CAR Part 125 for Air Operations involving medium sized aeroplanes in New Zealand. Due to the wide variation in the qualification levels of respondents, it was anticipated that there would be a large difference in the amount of flying that each participant considered they would normally complete on a daily basis. This was confirmed by a difference of 7.5 hours between the maximum and minimum amount that participants felt they flew during an average day. However, there did not appear to be a great deal of similarity between the average daily flight instructing hours, as reported in the Questionnaire, and the actual daily flight instructing hours that were recorded in the Time Diary. There was a very low correlation between the two sets of data, and the *t*-test also indicated a significant difference between the two samples. This showed that the data collected in the Time Diary regarding daily flight instructing hours was not very representative of an average day, as perceived by the participants in the survey. The actual daily flight instructing time had a mean value that was almost exactly half that of the reported average daily flight instructing hours, and a range of values that was only half as wide as that of the reported average times. This misrepresentation was corroborated by the fact that nearly two thirds of participants stated that the week during which they had completed the Time Diary was not an average one, however it could also have been due to participants overestimating how much they really fly in an average week.

Despite this, there were no days that recorded flying time of more than eight hours, either during an average week, or during the week that actual flights were recorded. Therefore there is no evidence in this study of participants exceeding safe daily flight time limits that would be imposed on an air transport pilot during a normal flying day. However, as this is based on data that is not necessarily representative of an average week, this does not mean that there is no evidence that Flight Instructors in general do not exceed this daily flight time limit.

The length of flights that made up the total daily flight time could have potentially contributed to fatigue in the Flight Instructors. As was found in the research that NASA conducted, many short flights contributed to fatigue in short-haul pilots, by each duty involving many takeoffs and landings, which are both periods of very high workload (Gander et al., 1998b). Only 15% of the flights recorded in the Time Diary were longer than 1.5 hours, and this indicated that the majority of flights were short instructional flights. These flights are usually quite intense for the flight instructor, involving completing a large number of tasks in a short time, and having to multi-task effectively during the flight. Among other responsibilities, they need to monitor the student and all their actions, keep a lookout for other aircraft, patter (talk) the student through a manoeuvre, either while the student is flying or while the flight instructor is demonstrating it, monitor the time so that the flight does not exceed the scheduled slot, to name just a few tasks. They also involve a takeoff and a landing within a very short space of time, along with its associated high workload. Being able to maintain this level of alertness and awareness over several flights in a day is extremely tiring, and it would be very easy to become fatigued, and to lose the required level of concentration. From the Time Diary it was found that 87.5% of days that involved flights had between one and three flights completed that day. This low number of flights per day indicated that Flight Instructors are only at minimal risk from getting fatigued through flying many short sorties, in contrast to what NASA researchers found that the short-haul pilots did (Gander et al., 1998b).

4.4 Weekly Flight Time

A combined flight time over a week of more than 35 hours was considered to have exceeded safe limits, the same as imposed on Air Transport Pilots flying under CAR Part 125. Once again with the wide variety of respondents to the Questionnaire and Time Diary there was a large range in the values reported. There was a difference of 42.5 hours between the lower and upper value of what participants felt they flew in an average week, as well as a large standard deviation. Those that actually flew more than 35 hours in a week exceeded the

nominated safe duty time, and this applied to only two people out of the 18 participants that completed a Time Diary.

Even when looking more closely at the samples of average and actual weekly flight instructing hours for participants, and focusing only on the one third of participants who considered that the week during which they completed the Time Diary was an average one, there was still a lack of correspondence between the two categories. The correlation was still very low, indicating that the actual weekly flight instructing hours were probably not very representative of an average week, although the *t*-test indicated that there was no significant difference between the two samples. Once again there is still the possibility that Flight Instructors over-estimated how much flying they really do in an average week. Again the range of values of actual flight hours was only approximately half that of the average flight hours, although the mean was closer to what it was for the average flight hours, being only 5 hours difference. There was only one participant that thought they would exceed 35 hours flight time in an average week, but none of the participants actually recorded weekly flight hours that would exceed the nominated safe air transport weekly flight hour limit of 35 hours. However, because the data from the study was not necessarily indicative of the general Flight Instructor population, Flight Instructors in general may quite often exceed this weekly flight time limit.

For the other two thirds of participants who did not consider that the week during which they completed the Time Diary was an average one, surprisingly the correlation was actually better than for those participants who thought that their week was an average one. A close look at the two samples reveals that there is almost no overlap between the actual hours recorded, and the average hours stated, and the *t*-test confirmed that there was a significant difference in the means of the two samples. This confirmed the participants perception that they did not fly an average week. As with the previous group, there was only one participant who considered that in an average week they would log flight hours exceeding 35 hours. However once again there were no actual flight hours recorded in the Time Diary that exceeded this maximum limit, therefore

there is no evidence of weekly flight times exceeding the nominated safe limits. There was also no evidence that those participants who indicated that Flight Instructing was their final career choice flew significantly more hours during the study week, than other participants.

4.5 Daily Duty Time

Another research question involved looking for any evidence of long daily duty times, including any secondary employment the participant was engaged in. The nominated maximum acceptable daily duty time limit was 11 hours, as used by Air Transport Operators flying medium sized aeroplanes in New Zealand, operating under CAR Part 125. Although the daily flight times recorded did not exceed any safe daily flight time limits, the duty times that were recorded did. 12.6% of the days during which participants completed the Time Diary showed daily duty times exceeding 11 hours. Seven out of the 17 participants whose data was used for this analysis exceeded 11 hours duty time at least once during the seven days they were completing the Time Diary, sometimes by as much as 4.5 hours. One participant stated that their standard time at work to be 12-14 hours a day (Participant #10). Add to this time for commuting between work and home, time for hygiene and meals, and this can lengthen, in principle, the duty time for the day to far beyond legal and safe limits. This has been found to happen in some larger air transport operations. For example a German study found that flight duty periods exceeded the legal standard duty time if other activities like travel between the airport and accommodation, eating a meal, and time for hygiene were included in a daily duty time (Samel et al., 1997). All of these activities also reduce the chance of having enough time for adequate sleep and a lack of sleep is a major cause of fatigue.

As well as the hours being flown on any day being low, the number of flights was also small, and this, combined with the long hours on duty that were recorded, had the potential to lead to fatigue. It has been found that long duty days combined with few flights but long periods on the ground between flights,

led to a poorer and shorter sleep that night (Graeber, 1988). The intensity of the duty day, rather than the length of it, had more impact on sleep, so a day with more flight segments led to longer and more restful sleep that night.

Most of the days during which daily duty hours were recorded only covered time spent in aviation related duties. There were only a very small number of days recorded that included time spent at other employment outside aviation, however all but one of these days took the daily duty time to its limit of 11 hours, and a third of these days exceeded the 11 hours daily duty time limit. This indicated that flight instructors who were also working at other employment were at greater risk of working long hours and exceeding safe duty time limits, and therefore had a greater chance of becoming fatigued. It is important to note that each participant who exceeded the daily duty time limit only did so once during the study week, but that given a longer period of time a stronger pattern of longer duty times for those with secondary employment may have emerged.

These results showed that there was some evidence of the nominated safe daily duty hour limits being exceeded, particularly by Flight Instructors with secondary employment outside of aviation. It also indicated that because these long duty days had few flights, there was a higher risk of fatigue.

4.6 Weekly Duty Time

A limit of 50 hours duty time over a week, including any secondary employment outside aviation, was used. This is the limit imposed on pilots flying Air Operations for airlines operating under CAR Part 125. With regards to the duty time spent over the week that the Time Diary was completed, over half the participants exceeded the 50 hours safe weekly duty time limit placed on air transport pilots. One participant exceeded this limit by 18.5 hours, the equivalent of almost two extra days of work that week.

This showed that there was strong evidence of weekly duty time limits as used

by Air Transport Pilots being exceeded by all participants, not just those who regard Flight Instructing as their final career choice. This excessive duty time was in spite of the fact that the recorded flight hours were quite low, and did not exceed any air transport limits. This indicated that it was not just hands on flying that kept pilots working long hours, but most likely all the extra duties and responsibilities were adding a considerable amount of work load to the pilot. These extra activities were a substantial aspect of a pilots' working day, and therefore must become a contributing factor towards any resulting fatigue, and associated performance decline. As one participant noted on their Time Diary, the preparations for extra activities were extensive, "resulting in a 6 day week for me! I was knackered!" (Participant #2). This is supported by research that has shown if people work more than 50 hours per week, then daily activities and sleep begin to compete for the same 24 hours, potentially resulting in sleep loss, and therefore fatigue (Benoff, 2001).

Only four of the participants in the survey had other employment, outside of their Flight Instructing. A much higher rate of secondary employment was found amongst those people who participated in the interviews. It was found that almost all of them had been involved in secondary employment in addition to their part-time Flight Instructing, with many having two or three other jobs. The average length of this secondary employment was two years, but did have a wide range of one month to five and a half years. Just over half of the interviewees continued to have other jobs while full-time Flight Instructing, although this was usually restricted to only one other job. Data from the interviews indicated that employment outside aviation was a major contributor to long duty times and lack of sleep. Without a chance to 'catch up' on lost sleep time, there is the strong risk of fatigue (Hayward, 1999).

4.7 Lack of Sufficient Sleep

From the hours of sleep per night that were recorded in the Time Diary, it would appear that most Flight Instructors on the majority of nights got a reasonable length of sleep time, i.e. at least 8 hours sleep. Less than a quarter of the

recorded nights had a sleep time of less than this, so there was no strong evidence of a lack of sleep. However it is possible that some participants recorded 'sleep' as any time that they were in bed, whether they were actually asleep or not. It has also been found that self reported sleep data is often different from physiological sleep measures recorded on subjects (Gander et al., 1998a). Therefore the amount of sleep recorded was quite likely to have been overestimated.

Despite the participants who completed the Time Diary appearing to get plenty of rest, there were other issues raised by those interviewed regarding a lack of sufficient sleep. From the interviews it was established that nearly two thirds of people who had been involved in employment outside of aviation thought that they had lost sleep due to working more than one job. This indicated that those who did have other work, apart from Flight Instructing, were more likely to have reduced sleep time, with lack of sleep being a major contributor to fatigue, and its associated performance decline.

The reason that these Flight Instructors felt it necessary to get second or even third jobs was predominantly due to the career path that most pilots go through, and this was highlighted in the response to one of the questions in the Questionnaire. The fact that nearly half the participants saw flight instructing as a "stepping-stone" to a commercial airline job is not unusual. Flight Instructing is often used to build the necessary hours in order to move on to an airline, and because of the way employers perceive this lack of long-term commitment to flight instructing, Flight Instructors are traditionally not very well paid. Because of this many Flight Instructors, especially ones with only a part-time flying position, get second, and sometimes even third jobs. As research has shown, the most evident cause of fatigue is a lack of sleep (Printup, 2001; Rosekind et al., 1994), and any loss or disruption to our normal sleep can affect every aspect of how we function. This includes an increasing rate of errors and poor performance (Edwards, 1990). Therefore this apparent requirement for secondary employment can lead to fatigue through long days of work, and often not enough sleep. The time of day that a person works also adds to the

disruption of sleep, and therefore to their fatigue level. This problem can be compounded if the non-aviation employment is a night job, or one that has late hours, such as working in a bar, restaurant, or service station. If the pilot is involved in any night flying then they are more likely to have a greater sleep loss than those who don't (Gander et al., 1998d; Samel et al., 1997), even if they try to recoup lost sleep time during the day. This is because their biological clock is telling their body that it should be waking up (Mann, 1999), or because of the rest of the world going about their daily business, so that noise, light, or other social demands are at the most predominant (Gander et al., 1998c).

4.8 Flying While Tired

There was some disturbing evidence collected from the participants regarding flying when tired. The extent that participants flew while feeling tired or sleepy was quite consistent across the Questionnaire respondents, with almost all participants responding that this did happen occasionally. The comments made during the interviews corroborated this, where once again almost all those interviewed stated that they could recall having flown while tired or fatigued. This mirrors what NASA found with long-haul pilots, where they admitted to nodding off in flight, or arranging for one pilot to nap while the other monitored the flight (Mann, 1999). While it is extremely unlikely that a Flight Instructor would leave a student to monitor the flight while they took a nap, it does show that flying while tired is not restricted to air transport flights in large aircraft. Therefore there was strong evidence of Flight Instructors flying while they are tired, and the fact that this was so universal was of great concern, as among other things, the potential for accidents to happen is much greater, response times are longer, and decision-making skills are decreased.

Unfortunately from the data collected in the Time Diary, it was difficult to pin point what made the Flight Instructor feel that they were tired, when completing a flight. Neither the number of hours of sleep the night prior to the flight, how long the flight was, nor whether this was the first, second, or third, etc, flight for

the day seemed to be able to predict how tired the Flight Instructor would be. It was found that the time of day that the flight was started did contribute a small but significant amount to predicting how tired the Flight Instructor felt during the flight. The later in the day the flight was, the more tired the Flight Instructor reported they were. It is possible that the sample size was too small to illustrate some relationships clearly.

4.9 Did Pilots Feel Their Performance Was Affected?

Participants completing the Time Diary were asked to rate how tired they felt, and if they thought that their performance was affected, during any flying that they completed. Those people interviewed were also asked about this aspect of their flight instruction, and whether they thought that their performance had been affected in any way due to feeling tired or fatigued.

From the Time Diary data, it was found that being able to predict if the Flight Instructor felt that their performance had been affected during a flight was a little easier than predicting if they would feel tired during the flight. Calculations showed that nearly half of the variation in performance levels was explained by how tired that Flight Instructor was feeling at the time. Whether or not the Flight Instructor had physiological symptoms of fatigue is not really relevant, as it was enough that they had the perception that they were tired. Although at present there is a lack of basic information on how pilots subjectively experience fatigue and monitor their own levels of tiredness in daily aviation operations, there is some research that suggests that pilots reporting high levels of fatigue may use different types of sensations to monitor when they are tired, than pilots reporting lower levels of fatigue (Petrie & Dawson, 1997).

Asking the participants, rather than taking physiological measures of fatigue, was considered to be valid, as fatigue is, essentially, an experience that can only be assessed by asking the individual (Feyer & Williamson, 1995). It was not practical in this study to try and obtain physiological measures of performance, and its decline with the onset of fatigue. Two thirds of those people interviewed gave some form of affirmative reply regarding their

performance being affected by flying when tired. This was a very similar response to the one that NASA researchers obtained when asking flight crew members how often they felt that fatigue affected their performance during a typical trip. The average response was that crew members did consider that fatigue sometimes affected their performance (Gander et al., 1998e).

It was clear from the comments that Flight Instructors made during the interviews that they were fully aware their performance was reduced, and even knew the symptoms that they showed when this was happening. For example not giving the student the full attention they should have, and even shortening the lesson, letting errors go uncommented on for longer than usual, and increasing their scan rate to compensate for a reduction in awareness. This increase in scan appears to be one of the ways that a body handles minor fatigue. In a study by Fairclough and Graham (1999) on drivers who had been deprived of sleep, it was concluded that the body compensated for increasing sleepiness by becoming more aware of its reduced performance and increasing discomfort. The participants tried to focus more intently on the task as they became sleepier. What is concerning is that the Flight Instructors continued to fly and train students, even though they knew that their performance was not at its usual high level.

Based on these findings, there was strong evidence that participants felt that their performance was affected, however they usually continued to complete flights in spite of this.

4.10 Preventative Strategies (Early Night)

Since fatigue can be affected by what activities are participated in, and choices made outside the work environment, as much as it is by working activities, preventing fatigue is just as much the responsibility of the individual, as it is of any organisation (Gander, 2001). The most obvious step in reducing pre-flight fatigue is to plan to get enough sleep before a duty starts (Printup, 2001). Despite this, having an early night prior to a long working day was not common

among participants, with most of them indicating that this happened somewhere between often and occasionally on the Likert scale, and some admitting that this almost never happened. This indicated that the utilisation of preventative strategies against fatigue was not widespread amongst Flight Instructors. This may come down to pilot education, as although they are made very aware of fatigue through their pilot theory studies, they may not have enough current information regarding the prevention of fatigue, or practical measures that they can integrate into their daily work and personal lives.

4.11 Operational Countermeasures (Meals and Breaks)

Just like the apparent lack of preventative measures against fatigue, the use of operational countermeasures also appeared to be absent from day to day operations. Optimal scheduling of work and rest is not always possible due to the intensity and unpredictability of flight operations (Caldwell et al., 2000), but planning the working day to include any meal breaks and rest periods was reported by 39% of participants as only occasionally happening, and the same amount of people reported that it almost never happened. The data from the Time Diary confirmed this lack of 'down time' from the working day. Nearly one third of the days during which people completed any duty time had no meal breaks or any shorter drink breaks. Without time away from an intense task, however short this time is, it is easy to become fatigued, with the mind simply wandering away from the current task. This lack of concentration could become a safety issue if something important is missed during a flight, resulting in an accident or incident. As NASA research has confirmed, a pilots performance will be reduced by long hours of steady work with no break (Hayward, 1999).

A third of the respondents to the Questionnaire also said that they often missed meals or ate at irregular intervals due to their flying, and all participants indicated that this happened to them at some time. This situation was a genuine concern, as along with inadequate rest periods or breaks, missed or disrupted meals can contribute to fatigue. If the body is not getting adequate nutrition it cannot maintain energy levels, therefore maintaining concentration

becomes more difficult, and performance may decline. Fatigue easily sets in if the body does not have enough stores of energy to call on.

4.12 Forgetfulness When Tired

Finally, from the Questionnaire it was found that the extent that participants felt that they became forgetful when tired had most participants answering either occasionally or almost never, so it appeared that this area was not perceived as a major concern by Flight Instructors. This was one of the symptoms most noticed by pilots when fatigued, during a study of 188 Air New Zealand pilots flying international routes (Petrie & Dawson, 1997). Memory lapses were also the most common form of unsafe act preceding a reported maintenance occurrence in a recent Australian report (Hobbs & Williamson, 1998). However, since this is not something that was reportedly frequently noticed by Flight Instructors who participated in this study, perhaps it does not apply to the general aviation arena, as much as it does to other areas of the aviation industry.

4.13 Characteristics of Participants who exceeded Flight and Duty Times

The type of participants that were involved in exceeding either a Flight Time or Duty Time Limit were generally male, with a far greater relative proportion than for females. They were usually aged in their late 20's or early 30's, with only two participants outside this range, one in her early 20's and one in his mid 40's. The majority of the Flight Instructors involved in this area were also usually quite experienced, with most of the Instructor endorsements that it is possible to qualify for. They nearly always had tertiary qualifications, and mostly flew with full-time students. They quite often had more than the average number of areas of duties and responsibilities in their aviation employment, and, surprisingly, usually did not have any other employment outside their aviation one. It did not seem to matter what role they considered Flight Instructing was playing in their career path, as there was a fairly even spread among those who considered this a 'stepping-stone' to the airlines, those who had decided Flight

Instructing was a final career choice, and those that had other ideas about the role that Flight Instructing played.

4.14 Limitations of the Study

The participants in this study had a wide range of ages, experience, qualification levels, and responsibilities. This should have allowed the sample to quite accurately mirror the general aviation arena as a whole. Unfortunately due to the use of a non-random sampling method, and a low number of respondents to the voluntary survey, there was no guarantee that the sample of Flight Instructors in this study adequately represented the Flight Instructor population as a whole. This is a common problem with self-selected samples, as since subjects have to take the initiative to be involved in the study they are often not representative of populations, and such small proportions of subjects respond. Busy people are also less likely to respond, and of course these are the people who it would have been very advantageous to get data from for this study. Out of 133 Information Packs that were distributed to various organizations, only 18 were returned. This corresponds to a very low response rate of only 13.5%.

Secondly, because of time restraints, it was considered practical for the Time Diary to only cover one week of the Flight Instructors time. Because of this, some outside influences on the timing of this week, for example public holidays, annual aircraft rallies, and especially weather, had a significant impact on the data gathered. As so many of the participants did not consider that the week during which the Time Diary was completed was an average one, other weeks would potentially have had quite different results.

Ideally there would have been more participants in the survey with other work outside their aviation employment. The data from the interviews indicated that this was a major contributor to long working hours and potential lack of sleep, leading to fatigue. Because of the requirement to protect the privacy of the participant, it was not possible to question who the CFI's were giving the

Information Packs to. People without other employment were also needed in order to be able to compare data, but a ratio of one participant with secondary employment to 4.5 without it, was a little skewed. Ideally 50% of participants with other employment and 50% without would provide a better comparison.

Chapter Five

CONCLUSION & RECOMMENDATIONS

5.1 A Summary

From these results it can be concluded that the actual recorded daily and weekly flight times did not appear to adequately represent the average reported daily and weekly flight times. Further, there did not appear to be strong evidence of safe daily or weekly flight time limits being exceeded with any regularity. No participant actually flew more than 8 hours on any day, or 35 hours over the week that the Time Diary was completed. This may be due, however, to factors such as the participants overestimating how much they actually fly during an average week, or more likely, that the week during which they completed the Time Diary was not an average one, as many of the participants stated.

In contrast to this, there was strong evidence of both daily and weekly safe duty times being exceeded, both during an average week, and during the week that the Time Diary was completed. As the flying had not exceeded any safe limits it was concluded that the long duty times must be, at least partly, as a result of the many other duties that the participants were involved in. Duties such as ground briefings/debriefings, staff supervision, theory lectures, staff training, reception/administration, flight examining, management, event planning and operations, accounts/budgeting, maintenance controller, quality assurance, and safety. The problem of long duty times was exacerbated if the participant had secondary employment outside their aviation job. Participants may need other employment due to the fact that Flight Instructors in general aviation are not very well paid, and these secondary jobs are often at night. Working at more than one job could result in a lack of sleep, and this was indeed a very common opinion among the people who were interviewed. This reduction in the amount of sleep can, in turn, lead to fatigue and a decrease in performance.

The vast majority of participants and people interviewed admitted to having flown while tired. It was difficult to ascertain from the data in the Time Diary what variables were responsible for the participants feeling this way, however the time of day that the flight took place did appear to play a small but significant part in predicting tiredness of the Flight Instructor. Another reason may have been the extremely large frequency of relatively short flights. This type of flight can be very tiring due to the high workload while taking off and landing, as well as the instructional stressors, all within a short amount of time. Many Flight Instructors involved in the study also thought that their performance had been affected at some time, and the data from the Time Diary showed that almost 50% of this could be explained by how tired the Flight Instructor was feeling at the time.

Despite many people having flown while feeling tired, there were few of them who engaged in using preventative strategies against fatigue, such as having an early night prior to a long day at work. Evidence of operational countermeasures was also lacking, with many people missing meals or eating at irregular intervals, and not planning any meal or rest breaks into their day.

Finally the generic type of Flight Instructor that exceeded the flight and duty times in this study was male, aged in their late 20's or early 30's. They were quite experienced Flight Instructors, with many endorsements to their Flight Instructor Rating, and often also a tertiary qualification. They mostly flew with full time students, and had more than the average number of duties and responsibilities. Surprisingly they often did not have any other employment, and it did not seem to matter what part Flight Instructing was playing in their career path.

Given that there was strong evidence of the potential for fatigue due to long duty times, even with the small number of participants in this study, it would appear that fatigue could be quite pervasive throughout the flight instructing population in the general aviation arena. If this is the case, it should be of grave concern to the New Zealand CAA as the governing aviation body. As a first

step there needs to be more education on practical ways for Flight Instructors to help prevent fatigue in their operations, not just on the theory of basic causes of fatigue and how it may affect pilots.

All legislators should regularly revise and, if necessary in the light of any new information, update their laws. In 1999 a representative of the FAA stated that:

“We believe that it is critical, whenever possible, to incorporate scientific information on fatigue and human sleep physiology into regulations on flight crew scheduling. Such scientific information can help to maintain the safety margin and promote optimum crew performance and alertness during flight operations.” (Gilligan, 1999, p.1).

In following this sort of thinking, the New Zealand CAA should look at legislation of Flight Instructors by imposing maximum Flight and Duty Times similar to what are used in Air Transport Operations. The FAA also looked into reducing the complexity of Flight and Duty Time rules by making them as standardised as possible across all types of flight operations (Gilligan, 1999), and to a certain extent this is already the case with New Zealand CAA laws.

If we consider that student pilots are just as much paying passengers as any person on a commercial flight with an airline, then they deserve to be given the same consideration with regard to their safety. To this end it should be ensured that any Flight Instructor is subject to the same restrictions that a pilot on any Air Transport flight is, and should have set maximum limits to the amount of time that they are allowed to work and fly. At present we are not able to control all the factors that contribute to a flight, so accidents will still happen. However if we can minimise the risk factors that play a role in these accidents, we can make each flight as safe as possible, given current technology and knowledge levels.

5.2 Areas For Future Research

Many issues raised in the discussion on the limitations of this study could easily be overcome if a large aviation organisation, such as the New Zealand CAA,

became involved. Since they have access to a full list of qualified Flight Instructors the sample to be studied could be more statistically random. They have the means to get a larger number of participants involved, and could also give an incentive for people to participate in the study. There could be more focus on part-time Flight Instructors, particularly those with secondary employment. The research could also cover a longer period of time, not just one week, so that factors that can't be controlled, such as weather, have less of an impact on the data. Finally physiological measures could be taken to back up subjective fatigue and tiredness data. If it was possible to precisely identify the type of Flight Instructor most at risk of succumbing to fatigue, then the New Zealand CAA could target them with better educational information regarding fatigue, and better legislate their work arena, to minimise the potential for fatigue.

Glossary

ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
CAA	Civil Aviation Authority
CAO	Civil Aviation Orders
CAR	Civil Aviation Rule
CFI	Chief Flying Instructor
CFIT	Controlled Flight Into Terrain
CRM	Crew Resource Management
EEG	Electroencephalographic
EMG	Electromyographic
EOG	Electro-oculographic
FAA	Federal Aviation Administration
IFR	Instrument Flight Rules
JAA	Joint Aviation Authority
LAME	Licensed Aircraft Maintenance Engineer
MCTOW	Maximum Certified Take-Off Weight
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
REM	Rapid Eye Movement
SCN	Suprachiasmatic nuclei
UK	United Kingdom
ULR	Ultra-long range
U.S.	United States (of America)
VFR	Visual Flight Rules

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APPENDIX A

Information Sheet



Flight and Duty Time Study **INFORMATION SHEET**

1. *Primary researcher:* Amanda J. Walton, B.Sc., School of Aviation, Ardmore Flight Systems Centre, A.J.Walton@massey.ac.nz, mobile: 021-470076, DDI: 09-296 4514

Supervisor: Dr Bernie Frey, School of Aviation, QA2.03, Albany, B.F.Frey@massey.ac.nz, mobile: 021-349969, DDI: 09-4418155
2. *The nature and purpose of the study:* This study aims to investigate the flight and duty times of Flight Instructors in General Aviation, and the time spent on other activities outside the flying environment.
3. *What will be asked of the participants, including time involved:* You are asked to complete a questionnaire, which should take approximately 10 minutes. You are also asked to complete a diary, noting how your time was spent throughout each day, for seven consecutive days. This should take approximately 10 minutes per day.
4. *How the information will be used:* The information that you provide will be compared with the flight and duty time schemes for Air Transport pilots, as laid down in Civil Aviation Rules.
5. *What will happen to the information when it is obtained:* The information that you provide will be stored on a password protected computer, and the paper documents stored in a locked filing cabinet in a locked office.
6. *How confidentiality and anonymity will be protected:* The documents contain no identifying references, unless you wish to include them. Any future reports that are prepared from this study will not contain any identifying personal information.
7. *The rights of the participant(s):* You have the right
 - to decline to participate;
 - to refuse to answer any particular questions;
 - to withdraw from the study at any time prior to posting the completed documents;
 - to ask any questions about the study at any time during participation;
 - to provide information on the understanding that your name will not be used unless you give permission to the researcher;
 - to be given access to a summary of the findings of the study when it is concluded.

This project has been reviewed and approved by the Massey University Regional Human Ethics Committee, Albany Campus, Protocol MUAHEC 02/024. If you have any concerns about the conduct of this research, please contact Associate-Professor Kerry Chamberlain, Chair, Massey University Regional Human Ethics Committee, Albany, telephone 09 443 9799, email K.Chamberlain@massey.ac.nz.

If you wish to receive information about the findings of this study, please complete your name and address details below:

NAME:.....

POSTAL ADDRESS:.....

.....

.....

.....

APPENDIX B

Questionnaire



As part of the Flight and Duty Time Study, please take a few moments to answer this questionnaire.

1. **Gender:** (please tick one) ☐ Male ☐ Female
2. **What is your age?**years old
3. **What year did you start your own flight training?**
4. **When did you gain your Flight Instructors Rating?**.....
5. **What flying qualifications do you currently hold?** (please tick as many as necessary)
 - ☐ D Category Flight Instructor Rating
 - ☐ C Category Flight Instructor Rating under direct supervision
 - ☐ C Category Flight Instructor Rating out of direct supervision
 - ☐ B Category Flight Instructor Rating
 - ☐ A Category Flight Instructor Rating
 - ☐ Night Instructor Rating
 - ☐ Multi-Engine Instructor rating
 - ☐ Aerobatics Instructor Rating
 - ☐ Instrument Flight Instructor privileges
 - ☐ Flight examining privileges (including any internal flight tests required by your organisation)

6. **What type of students do you fly with?** (please tick as many as applicable)
- ☐ student attending a full-time aviation course
 - ☐ student flying on a casual basis
 - ☐ Other (please state).....
7. **What duties do you carry out as a Flight Instructor at your organisation?** (please tick as many as necessary)
- ☐ Airborne Flight Instruction
 - ☐ Ground flight briefings/debriefings
 - ☐ Supervision of other Flight Instructors
 - ☐ Supervision of solo student flights
 - ☐ Ground Theory Lectures
 - ☐ Other paperwork
 - ☐ Staff training
 - ☐ Reception/Administration
 - ☐ Flight Examining
 - ☐ Air Transport Operations
 - ☐ Other duties (please state).....
8. **On average, how many hours per week do you spend involved in flight instruction (both airborne and ground)?**.....Hours/week
9. **On average, how many hours per day do you spend involved in flight instruction (both airborne and ground)?**.....Hours/day
10. **Do you have any tertiary qualifications (e.g. Bachelor Degree, Trade Certificate):** (please list)
-
-

11. What recreational activities are you involved with outside of flying (e.g. Sports clubs):

.....

.....

.....

12. Do you have other employment apart from Flight Instructing? (please tick one)

- ☐ No (please skip to Question 13)
- ☐ Yes

12a. Please indicate type of employment (If you have more than one job, please tick all applicable categories).

Please tick	Specify type of work	Hours per week (average)
<input type="checkbox"/> Full-time		
<input type="checkbox"/> Part-time		
<input type="checkbox"/> Casual		
<input type="checkbox"/> Self-employed		

13. What role do you consider Flight Instructing to play in your career path? (please tick the one that best describes your situation)

- ☐ Final career choice
- ☐ 'Stepping stone' to airlines
- ☐ Other(please state).....

14. **Consider the following statements:** (please circle the one that best describes your situation)

To what extent do you miss meals or eat at irregular intervals due to flying?

Very Often Often Occasionally Almost Never Never

To what extent do you fly when feeling tired or sleepy?

Very Often Often Occasionally Almost Never Never

To what extent do you have an early night if you know the following day is going to involve long working hours?

Very Often Often Occasionally Almost Never Never

To what extent do you carefully plan your day to include meal breaks and rest periods?

Very Often Often Occasionally Almost Never Never

To what extent do you feel that you become forgetful when you are tired?

Very Often Often Occasionally Almost Never Never

APPENDIX C

Introduction to the Time Diary

- Please complete one page per day, over seven consecutive days. Don't forget to note the date at the top of the page.
- Tick the category of the one main activity that occurs during that 30 minute block
- The first eight categories relate to activities outside the flying environment.
- The second eight categories relate to activities within the flying work/environment

Explanations of categories:

Non-flying:

- Sleeping: either in bed at night, or naps during the day
- Dining: eating meals at home or out at café/restaurant
- Commuting: travel to or from work/social events
- Chores: cleaning, getting groceries, tidying, mowing lawns, doing washing
- Socialising: partying, movies, meeting friends at a café/restaurant/private house
- Relaxing: at home, not working, watching tv in bed
- Work: non-aviation related employment
- Other: anything not covered in previous categories

Flying:

- Staff Training: Flying or briefing other staff for initial issue or renewal training
- Paperwork: any paperwork required by your organisation
- Briefing: briefing students prior to or after a flight
- Lecturing: lecturing a class on theory topics, preparation for these lectures
- Flight Exams: examining a student/staff member
- Lunch/Breaks: time off work to eat, grab a coffee
- Other: anything not covered in previous categories
- Flying: flight instructing (airborne). With this category you are asked to rate on a scale of 1 to 5, how tired / wakeful you were feeling during the flight.
 - 1 = not at all tired
 - 2 = a little tired
 - 3 = somewhat tired
 - 4 = very tired
 - 5 = extremely tired

You are also asked to indicate if your performance was affected by how tired / wakeful you felt (Scale of 1-5)

- 1 = not at all
- 2 = a little
- 3 = somewhat
- 4 = very
- 5 = severely

APPENDIX D:

Time Diary

Date (Day 1): _____

TIME:	Sleeping	Dining	Communting	Chores	Socialising	Relaxing	Work	Other	Staff Training	Paperwork	Briefing	Lecturing	Flight Exams	Lunch/Breaks	Other	Flying Related:	
																Do you feel tired? 1 = not at all 3 = somewhat tired 5 = extremely tired	Was your performance affected? 1 = not at all 3 = somewhat 5 = severely
0000-0030																1 2 3 4 5	1 2 3 4 5
0030-0100																1 2 3 4 5	1 2 3 4 5
0100-0130																1 2 3 4 5	1 2 3 4 5
0130-0200																1 2 3 4 5	1 2 3 4 5
0200-0230																1 2 3 4 5	1 2 3 4 5
0230-0300																1 2 3 4 5	1 2 3 4 5
0300-0330																1 2 3 4 5	1 2 3 4 5
0330-0400																1 2 3 4 5	1 2 3 4 5
0400-0430																1 2 3 4 5	1 2 3 4 5
0430-0500																1 2 3 4 5	1 2 3 4 5
0500-0530																1 2 3 4 5	1 2 3 4 5
0530-0600																1 2 3 4 5	1 2 3 4 5
0600-0630																1 2 3 4 5	1 2 3 4 5
0630-0700																1 2 3 4 5	1 2 3 4 5
0700-0730																1 2 3 4 5	1 2 3 4 5
0730-0800																1 2 3 4 5	1 2 3 4 5
0800-0830																1 2 3 4 5	1 2 3 4 5
0830-0900																1 2 3 4 5	1 2 3 4 5
0900-0930																1 2 3 4 5	1 2 3 4 5
0930-1000																1 2 3 4 5	1 2 3 4 5
1000-1030																1 2 3 4 5	1 2 3 4 5
1030-1100																1 2 3 4 5	1 2 3 4 5
1100-1130																1 2 3 4 5	1 2 3 4 5
1130-1200																1 2 3 4 5	1 2 3 4 5

TIME:	Sleeping	Dining	Communting	Chores	Socialising	Relaxing	Work	Other	Staff Training	Paperwork	Briefing	Lecturing	Flight Exams	Lunch/Breaks	Other	Flying Related:	
																Do you feel tired? 1 = not at all 3 = somewhat tired 5 = extremely tired	Was your performance affected? 1 = not at all 3 = somewhat 5 = severely
1200-1230																1 2 3 4 5	1 2 3 4 5
1230-1300																1 2 3 4 5	1 2 3 4 5
1300-1330																1 2 3 4 5	1 2 3 4 5
1330-1400																1 2 3 4 5	1 2 3 4 5
1400-1430																1 2 3 4 5	1 2 3 4 5
1430-1500																1 2 3 4 5	1 2 3 4 5
1500-1530																1 2 3 4 5	1 2 3 4 5
1530-1600																1 2 3 4 5	1 2 3 4 5
1600-1630																1 2 3 4 5	1 2 3 4 5
1630-1700																1 2 3 4 5	1 2 3 4 5
1700-1730																1 2 3 4 5	1 2 3 4 5
1730-1800																1 2 3 4 5	1 2 3 4 5
1800-1830																1 2 3 4 5	1 2 3 4 5
1830-1900																1 2 3 4 5	1 2 3 4 5
1900-1930																1 2 3 4 5	1 2 3 4 5
1930-2000																1 2 3 4 5	1 2 3 4 5
2000-2030																1 2 3 4 5	1 2 3 4 5
2030-2100																1 2 3 4 5	1 2 3 4 5
2100-2130																1 2 3 4 5	1 2 3 4 5
2130-2200																1 2 3 4 5	1 2 3 4 5
2200-2230																1 2 3 4 5	1 2 3 4 5
2230-2300																1 2 3 4 5	1 2 3 4 5
2300-2330																1 2 3 4 5	1 2 3 4 5
2330-0000																1 2 3 4 5	1 2 3 4 5

Please note: This shows only one day of the Time Diary. The other six days were identical to this.

Thank you for taking the time to participate in this study. Finally, do you think that the past week, during which you have been completing the Time Diary, has been an average one (please circle one)? **YES / NO**

If not, please explain why. _____

APPENDIX E
Interview Sheet

Good morning/afternoon. I am currently completing a thesis on Fatigue in Flight Instructing in General Aviation Flight Instructors. I would like to ask you some questions regarding other employment that you may have had while working as a Flight Instructor. This will only take 3 minutes of your time, and the information would be very helpful to my research. Would you like to participate in this study??

(If no) Thank you for your time. (Terminate Interview).

(If yes) Thank you. You may choose to not answer any of the questions, and can terminate the interview at any time. Your name will also not be used, to ensure your privacy. Finally, I will be writing down your answers in full, so please be patient if I ask you to pause at any stage.

1. Have you ever had any other employment while you were part-time Flight Instructing?
2. (If yes) What industry was this employment in?
3. Have you ever had any other employment while you were full-time Flight Instructing?
4. (If yes) What industry was this employment in?
5. Do you think you lost sleep due to working more than one job?
6. How long did you work at more than one job for?
7. Do you recall ever doing airborne Flight Instructing while you felt tired?
8. Do you think your performance was affected in any way due to feeling tired or fatigued?

Thank you for your participation and time. If you would like to receive a copy of the results of this study, I will separately note your name and address.

APPENDIX F
Participating Organisations

Places participating:

Name:	Number of copies:	Date given/posted:
Ardmore Helicopters	2	22-10-02
Auckland Aero Club	7	30-10-02
Canterbury Aero Club / IAANZ	6	16-10-02
Christchurch Flying School	4	16-10-02
Flight 2000	?	30-10-02
Greymouth Aero Club	2	30-10-02
Helipro Palmerston North	1	30-10-02
Kaikoura Aero Club	1	30-10-02
Kapiti Aero Club	10	29-10-02
Massey University, Ardmore	16	13-10-02
Massey University, P. North	11	22-10-02
Mercer Flying Centre	3	22-10-02
Nelson Aero Club	6	30-10-02
Nelson Aviation College	17	30-10-02
Northland Districts Aero Club	3	30-10-02
North Shore Aero Club	15	29-10-02
North Shore Helicopters	4	22-10-02
Otago Aero Club	3	30-10-02
Tauranga Aero Club	9	30-10-02
Rotorua Aero Club	5	31-10-02
Wakatipu Aero Club	5	30-10-02
Wellington Aero Club	3	31-10-02
Total:	133	