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Aircrew Fatigue Management in the New Zealand Aviation Industry

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ABSTRACT

In the past two decades, fatigue has been widely studied and has proven scientifically to be a threat to flight operations and aircrews, as evidenced in disastrous aviation accidents. Internationally, it is recognised that the prevention or minimization of fatigue requires a collaborative approach, hence not just individuals. However, because of individual differences in coping with fatigue, the complex factors associated with fatigue, and the dynamics in aviation operations, it has proven unrealistic to expect to have a "one size fits all" policy to manage fatigue.

Nevertheless, with increased competition in the aviation domain, aircrews are increasingly made to work according to organisational requirements through rosters or schedules that function in "24/7" settings. Such arrangements have been, and are still being mandated by flight and duty time limitations in civil aviation rules elsewhere. With increased knowledge on the effects of fatigue in the cause of accidents and incidents, it has for some time been known that the historical prescriptive approach does not address potential fatigue-related factors. Australia and New Zealand Civil Aviation Authorities have led the way in developing an alternative approach in the management of fatigue, in a move to operate beyond mandated flight and duty time limitations. Such an approach does not intend to breach current prescriptive rules, but rather incorporate industry views by establishing an alternative strategy in managing aircrew fatigue considered best for the operation, organisation and the pilot.

Given the minimal information available on fatigue management in the New Zealand Aviation Industry, this study was initiated to gather perceptions from management, rostering staff and pilots on how their organisations are currently managing fatigue, via a questionnaire.

Results of the study showed that 33% of participants reported maintaining AC119-2 in meeting their flight and duty time limits, 9% indicated using AC119-2 with

dispensations, 11% stated that they have an accredited fatigue management scheme, 10% indicated "don't know" and 38% reported using "other" methods as an alternative to mandated flight and duty time rules. The high percentage of participants opting for "other" methods is an indication that participants are not confident in positively identifying constructive strategies existing within their organisation. This reveals that knowledge on current rules and guidelines pertaining to flight and duty time limitations is lacking.

The main implication of the study is that knowledge on prescribed flight and duty time limitations (AC119-2) and fatigue management (AC119-03) in the aviation industry requires substantial enhancement to ensure an effective and sustainable non-prescriptive approach in the management of fatigue. The study further suggests that more informed education on AC119-2 could be advocated in the industry as a starting point, which may form a strong and mature basis for the development of successful and effective fatigue management schemes. These suggestions warrant a participatory and combined effort involving the New Zealand Civil Aviation Authority and the New Zealand Aviation Industry.

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INTRODUCTION

The present study was undertaken to gather information on how aircrew fatigue is managed in the New Zealand Aviation Industry.

Chapter One of this thesis outlines the scientific knowledge on fatigue and how it has contributed largely to the need for fatigue management in the aviation industry. Three main contributing factors of fatigue are discussed:

- *Circadian factors*: the underlying physiological processes that effectively programme individuals to sleep at night and stay awake during the day;
- *Sleep-related factors*: the physiological requirement for an optimal daily amount of good quality sleep and;
- *Work-related factors*: the type of work being performed, workload and the duration of the duty period.

This chapter further investigates fatigue and its impacts on current activities and arrangements in light of the move from a prescriptive approach to a non-prescriptive approach in the management of fatigue. The chapter concludes with the aims of the study.

Chapter Two presents the methods utilised in this study, with a description of the collection of data, along with data management and statistical analyses.

Chapter Three consists of descriptive results of the study. Results are primarily presented by way of bar graphs and tables.

Chapter Four draws together the study findings and presents implications of the results. In addition, future recommendations and conclusions are presented which could be of significant use to the New Zealand Aviation Industry, in particular the New Zealand Civil Aviation Authority (NZCAA).

Terminology

The term “aircrew” refers to pilots, flight engineers, flight navigators, flight attendants and other responsible persons who make up the team in a particular flight and whose primary function is to ensure safety of that flight. “Pilots” therefore are members of aircrew and the two terms will be used interchangeably.

The term “fatigue” specifically refers to aircrew or pilot fatigue; however, in cases of broader exploration and comparison, it also refers to people in other workplaces.

An “occurrence” is a term referring to an accident or incident (CAA, 1999). However, in cases where specific occurrences are reported, the terms, “accident” and “incident” will be used separately.

For the purpose of this thesis, the terms “Operators” and “participants” refer to those people in Part 119 Certificated Organisations and, therefore, will be used interchangeably.

CHAPTER ONE
BACKGROUND AND LITERATURE REVIEW

Humans are diurnals with circadian rhythms that are mandated by their internal body clock or pacemaker to be active in the day and asleep at night (*OTA-BA-463*, 1991). Intensive research on fatigue and its causes has had a significant impact in enhancing knowledge and understanding this area of study, which is of great importance to industries including aviation. Uncontrollable sleepiness at one end of the continuum, and tiredness at the other less severe end are better understood than in the past three decades (Gander, 2000). Although agreement on the definition of fatigue remains a pertinent issue, it is accepted that fatigue "makes a person unable (as opposed to unwilling) to achieve a sufficiently high standard of performance" (Gander, 2000 p. 51). Therefore, on the basis of this understanding, a positive step to effective fatigue management is to focus not only on the individual worker but also to be integrated and involve governments, policy makers, regulators and everyone who has a direct or indirect role to play in safety, hence, a comprehensive approach (NTSB, 1994; Rosekind, Gander, Gregory, Smith, Miller, Oyung, Webbon & Johnson, 1996; Gander, Waite, McKay, Seal & Miller, 1998).

1.1 General Overview

The aviation industry is continuously expanding as a result of increased competition. As a result, 24-hour operations emerged with advanced technology which culminated in the demand for more workers to ensure work continuity and productivity. Consequently, this results in significant changes in the industry in terms of workforce requirement, and in particular, the times at which people are required to work. Working outside normal hours, extended hours of work, and morning/night shifts in an around-the-clock time frame, are part of this new requirement (Dinges, 1995).

Although this new pattern of work positively contributes to the industry's economic productivity, it has been recognised to have negatively affected the physiological patterns of humans (*OTA-BA-463*, 1991).

Humans, on the other hand, remain central to the challenges posed by this new change. Amongst these challenges is the widely reported and recognised effect of *fatigue*, which is often exacerbated by the contributory effects of jet lag and shift-work in aviation operations and activities (Mitler, 1988; Wiegmann, 2000).

1.2 Fatigue in Aviation Operations

1.2.1 Defining fatigue

> "………for fatigue to be managed effectively, it must be defined and its major causes understood."
>
> **(Gander, 2000 p. 51)**

Fatigue is a term referring to a range of negative experiences such as sleepiness, tiredness and exhaustion and has always been a normal response to flight operations (Strauss, 1999; Bourgeois-Bougrine, Cabon, Gounelle, Mollard & Coblentz, 2003; Caldwell, 2003). Defining fatigue has proven difficult. Such difficulty appeared to be more related to the imprecision of identifying real causes of fatigue (statement by Dr. Williams Dement, cited in Caldwell, 2003). As such, Dr. Dement stated that "95% of fatigue results from either sleep deprivation or undiagnosed, untreated sleep disorders rather than boredom, monotony, stress, or unclearly defined biological processes" (Caldwell, 2003). In line with this, other researchers have concluded that "fatigue has yet to be fully defined in a concrete fashion" (Maher & McPhee, 1944 cited in Battelle Memorial Institute, 1998 p. 1) and others stating that "the major problem with fatigue issues is the lack of a coherent definition of fatigue itself…" (Bourgeois-Bourgrine et al., 2003 p. 1072).

Fatigue, then, has never been universally defined; however, conceptual definitions of such a term used in the transport industry have referred to both symptoms and contributory factors as follows:

- Impaired performance (loss of attentiveness, slower reaction times, impaired judgement, poorer performance on skilled control tasks and increased probability of falling asleep) and subjective feelings of drowsiness or tiredness;
- Long periods awake, inadequate amount of quality sleep over an extended period, sustained mental or physical effort, disruption of circadian rhythms (the normal cycles of daytime activity and night sleep), inadequate rest breaks, and environmental stresses (such as heat or extreme temperatures, noise and vibration).

(Fatigue Expert Group, 2001 p. 21)

Based on given symptoms and contributory factors in defining fatigue, the above components are not different from those highlighted in an earlier report which stated that a "common fatigue symptom is a change in the level of acceptable risk an individual will tolerate" (Battelle Memorial Institute, 1998 p. 2). Additionally, these authors suggested that these theoretical definitions of fatigue are caused by both "antecedent and consequent events and variables" which have "physiological and performance consequences".

In order to understand the possibility of minimizing or preventing fatigue, it is therefore important to consider these antecedent conditions which are relevant for our discussion:

- Time on task, including flight time and duty period duration;
- Time awake when beginning the duty period;
- Acute and chronic sleep debt and;
- Circadian disruption, multiple time zones, and shift work.

(Battelle Memorial Institute, 1998 p. 2)

Sleep and circadian factors appear to be the main contribution to fatigue as given in the above definitions. This is in line with other reports stating that sleep and circadian factors are "especially problematic for modern aviators" (Caldwell, 2003) and others highlighting "two principal physiological factors that account for 85 to 90% of fatigue are sleep and the circadian clock", (Rosekind, et al., 2002). A sleep expert identified and described the three main causes of workplace fatigue as follows:

- Trying to work after inadequate sleep. Both the duration and quality of sleep are important for restoring waketime function.
- Trying to work against the circadian biological clock in 24-hour operations.
- The duration of a duty period, and the pattern of workload and breaks across it.

(Gander, 2000 p. 51)

According to the above findings, the symptoms of fatigue are evident after a significant amount of sleep deprivation as experienced by pilots. Acute sleep deprivation or sleep loss often accumulates into a sleep debt, which is also frequently identified as an antecedent condition of fatigue in pilots (Airbus Industries, 1995).

Fatigued individuals are found to be more inclined to accept risk or engage in activities considered more risky, in an attempt to avoid additional effort (Barth, Holding & Stamford, 1976). This behaviour has been identified to be evident in individuals who have been sleep-deprived, or when they were working during their "window of circadian low"[1] (Hamilton, Wilkinson and Edwards, 1972).

Given these two underlying factors described to be the main causes of fatigue, and since pilots' duties generally involve working in the abnormal hours of the day (shift-

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[1] It is the period of lowest activity across physiological systems and human functioning. According to the authors, there are two periods of circadian low. One is a larger window covering the hours of 12am to 6am, while the second window covers a period in the afternoon, 3pm to 5pm in which sleepiness is greatest (Rosekind, Gregory, Miller, Co, Lebacqz and Brenner (1996).

work), unpredictable schedules, and crossing different time zones (most common among long-haul operations), "fatigue" will be defined in this thesis as:

> "the state of tiredness that is associated with long hours of work, prolonged periods without sleep, or the requirement to work at times that are 'out of synch' with the body's biological or circadian rhythms."
>
> **(Caldwell, 2003 p. 15)**

1.2.2 Examples of fatigue in occurrences

A statement from a group of international scientists reported by NASA Ames Research Centre and NTSB identified:

> "........fatigue as the largest identifiable and preventable cause of accidents in transport operations (between 15 and 20% of all accidents), surpassing that of alcohol or drug related incidents in all modes of transportation."
>
> **(Rosekind et al., 2000 p. 1)**

Human need for quality sleep and a stable circadian clock can be disrupted by 24/7 operational requirements. This disruption can lead to fatigue and decreased performance and alertness, errors, incidents and accidents (FAA, 2004).

In other sectors, the increase in fatigue risk has also been widely regarded as a significant safety factor in incidents and accidents. For example, in a 1990 review of the United Kingdom confidential aviation safety reporting system (CHIRP), approximately 13% of Air Traffic Control incident reports were related to controller fatigue or fatigue-related factors (Gander, 2000).

In the United States, fatigue was determined to be the "most common probable cause" (31%) of fatal-to-the-driver heavy trucking accidents (Gander & Miller, 1999). Causes of incidents and accidents such as the 1979 Three Mile Island nuclear power plant, the 1984 pesticide plant disaster in Bhopal, the 1986 Chernobyl nuclear power plant explosions, and the grounding of the oil tanker Exxon Valdez, were all related to fatigue (Dinges, 1995; Lauber & Kayton, 1988; Mitler et al., 1988; Mitler et al., 1994,).

The Canadian Trucking Association reported that 30 to 40% of collisions in the heavy truck industry in North America were related to fatigue (Canadian Trucking Association, 1996).

In current aviation operations, human fatigue is internationally widely recognised as a contributory factor (Wiegmann & Shappell, 2000; Goode 2003; Caldwell & Caldwell 2003; Mallis, 2003). More in-depth investigations and the growing knowledge on fatigue, have led to more recent scientific-based studies. These studies have enabled identification of fatigue as a causal factor evidenced in the following occurrences (Rosekind et al., 1996; NTSB, 1996). The first air accident ever to be identified as caused by fatigue occurred in August 1993 and involved a DC-8-61 freighter, flying into Cuba (Flight Safety Australia, 1999). The NTSB (National Transport Safety Bureau) reported:

> "that the probable causes of this accident were the impaired judgment, decision-making, and flying abilities of the captain and flight crew due to the effects of fatigue......"
>
> **(NTSB, 1994 p. 78)**

The captain was concentrating on one part of the approach procedure and had neglected to respond to warnings from the other pilot saying that they were approaching stalling speed (NTSB Aircraft Accident Report, 1993). The NTSB recognised this failure as a common symptom of fatigue.

Six years later, in 1999, another accident was investigated and the NTSB concluded fatigue was a causal factor. The accident involved Korean Air Flight 801 conducting an instrument night approach into Guam Airport when it descended 800 feet below the minimum prescribed altitude. It was reported that the ILS glide slope was unavailable so the aircrew were advised to switch to VOR/DME approach. The Captain failed to brief the First Officer and execute the non-precision approach. The disaster was due to fatigue which was concluded by the NTSB as stated below:

> "the captain was fatigued, which degraded his performance and contributed to his failure to properly execute the approach."

(NTSB, 2000 p. 173)

Broadbent (1953) and Horne (1988) stated that fatigued workers lose the ability to perceive and adjust to a given new task or setting. They also stated that workers have been identified as being unable to shift quickly and effectively from one system to another.

1.2.3 Why is fatigue under-reported?

An analysis determining fatigue in relation to incidents in the United States was carried out in 1980 using data available from the National Aeronautics Safety Administration (NASA) through its Aviation Safety Reporting System (ASRS) (Lyman & Orlady, 1980). The analysis indicated that, since 1976, only 3.8% of air accidents were directly related to fatigue. However, when all occurrences that mentioned fatigue were added, it was found that the figure increased to 21% of all air accidents (Graeber, 1988; Battelle Memorial Institute, 1998).

Fatigue has been recognised in Australia to be a contributory factor to aviation accidents. This recognition led to efforts to analyse accidents related to fatigue. Estimates revealed that approximately 7% of all air accidents were related to fatigue, however, it was generally argued that this figure was relatively low and that actual figures could be much higher (*Beyond the midnight oil*, 2000).

In New Zealand, the Civil Aviation Authority (NZCAA) reported that only 0.2% of aviation incidents were fatigue-related, however, the CAA recognised that this figure was an underestimate and that the real rate could be closer to 25% (CAA, 2000).

It was argued that the system of reporting fatigue used was based on 'self-reporting and individual assessment (Graeber, 1985). Additionally, due to the absences of 'fatigue-markers' and blood test, the situation has made it difficult for investigators to determine individual levels of fatigue (Caldwell & Caldwell, 2003).

Researchers have identified that an individual's assessment of fatigue can be unreliable because it has always been a personal experience (Lyman & Orlady, 1980; Graeber, 1988; Kirsch, 1996 cited in Battelle Report, 1998). For example, some pilots thought they were alert when in fact they were falling asleep (Dement, Carskadon and Richardson, 1978; Roth, Roehrs, Carskadon and Dement, 1994). Some pilots may view occurrences to be related to fatigue, while others may perceive them to be associated with lack of concentration and/or communication (Graeber, 1988; Battelle Memorial Institute, 1998).

More recent scientific studies have identified inadequate sleep and sleep loss to be the main causes of fatigue (Rosekind et al., 1997). However, it has been indicated that individuals cannot judge their own levels of biological sleepiness (Neri, Dinges and Rosekind, 1997; Mallis, 2003). Because of this inability, it is believed that pilots cannot assess their own levels of fatigue and therefore may be unable to identify fatigue as a probable cause of an occurrence (Mallis, 2003).

1.2.4 Fatigue in long- and short-haul flight operations

Flight operations can be categorized into two types: long-haul and short haul. Because such operations differ in flight duration and workload involved, it is important to examine the extent to which fatigue is experienced by aircrews working in the two types of flight operations. Significant features of long-haul flight operations generally involve crossing multiple time zones and long duty hours that sometimes coincide with circadian nadir of performance (Wright & McGown, 2001). Short-haul flight operations are generally associated with multiple flight segments and overnight layovers after successive day duties (Gander et al., 1994).

In a study of international pilots, (n=188) by Petrie and Dawson (1997), pilots of both long-haul and short-haul operations described their problems in relation to fatigue as follows:

- Sleep deprivation and circadian disturbances were experienced due to impacts of crossing time zones amongst aircrew flying long-haul flight schedules.
- Sleep or rest considered not quality due to environmental factors such as noise, turbulence, temperature, lighting and other negative factors amongst long-haul aircrew.
- In short-haul operations, pilots attributed their fatigue levels to sleep deprivation and higher workloads than long-haul pilots.
- Overall, both long-haul and short-haul pilots were being challenged by problems associated with scheduling factors, extended duty periods, sleep deprivation and circadian disruptions.

Studies that examined fatigue in pre-, in- and post-flight operational settings were carried out amongst aircrew of long-haul flight operations on transmeridian routes in Germany. Flight durations for such flights extended between 8:50 to 11:50 hours (Samel et al., 1997). They found that fatigue was pronounced, particularly on return flights, and consequently, several pilots rated the condition as 'critical'.

The effects of fatigue in long-haul flight operations in Australia have recently been examined (Flight Safety Australia, 2005). Their findings showed that fatigue in these flight operations could be caused by various factors including "transmeridian travel causing a mismatch between patterns of sleep and the cycle of day and night; extended overnight flights; consecutive night work; and the length of time worked".

Also, during long-haul flight operations, in-flight evaluations via EEG experiment have been conducted to determine the presence of microsleeps occurring amongst aircrews. Results indicated that microsleeps do occur in cockpit crews during to low workload (Cabon et al., 1993) and were often more pronounced during the cruise portion of flights, most of which were conducted during the night (Wright & McGown, 2001).

A study determining fatigue was conducted on commercial short-haul trips. Such trips involved crossing no more than one time zone, lasted an average duty time of 10.6 duty hours, and included 4.5 to 5.5 of flight hours (Gander, Gregory, Graeber, Miller and Rosekind, 1998). They found that "the crewmembers slept less, woke earlier, and reported having more difficulty falling asleep, with lighter, less restful sleep than pretrip."

The causes of fatigue in short-haul flight operations were related more to insufficient and poor quality sleep (Flight Safety Australia, 2005), prolonged duty periods and early wake-up times (Bourgeois-Bourgrine et al., 2003).

In summary, fatigue, its symptoms and causes need to be understood explicitly for it to be managed, its risks minimized, and prevented from potentially affecting aircrew.

1.2.5 How does fatigue contribute to accidents?

International organisations such as the International Civil Aviation Organisation (ICAO) and agencies like NTSB and ATSB have carried out much academic work into incident/accident investigations. One of the most widely used models for determining the causes of safety-related occurrences was designed by James Reason (1990) (CAA, 2000). The model has been used and adapted by various organisations, including human factors experts in aviation such as those of the FAA (Shappell & Wiegmann, 2000) and personnel responsible for incident investigation policies such as those in the NZCAA (CAA, 2000).

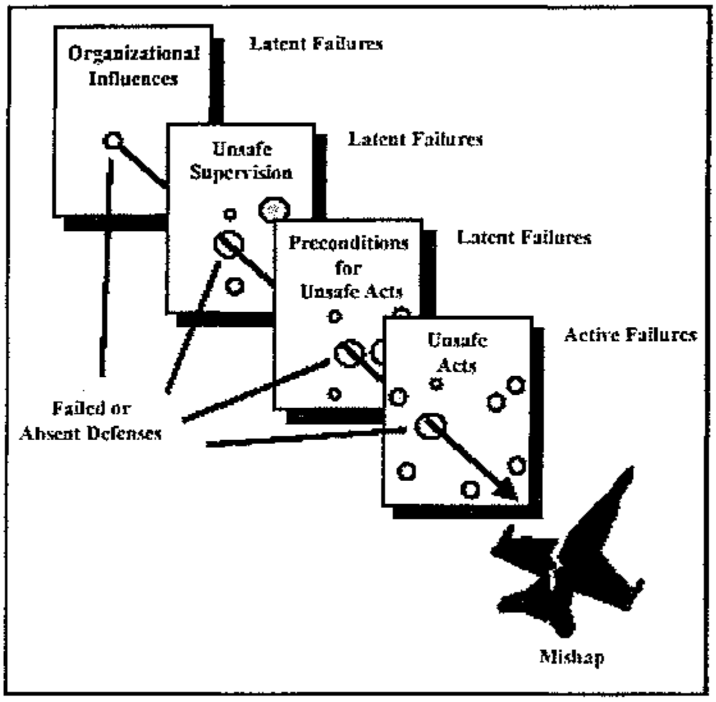

Figure 1.1 Latent failure model of human error causation, "the Swiss Cheese", by James Reason (1990). Adapted from Shappell & Wiegmann (2000)

The model above (Figure 1.1) describes the basic principles of human failure existing on four different levels, each influencing the next, with 'holes' indicating the chances that accidents can happen at anytime in any part of a system. Prevention of such accidents requires collaborative effort between everyone in an organisation, including decision makers (organisational influences, at the far end of the mishap continuum), line management (unsafe supervision) and aircrew (unsafe acts, mostly referred to as pilot error) at the first level next to where the mishap happens. Sadly, but realistically speaking, pilots in particular are most vulnerable to mishaps. The third level (preconditions for unsafe acts) is referred to as a level involving conditions such as fatigue, poor communication and coordination practices (frequently referred to as crew resource management) (Shappell & Wiegmann, 2000).

The significance of such an approach in determining the causes of safety-related occurrences is that it freely allows the organisation to recognise, manage and prevent these preconditioned unsafe acts from occurring and causing an accident. Such preconditioned unsafe acts or latent failures, one of which is fatigue, may have been lying dormant within a system and consequently, have often been overlooked by investigators (Shappel & Wiegmann, 1996, 1997a, 2000).

It is therefore evident that, for fatigue to be managed effectively, it requires a combined and collaborative effort from all levels in an organisation in the prevention of an accident.

1.2.6 Fatigue and domestic activities

> "Fatigue is different from many other workplace hazards in that it is affected by life outside of work as well as work demands"
>
> **(Gander, 2003 p. 159)**

Under the Occupational Health and Safety Act of 1992, employers have a responsibility to provide a safe work place and safe work practices for their employees. On the other hand, employees have a duty of responsibility under this Act to report fit for work, perform work to an acceptable standard, and behave in a safe manner (Baker et al., 1999; Gander, 2003).

From this perspective, fatigue may theoretically be caused by either work-related or non-work related activities (Baker et al., 1999). For example, work-related fatigue could be a result of concentration for extended periods of time or working in high-risk situations such as those found in approach-landing phases of a flight. Non-work-related fatigue could arise from difficulties such as domestic problems, which may include ill family members, financial pressures or social disputes. Such problems could negatively affect the performance of an individual because they are essentially part of life that demand energy, time and attention (Gander, 2003) and therefore may add to the burden of an already fatigued individual.

A second job, extended hours of work, and working outside normal working hours could cause the individual to compensate for increased time spent at work, thereby reducing time available for sleep, friends, family and domestic activities (Baker et al., 1999; Fatigue Management Guide, 2005).

Providing fatigue education to aircrew and their family members could be one way of fostering cooperation and awareness for aircrew to better manage their own safe practices (Gander, 1998).

1.3 Underlying Biological Factors

One approach in determining fatigue effects on aircrew performance would be to examine circadian, sleep and work-related factors.

1.3.1 Circadian factors: overview

The human system has numerous biological activities that 'wax and wane' in cyclical patterns and function in certain periods, such as in a day, a month or a year (OTA-BA-463, 1991). Rhythms that repeat in cycles of approximately 24 hours are called *circadian rhythms*. The word circadian, comes from the Latin words *circa*, meaning around, and *dies*, day.

The internal clock or the pacemaker, located in the region of the brain called the suprachiasmatic nucleus (SCN) generates circadian rhythms, controls and maintains them in synchrony with many other cycles, which include digestion, hormone secretion, body temperature, cognitive and performance levels, responses to stimuli, and sleep-wake cycles (OTA-BA-463, 1991; Ashcoff, 1969; Ashcoff et al., 1974). The rhythms of these processes have peaks and lows during their cycles over a period covering day and night. Additionally, these internal rhythms are exogenously timed by *zeitgebers*[2] (the German word meaning time cues) through the controlling mechanism of the

[2] Those external influences which are capable of entraining the internal clock (Aschoff, 1954, 1958 cited in Minors & Waterhouse, 1991).

internal clock. Zeitgebers tune these rhythms to the environmental time cues, producing normal diurnal and nocturnal activities (Minors & Waterhouse, 1981). For example, a human being eats and drinks to be active in the day time and reverses these activities to sleep at night time.

In order to be active in the day, an internal mechanism (influenced by the circadian clock) drives the secretion of certain hormones over night in preparation for the body's activities in the day time. Therefore, the 24 hour daily cycle occurs as a result of internal and external cues (exogenous activities such as light/dark exposures, interpersonal communication, work schedules, or group activities) that naturally vary with the rotation of the earth (Mills, 1966; Minors & Waterhouse, 1981)

Consequently, when circadian rhythms conflict with those patterns of activities in the environment, fatigue arises as a result of disrupted sleep patterns and impaired performance, and health complications arise. Such negative results have been shown to be found mostly in shift-workers, including pilots (OTA-BA-463, 1991; Caldwell, 2003).

Examples of Circadian Rhythms

Of the many internal human processes, described earlier, some of them are presented as examples showing their rhythms that peak and trough in a 24 hour period. An elegant study showing some of these processes is shown in Figure 1.2 (Gander, Graeber, Foushee, Lauber and Connell, 1994).

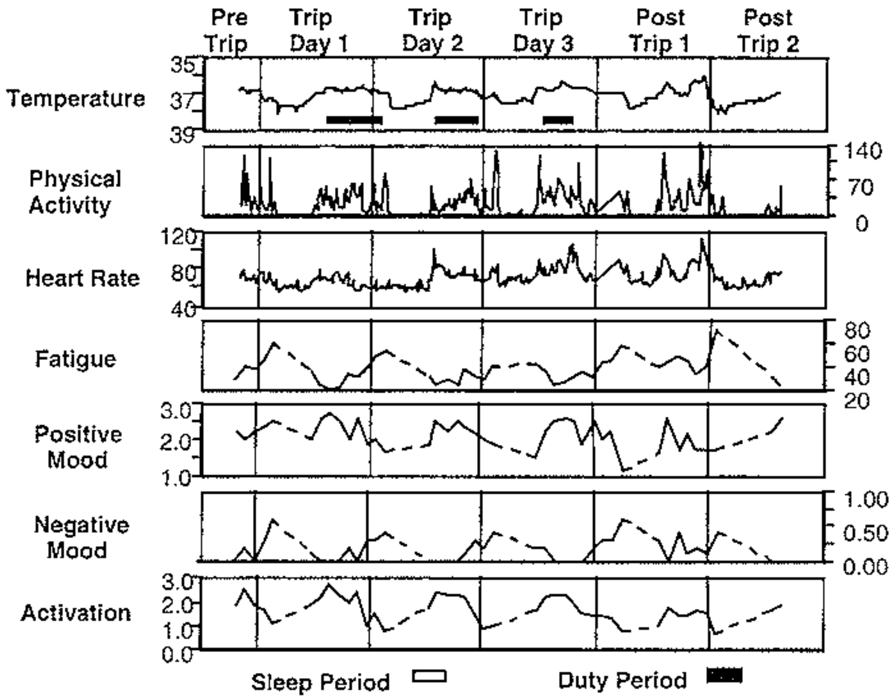

Figure 1.2 Daily rhythms of a domestic airline pilot before, during, and after a 3-day trip

In this study the rhythms of a 46 year-old DC-9 First Officer were monitored before, during, and after three days of daytime flying up and down the East Coast of the USA. These trips did not involve changing time zones. Objective measures were used to assess the pilot's temperature, physical activity and heart rate levels using certain devices. These devices included a rectal probe, which measured his core temperature; a movement recording device (now known as Actigraphy) that measured his physical activity, and three electrodes that measured his heart rate. As can be seen from the illustration, his core temperature started to rise each morning *before* he woke up. This indicates that his body was getting ready for greater energy demands of being more physically active. His circadian clock played a vital role in such preparation because it was keeping track of the time. Without the work of his circadian clock, the pilot's core temperature would only rise once he started to be more physically active.

The recording on the second panel from the top shows the pilot's physical activity levels. As can be expected, there were no or little recordings observed at night when there was very little activity. Much higher levels of activity were observed during the daytime with occasional "spikes" when he was very active. In the third panel from the top, the pilot's heart rate levels fluctuated similarly to his physical activity levels.

Subjective ratings of fatigue were also recorded by the pilot. He rated himself least fatigued about 2-4 hours after he woke up. His fatigue ratings began to climb steadily across the day. The pilot rated himself more fatigued at certain times in the experimental period. These times were found to be throughout his duty period (as illustrated by the dark black rectangles) and when both his physical activity levels and heart rates were higher. Furthermore, he rated himself less fatigued towards the end of his duty period when his physical activity levels were decreasing.

Times of peak function

There are certain times of the day where physiological and behavioural functions are at their highest level while other times have been identified when they reach their lowest levels (Rosekind et al.,1996; Dinges et al., 1996). Experts reported that these rhythms are at their lowest levels during the hours of 0200 to 0600 (Dinges et al., 1996). These particular hours fall well within the low body temperature range indicated in Figure 1.2. As a result, the level of performance largely degrades during these times. Highest subjective fatigue levels were found to happen around 0600 hours (Spencer et al., 1997).

Further, regardless of how hard one tries to override normal circadian patterns and functioning, (by working during the hours mentioned above, or by being awake instead of sleeping), the SCN will still maintain its normal schedule with time cues from the environment (Rosekind et al., 1996; Caldwell & Caldwell, 2003). This can cause sleep loss and poor sleep quality further degrading alertness and performance (*OTA-BA-463*, 1991; Monk, 2005).

The significance of light in circadian phase resetting

Knowledge pertaining to extrinsic factors (e.g., air travel across time zones and shift work) capable of disrupting circadian rhythms has multiplied. Because fatigue is triggered by the process of desynchronization caused by these extrinsic factors, scientists have examined a number of agents capable of resetting the circadian clock either by delaying or advancing it (Czeisler et al., 1990; Eastman, 1991; Gander, 2003; *OTA-BA-463*, 1991; Minors & Waterhouse, 1981; Reilly, 1998; Wever, 1979).

One of the most powerful agents capable of manipulating the circadian clock is light, which can have opposite effects on the circadian clock. The effect of light has been tested by isolating individuals from all time cues, that is, in an environment where the subject did not have any knowledge of time indicators, some of which are light, noise and clock time (Gander, 2003). In the example cited, on the fourth day, the subject was exposed to light for 3 hours after waking up. The result of this light exposure was that the subject went to sleep earlier. However, when light was introduced to the subject for 3 hours before going to bed, the subject went to bed later and woke up later. Therefore, the effect of light introduced after the subject woke up was a phase advance in his circadian clock. When light was introduced before the subject went to bed, the pattern reversed, that is, his circadian clock was phase delayed by the effect of light.

The significance of such experiments revealed that the introduction of light could assist in adjusting circadian rhythms to a new schedule which also speeds recovery from jet lag or shift-work (Gander, 2003; *OTA-BA-463*, 1991; Rosekind et al., 2002). For example, before travelling on a westward flight, pilots could expose themselves to light before going to bed in order to sleep later to prepare their circadian clock in adjusting to the new time zone. When travelling on an eastwest flight, that they could reverse the pattern. The three most important aspects of light (affecting its strength in phase shifting the circadian clock) are the time when individuals are exposed to light, the intensity of light, and the duration for which individuals are exposed to it (Gander, 2003). It was found that very bright light introduced 3 hours immediately preceding or following normal wake-up time shifted circadian rhythms the most (Gander, 2003; *OTA-BA-463*, 1991).

Jet lag

Aircrew whose duties involve rapid time-zone transitions are disassociating their endogenous rhythms from exogenous time cues. The endogenous rhythms are not able to adjust to the new time zone quickly. Research has shown that it takes on average about one day of adjustment for every one hour of time-zone change (Minors & Waterhouse, 1981; Caldwell & Caldwell, 2003). While this adjustment is taking place, a person is said to show 'desynchronosis' or 'transmeridian dyschronism' and often suffers from a feeling of a general discomfort known as jet lag (Minors & Waterhouse, 1981).

The body clock is quicker to adjust after a westward flight than after an eastward flight (Battelle Memorial Institute, 1998). When flying westward, body clock adjustment is faster (on average 1.5 hours per day) while body adjustment when flying eastward occurs at only 1 hour per day on average (Klein & Wegmann, 1980). This is because day is lengthened travelling west and consequently the body's sleep/wake cycle has ample time to adjust itself whilst, travelling eastward, day is shortened, and therefore the sleep/wake cycle has limited time to adjust itself (Caldwell & Caldwell, 2003; Caldwell, 2004). Resynchronization is not a linear process. About half the remaining shift is completed each 24 hours (Gander, 2003).

Shift-Work

Society can no longer rely on most people working a normal 8 hour period of daytime work (Monk, 1983; Gander, 2003). Consequently, this situation leads to greater need for shift-work.

Shift-work refers to working non-standard working hours, that is, outside the traditional hours of 8am to 5pm, Monday to Friday, in a working week (the New Zealand pattern) or on a regular weekly basis from 7am to 6pm (the US pattern) (Gander, 2003; Monk, 2005).

Although working outside normal hours may suit some people, it has been shown that working day and night shifts disrupt the normal rhythm of the circadian clock, which has direct impacts on performance and alertness (Akerstedt, 1995; Rosekind et al., 1996; Monk, 2005).

One fifth of all workers in the United States (approximately 20 million) are involved in working outside a normal daytime schedule (Monk, 1983; *OTA-BA-463*, 1991). Shift-workers in Britain increased from 12.5% in 1954 to 25% in 1968, while the estimated percentages of shift-workers in the Netherlands and France were approximately 19% and 21% respectively in the 1970's (Pati, et al., 2001).

According to the Australian Bureau of Statistics more than 500,000 Australians are involved in work that involves a rotating shift and most of the shift-workers work in safety critical areas (Australian Social Trends, 2003). For example, 43% of the shift-workers work in mines and 32% work in the transport industry. Additionally, 2.3 million Australians work at night.

There are currently no statistics showing the number of shift-workers in New Zealand because standard surveys carried out by Statistics New Zealand do not include the times of work (Gander, 2003). Consequently, the information generated does not include indication of the proportion of New Zealanders engaged in shift work. However, an estimate comes from a Time Use Survey data was carried out by the Department of Labour, in which 4,900 employed persons aged 15-64 years old participated. Results indicated that 53% of males worked early mornings and early evenings[3] while only 29% of females were at work some time between 6am and 8am (Callister & Dixon, 2001). The analysis also identified that only 6% of all paid working hours were undertaken between 7pm and midnight in a week. Further, the report found that 17% of people who were employed and approximately 25% of those who were at work on a particular day reported doing some work between 7pm and midnight.

It has been concluded that people working outside normal working hours are prone to the negative effects of shift-work. Pilots, like many other workers in any profession are known as shift-workers because, in most cases, they are at work when they should be sleeping (Gander, 2003; Monk, 2005).

The effects of shift-work

Aircrews often experience a phase shift in their internal rhythms as a result of shift-work due to the type of work schedule or roster and natural time cues they are exposed to (Pati et al., 2001). A phase shift in circadian rhythms results in fatigue, sleep disturbances, sleepiness, alteration of mood, health problems such as cardiovascular and gastrointestinal complications (Pati et al., 2001; Freedman, 2004).

It has been documented that the time when people work and sleep is an important factor in determining the amount of sleep obtained, the quality of sleep and the subsequent fatigue experienced (*Fatigue Management Guide*, 2005). For example, a person sleeping during the day, in compensation for loss of sleep experienced in the previous night, may not get quality sleep. This is because sleep during the daytime is generally shorter because it is in the wrong part of the circadian clock cycle and because of negative environmental factors such as light and activities that normally happen in the day time (Baker et al., 1999)

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[3] Early morning means before 8am averaging 22 minutes. Early evening means between 6pm and 8pm averaging 14 minutes and between 8pm and midnight averaging 10 minutes.

1.3.2 Sleep Factors

Although there is no brief and standard definition of sleep, Pieron (1913) defined sleep as follows:

> "......a suspension of sensory-motor activities (independent upon internal necessity and not on external conditions) characterized by an almost complete absence of movement and an increase in the thresholds of general sensitivity and of reflex irritability"

Briefly, sleep, in the given definition, is characterized by inactivity as caused by internal rather than external forces. Also, the definition differentiates the condition of sleep from others found in states of coma, anaesthesia and trance, as normally a person when asleep has the ability to awaken or to be aroused (Kleitman, 1963).

However, with the increasing knowledge of human physiology and behavioral processes, sleep has been defined as:

> "......a reversible behavioral state of perceptual disengagement from and unresponsiveness to the environment and is a complex mixture of physiologic and behavioral processes".
>
> **(Carskadon & Dement, 2005 p. 13)**

Sleep is a vital physiological need and since inadequate sleep, sleep loss and other sleep disorders contribute to fatigue, examining sleep factors is important to prevent and minimize aircrew fatigue (Rosekind, 1999; Caldwell & Caldwell, 2003; Gander, 2003).

The circadian pacemaker regulates and controls sleepiness within the human system (Carskadon & Roth, 1991; Dinges et al. 1994). The authors added that when an individual loses as little as 2 or 3 hours of sleep continuously, the pattern can lead to cumulative decline in alertness and performance.

The homeostatic drive maintains sleep and wakefulness as a function of the amount and quality of sleep and the amount of continuous wakefulness prior to a given task. The homeostatic drive also increases sleepiness in association with increased length of wakefulness. Therefore, when a person increases sleep hours, the result is increased time of wakefulness. Conversely, when a person decreases sleep hours, the tendency for a person is to fall back to sleep again (Caldwell, 2004).

Consequently, the interaction of the circadian pacemaker and the homeostatic drive (known as the two primary forces) for sleep determines the level of alertness and performance in association with rest and activity patterns (Froberg et al., 1975; Arkerstedt & Folkard, 1990; Dinges, 1995; Horowitz et al., 2003). Therefore, regardless of attempts to eliminate sleepiness (such as through training, change of job, education, motivation, skill level, intelligence or one's commitment to be fully alert), sleepiness will always be present as it is 'hard wired' into the functioning of every human brain (Dinges, 1995; Caldwell & Caldwell, 2003).

Sleep Deprivation

Numerous studies have been undertaken in the past ten years on sleep deprivation and results were shown to be remarkably consistent, that is, performance level and alertness or vigilance decreased with increased sleep loss (Mullin & Kleitman, 1934; Williams et al., 1959; Doran et al., 2001; Mitler et al., 2005). When individuals are sleep deprived, or even when they experience restricted sleep schedules, their performance degrades (Van Dongen & Dinges, 2000). However, there is variability in individuals, that is, some require 8 hours of sleep to be fully alert in order to perform tasks efficiently while others need fewer hours. Laboratory experiments have shown that after two days without sleep, subjects will fall asleep immediately within as short a time as less than 2 minutes (Neri et al., 1997).

Acute sleep loss and its effects

Acute sleep loss is defined as getting less sleep then needed (or none at all) in a 24 hour period (Bonnet, 2005). It is often experienced by shift-workers because naturally, their patterns of work result in disturbed and inadequate sleep (Monk, 2005). One of the obvious effects of acute sleep loss is sleepiness, which could be inferred from subjective reporting, tests such as the multiple sleep latency test (MSLT), changes in the records produced by the electroencephalogram (EEG) or signs of tiredness that could be recognised on an individual's face (Bonnet, 2005).

Reliable tests have been carried out to determine the effects of acute sleep loss, such as determining the sustainability of alpha[4] (Rodin et al., 1962). The findings indicated that subjects were unable to sustain alpha any longer than 10 seconds after 24 hours of sleep deprivation. The inability continued to decline, with ranges of between 4 to 6 seconds after 72 hours of sleep deprivation and 1 to 3 seconds after 120 hours of sleep deprivation (Rodin, Luby and Gottleib, 1962). The effect of sleep deprivation after 115 hours was closure of the eyes, thereby preventing any alpha activity (Naitoh, Kales, and Kollar, 1969).

A more recent study, using equipment known as "positron emission tomography" showed that brain activity decreased with increasing sleep loss, and as such, subjects were struggling to perform verbal learning tasks (Drummond, Gillin and Brown, 2001).

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[4] An electrical rhythm of the brain with a frequency of 8 to 13 cycles per second that is often associated with a state of wakeful relaxation called also *alpha*. (Dictionary.com)

Chronic sleep loss

Chronic sleep loss is normally referred to as partial sleep loss which is caused by a variety of problems including medical conditions, shift-work, work demands, social and domestic commitments, which continues day after day (Dinges et al., 2005). It is referred to as "preventing subjects from obtaining their usual amount of sleep within a 24-hour period" (Webb, 1969). Experimental reports, dating from the 1970s to the 1990s concluded that, generally, cumulative effects of chronic sleep loss were experienced by subjects when they were restricted to less than 7 hours of sleep a night. Increased subjective sleepiness was reported however, little or no effect on cognitive performance capabilities was encountered (Dinges et al., 2005).

Time awake

When analyzing domestic air carrier accidents that occurred between 1978 and 1990, the fatigue-related factor that appeared dominant in the analysis was time awake (NTSB, 1994; Battelle Memorial Institute, 1998).

This time begins when a person awakens and ends when they sleep again. Translating this to aviation operation, it includes all working activities including flight duty (Rosekind et al., 1996).

The number of hours for which day workers are typically awake prior to working ranges from 1 to 2 hours, while night workers are generally awake between 10 and 16 hours (Akerstedt, 1995). The extra hours prior to the commencement of work in the day time normally comprise preparation and travel time needed by the individual. It is different in the case for night workers as they have been awake most of the day before commencing work and therefore, time since wake for them is longer than for day time workers.

Increased accident rates have been identified as happening during afternoon shifts (Folkard et al., 1999). It was suggested that the reason for this is the increased fatigue resulting from a longer period of time since wake (Folkard et al., 1999). Others have reported that both low (morning only) and high (morning to afternoon) time since wake contribute to aviation accidents (Battelle Memorial Institute, 1998). For example, as low as 3 to 4 hours to as high as above 13 hours of continuous wakefulness were found to be critical in pilot performance (Folkard et al., 1997).

Furthermore, others have shown that the result of flight time or workload adds to performance decline, which was found to be a consequence of time since wake (Belenky, Penetar, Thorne, Popp, Leu, Thomas, Sing, Balkin, Wesensten and Redmond, 1994).

Effects of staying awake on performance

Individuals attempt to stay awake and perform tasks, for example shift-workers working at night or other workers working after periods of inadequate sleep. Problems result and are summarised as follows:

- The tendency to sleep increases as indicated by reduced latency[5] from wake to sleep and from light sleep to deep sleep (Carskadon & Dement, 1987);
- The effort needed to stay awake to perform better also increases (Akerstedt & Gillberg, 1990a; Dinges et al., 1992);
- Microsleeps occur more frequently and increase in duration (Armington & Mitnick, 1959; Mirsky & Cardon, 1962);
- Performing poorly and inefficiently increases in duration (Johnson, 1982; Dinges & Kribbs, 1991; Dinges, 1992). Such deficits are associated mainly with cognitive functions which are characterized as follows: non-responding and delayed responding when attempting to be attentive while carrying out particular

[5] The period of apparent inactivity between the time the stimulus is presented and the moment a response occurs (Retrieved from http://dictionary.reference.com).

tasks, slowing down in processing information, increasing reaction times, reducing accuracy and accelerating degradation of performance (Dinges, 1995).

What are Microsleeps?

Microsleeps are another useful factor in determining the effects of fatigue and sleep-related variables and were first called "blocks" by Bills (1931). More recently, microsleeps have been described as "gaps" and "lapses" (Battelle Memorial Institute, 1998). They have been fully described as "brief (several seconds or less) episodes of total perceptual disengagement from the environment" (Neri et al., 1997). Microsleeps have been found to occur in flight operations, with or without the knowledge of aircrews and therefore, they are of significant concern to the safety of flight operations (Battelle Memorial Institute, 1998).

Generally, people are not aware of microsleeps or the time when they will occur because they happen uncontrollably and very quickly. Additionally, microsleeps can be experienced by people even when their eyes are open. Further, they can occur during periods of acceptable performance (Neri et al., 1997). It is, therefore, an issue that requires significant consideration. Additionally, considering the inevitable fast speed of aircraft, aircrew must be aware of microsleeps and their causes.

A study conducted by NASA (1994) showed evidence of microsleeps amongst crew flying several trans-Pacific routes. Results of the study reported that 154 microsleeps occurred, half of which lasted for 10 seconds or more. Additionally, at least 38 microsleeps were found occurring in the approach and landing phases of the flights (Landre, Boag and Fletcher, 2002).

An earlier study indicated that microsleeps were found to occur 3 times more often during the night than during the day (Samel et al., 1995). The study indicated that microsleeps associated with fatigue occurred on the job as a result of sleep deprivation, increased as a factor of time awake and happened more towards the end of the day including night time. Therefore, time of day is a significant issue for microsleep occurrence, particularly for the later phase of the flight, the critical approach and landing phase (Battelle Memorial Institute, 1998).

Another study was carried out by Samel et al. (1997) in which they showed evidence of microsleeps amongst pilots on a particular route. On the outbound leg, average microsleeps found per pilot was 1.38 every hour, while, on the return leg (that occurred at night time), microsleeps per pilot per hour averaged 2.47. Additionally, it was reported that as flights progressed, the feeling of fatigue and the occurrence of microsleeps increased (Battelle Memorial Institute, 1998).

How much sleep is adequate?

Amongst many other factors, volitional control is dominant in determining the length of nocturnal sleep and therefore has made it difficult for scientists to provide a standard definition of adequate sleep hours (Carskadon & Dement, 2005). An approximation of 7.5 hours of sleep by young adults has been reported to occur on weekday nights with a higher number of 8.5 hours on weekend nights. There is variability in the number of sleep hours between individuals and from night to night (Carskadon & Dement, 2005).

The most recent poll on the number of hours slept per night by American adults on weekdays is available in Figure 1.3 below. A significant feature of the information shows that more Americans continue to sleep less hours. For example, there was a significant increase (6%) in the number of people sleeping 6 to 6.9 hours from 2001 to 2005 (Sleep in America poll, 2005).

Number of Hours Slept per Night on Weekdays (past two weeks)

	1998 B	2001 C	2002 D	2005 E
Less than 6 hours	12%	13%	15%$_E$	16%$_{BC}$
6 to 6.9 hours	23$_C$	18	24$_C$	24$_C$
7 to 7.9 hours	28	31	29	31
8 or more hours	35$_{DE}$	38$_{DE}$	30$_E$	26
Mean (# of hours)	na	7.0	6.9	6.8
Median (# of hours)	na	7.0	7.0	7.0

Base = Total sample (n=1,506)
Letters mean they are statistically significant at the 95% confidence interval.
na = Not available
Q3

Figure 1.3 Number of hours slept by American adults (Sleep in America poll, 2005)

It has been reported that 7.4 hours of sleep is the average reported by New Zealand adults and that 37% of the study population reported that they 'rarely' or 'never' get enough sleep (Gander, 2003).

Research has indicated that on average, an individual requires at least 8 hours of sleep to be fully alert and to be functioning efficiently during waking hours (Rosekind et al., 1996; Battelle Memorial Institute, 1998).

However, different people require different amounts of sleep, suggesting that 8 hours is not adequate due to complex physiological factors (Rosekind et al., 1994). In addition, the amount of adequate sleep depends largely on the quality of sleep. Disruptions during sleep reduce its restorative quality. The disruption of sleep is the result of many factors such as noise, light, temperature, family worries, sleep disorders and many others (Rosekind et al., 1994).

1.4 Work-Related Factors

Industrial and cultural changes have significantly emerged with the development of increasing technology. These changes have expanded the transport industry workforce (Dawson, 2005; Rosekind, 2005). The transport industry has turned into a

24-hour operational system to meet demands, hence the need for longer and more flexible hours for workers.

It has also been identified that many other work schedule (roster) factors, including extended hours of work and unplanned work extensions affect sleep, circadian rhythms and alertness (Rosekind, 2005). According to Dawson (2005) and Baker et al. (2000), longer hours of work cause inadequate sleep which may create a competition between the need to sleep and the obligation one has to make a daily living which may, in turn, result in the accumulation of fatigue.

Secondly, the obligation to work at night results in the disruption of the circadian system. As more night hours are required by a worker, more is required of sleep. Sleep in the day time for a night worker is of less quality and quantity compared to sleep at night time (Baker et al., 2000; Dawson, 2005).

Thirdly, less time for family and social activities could lead to a feeling of "guilt" which may culminate in "social debt" and may shorten the opportunity for sleep (Dawson, 2000).

1.4.1 Different types of tasks at particular times of the day

The earlier works of Kleitman (1963) and Colquhoun (1971) and colleagues showed that, for a number of different tasks, a parallel relationship between temperature and performance circadian rhythms exists at certain times of the day (Monk, 1983). For example, performance levels of ***non-complex tasks*** showed a steep rise throughout most of the morning, a more gradual rise across the afternoon with a peak in late afternoon, and followed by a sharp decline towards sleep hours. However, performance levels for those tasks involving ***high working memory***, in contrast, decline across the day and rise again during early evening when the body is getting ready to sleep (Folkard & Monk 1980). The findings suggested that in ascertaining times of day for best and worst performance, the different components of the tasks need to be considered (Folkard, Knauth, Monk and Rutenfranz, 1976).

Similarly, previous research has also shown that some types of work are better performed at particular times of the day (Baker et al., 2000). For example, the type of work that requires monitoring instruments during a normal flight operation may improve over the day but may degrade at night or may not be maintained over longer periods. However, during critical stages of the flight and when in unfavourable situations (restricted weather), monitoring instruments could turn into a stimulating task and thus could be performed better and maintained for longer periods of time.

From this perspective, it is important to understand whether or not certain types of task and the components thereof contribute to the effects of fatigue and whether or not they could be excluded from a duty period.

Currently, aircrew duty times do not have defined limits. For example, no limits have been standardized with regards to duty periods in AC 119-2 (CAA, 2000) and NPRM 95-18 (Battelle Memorial Institute, 1998). The difficulty in standardizing duty period limits is more related to the complex types of task involved in different types of flight operations. For example, boredom and cognitive fatigue due to vigilance could be the main task-related fatigue typically found in fights across the ocean, i.e. a single leg involving six or more hours (Battelle Memorial Institute, 1998). It is suggested that activities involved in different types of task could contribute to fatigue in the form of time-since- wake.

1.4.2 Workload

Workload has multifaceted definitions including the type of work carried out, the ability of an individual to carry out the particular task, and the place where the task is performed (Jex, 1988). Individuals, and in particular pilots, are faced with enormous workload in flight, especially during critical phases of the flight, in adverse weather conditions, in emergency situations and other unplanned demands. Often, pilots are challenged in order to meet high performance and such challenge increases high workload (Skinner & Simpson, 2001).

The result of the diary study of air traffic controllers carried out by Spencer et al. (1997) indicated that "the level of workload has a direct impact on the level of fatigue".

However, workload has been shown to be difficult to measure using subjective ratings, because results of some tests were found to be inconsistent with physiological ratings (Skinner & Simpson, 2001). For example, when heart rates were recorded as accelerating, subjective ratings did not reflect a high workload rating. Additionally, participants rated their performance 'good' despite reported high workload ratings.

One way of determining the level of physiological workload was to assess heart rate (Gander et al., 1994). However, it was found that a more reliable way of assessing workload was to combine subjective with physiological measures when assessing heart rates of pilots (Skinner & Simpson, 2001).

A study by Gander et al. (1994) of short-haul pilots, found that when comparing heart rates for pilots performing tasks in different phases of the flight, the approach and landing phase produced the fastest heart rates. The finding suggests that workload in highly cognitive tasks results in faster and higher heart rates, a resemblance of high workload (Battelle Memorial Institute, 1998).

A more recent study was conducted amongst pilots, using heart rate and multi-dimensional subjective-ratings (a Cardiovis ECG system and NASA Task Load Index) (Lee & Liu, 2003). Their study reported significant increases in heart rates in the take-off and landing phases of the flight. More importantly, both physiological and subjective ratings were highest during the take-off and landing. This is an indication that subjective ratings were more reliable when aided by multi-dimensional measures.

Advanced cockpit automation systems have provided another option besides manual flying. One of the advantages of having such a system is to reduce pilot workload. However, it has been argued that by using such a system, the reduction of pilot workload has reduced to such levels that dreariness or boredom occurs and a pilot is no longer alert. This situation may reduce the quality of work significantly and negatively contribute to performance levels (Campbell & Bagshaw 2002). Additionally, the use of an auto-pilot system is common during the cruise phase of a flight. Aircrew experienced fatigue and boredom as a result of monitoring tasks over long periods of time (Lee & Liu, 2003). Another finding on air traffic controller workload indicated that low workload may result in lower levels of alertness and boredom. Such a situation could impact adversely on the controller's performance if he/she is already fatigued (Airservices Australia, 2004).

On the other hand, it has been suggested that a cockpit automation system increases workload because of the requirement for tasks such as programming and monitoring, and that such procedures may be required at critical phases of the flight. Further, workload could be greater when performing such tasks at times of unfavourable weather (Campbell & Bagshaw, 2002).

It appears that the level of workload could be reliably assessed by a combination of measures such as multi-dimensional subjective measures and physiological measures.

1.4.3 Time on task

In aviation operations, time on task is referred to as duty period. It may be reasonably accepted that to assess fatigue as a result of time on task, previous studies investigating the effects of extended shift durations on worker performance could be relevant to this study. Rather than assessing fatigue as a function of performance decrements accruing on a single task, it would be more appropriate and relevant to assess fatigue and performance as a function of the ***set of tasks*** performed during a shift. This is because the work of pilots often involves more than one task in a given duty period (Battelle Memorial Institute, 1998). The definition of duty period is "a continuous period of time during which tasks are performed by the Operator; determined from report time until free from all required tasks" (Dinges et al., 1996).

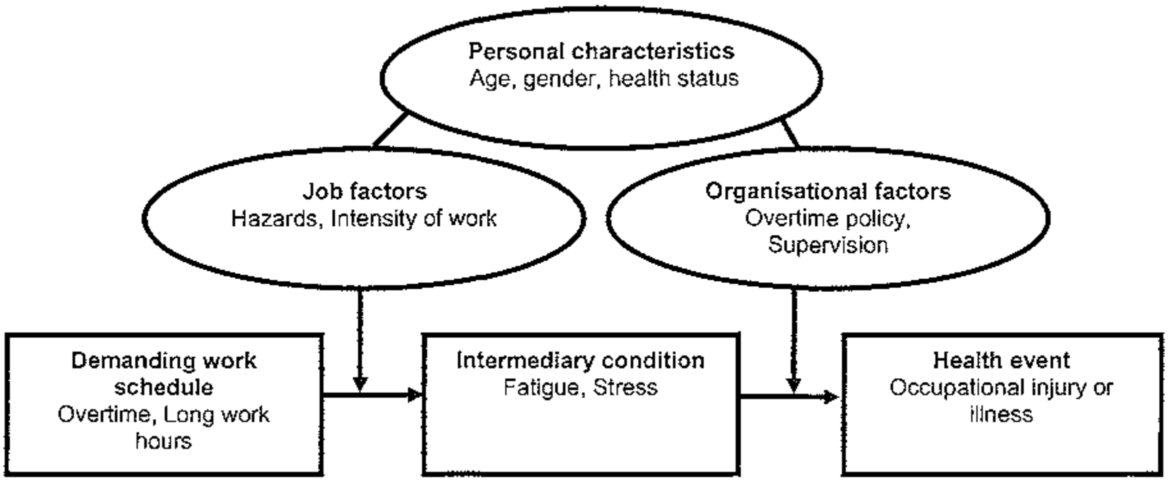

Figure 1.4 A conceptual model linking work schedules, intensity of work, long work hours and fatigue (Schuster & Rhodes, 1985)

Time-on-task studies have shown that performance starts off at low levels followed by optimal performance and later degradation, varying according to the type of task performed (Vries-Griever & Meijman, 1987). Long hours are widely recognised as a major contributor to fatigue (Akerstedt & Gillberg, 1980; Arnold et al., 1997; *Beyond the midnight oil,* 2000; Buchanan & Bearfield, 1997; Carey & Fishburne, 1989). Individuals normally reach their optimal levels of performance after a few hours from the beginning of a shift, and then decline over an eight hour shift. Generally, in most studies, performance declined and fatigue was persistent in shifts of more than 8 to 10 hours. This decline resulting from fatigue was confirmed in previous studies conducted amongst nurses (Mills et al., 1983), sea watch keepers (Colligan & Tepas, 1986) and truck drivers (Hamelin, 1987). These findings confirm that as more hours are worked, fatigue increases over the work period.

The probability of an accident occurring in a 12-hour shift has been found to be greater (Hamelin, 1987). This study was also in line with other studies conducted at later dates. For example, Askertedt (1995) determined the increase in the likelihood of accidents occurring in 14- and 16-hour shifts. Results indicated that the likelihood of accidents occurring in a 14-hour shift was 2.5 times that of the lowest point in the first eight hours of duty, while it was three times greater in a 16-hour shift. However, in a study conducted by Harris and Mackie (1972), they found that the likelihood of accident risks was three times greater after over 10 hours of driving.

A more recent study carried out in the United States, determined hazard rates as a function of hours of work (Dembe et al., 2005). The researchers found that working at least 12 hours a day was associated with a 23% increased hazard rate, while working beyond this number of hours increased the hazard rate to 37%.

What is the upper limit for time on task?

The 12-hour duty shift could be accepted as the upper limit (Battelle Memorial Institute, 1998). However, it was recommended by Dinges et al. (1996) that, overall, cumulative duty must not exceed 14 hours within a 24-hour period.

From the preceding findings, it would be acceptable to argue that the upper limit (as a function of hazard or risk) is 12 hours but must not exceed 14 hours of cumulative duties within the 24 hour period.

1.5 Individual Differences

Studies by Mallis et al. (2001) and Van Dongen et al. (2002) have indicated that the underlying factors associated with individual differences in association with fatigue vulnerability are still yet to be determined. They indicated that if an individual is fatigue resistant on one occasion, this person is likely to be fatigue resistant on other occasions and vice versa. Morgan et al. (1980) studied the effects of acute sleep deprivation involving continuous wakefulness for 44 hours. They found that work performance of some participants was degraded by as much as 40%, whereas others were unaffected.

A recent study by Caldwell et al. (2005) may encourage other scientists and researchers in determining the biological factors associated with individual differences. They found that different patterns of brain activity correlated with individual differences in how tired pilots performed mentally. Their study found that the performance of one of the ten pilots was virtually unaffected after 37 hours of continuous wakefulness, while the performance of the remaining nine pilots degraded from 11 to 60 percent and reached as high as 135 percent. The researchers suggested that "the greater the amount of baseline cortical activation, the less performance will be affected by fatigue during a period of sleep deprivation". The researchers added that their experiment did not reveal why individual differences in performance are associated with different patterns of brain activation and therefore further experiment and study is warranted.

1.6 What is Being Done to Manage Fatigue?

Worldwide, collaborative efforts are evident in the formulation of guidelines and policies addressing fatigue.

1.6.1 Government and company initiatives

At the international level, the International Civil Aviation Organisation (ICAO) is conducting a review on current information from contracting states in relation to fatigue, with a proposal to update the current SARPS (Fallow, 2004). According to the report, Annex 6 Part I that governs the operations of aircraft will be updated to include recent proposals. A group of scientists from NASA and representatives from the authority have been tasked to make further proposals and recommendations for approval by ICAO.

The NASA Fatigue Countermeasure Group Program (formerly the Fatigue/Jet Lag Program) was formed by a mandate from the US Congress to examine the extent to which fatigue, sleep loss and circadian disruption impact on the performance of aircrew. For the program to be effective and ongoing, one of its components was to develop and evaluate fatigue countermeasures which could be used to educate those involved (Mallis, 2003).

The European Transport Safety Council (ETSC) recognised that the relevant scientific knowledge on fatigue was lacking in the new proposed framework of regulations governing flight duty limits. As a result, the European Commission, in 1996, called for a group of international scientists to provide scientific input and make recommendations to the proposed framework of new regulations, allowing some flexibility beyond existing flight duty limits (within acceptable limits) to better manage fatigue in European aviation organisations (Akerstedt et al., 2003).

In Australia, the government recognised the importance of fatigue as a potential hazard in aviation, and consequently asked the House of Representatives Standing Committee on Communications, Transport and the Arts to look into and report on fatigue across all transportation sectors (*Beyond the midnight oil*, 1999). In response, the report, 'Beyond the Midnight Oil' was released, which made recommendations to the Civil Aviation Safety Authority (CASA). The basis of the recommendations was that fatigue management should be included as an essential component of its air operator's safety system.

CASA, in response to these recommendations, is developing a fatigue management system. However, rather than just managing the flight and duty times of aircrew, it includes the management of fatigue risks. In determining these fatigue risks, CASA is recognizing that there are signs of fatigue that could be recognised and treated before they cause incidents and that fatigue may happen on the job for which identified measures must be taken (*Beyond the midnight oil*, 2000).

In New Zealand, the Civil Aviation Authority is allowing Air Transport Operators to either develop their own tailored schemes to better manage fatigue, or to adopt the entire content of the revised flight and duty time scheme contained in Advisory Circular (AC) 119-2 (IFALPA, 2004). Both approaches aimed at providing more solid guidelines for the management of fatigue and upholding flight safety amongst aircrew and flight operations.

As a result of long-term research on aircrew fatigue, a collaborative and comprehensive approach to fatigue management in Canada emerged and was developed by organisations whose responsibilities involve ensuring the safety of aircrew and flight operations (Transport Development Centre (TDC), 2000). These organisations include TDC, Transport Canada's Civil Aviation Directorate, the Air Line Pilots Association, Canada 3000 and Applied Brain Behaviour Systems. The unique approach utilized multi-task methods and self-administered methods of measuring and counteracting the effects of fatigue, to establish pilot profiles. After assessment, such profiles are made available to pilots, allowing them to assess and update their own profiles. As these profiles or databases accumulate, so does pilot understanding in addressing their own levels of fatigue.

At an organisational level, fatigue was investigated amongst aircrew of Air New Zealand and as a consequence, it has developed a Crew Alertness Study Group (CASG), comprising airline management, union representatives and medical staff who monitor fatigue trends and look at the extent of fatigue on particular routes (Van Den Bergh, 2005). The main purpose of CASG is to develop a system to counteract the effects and problems of fatigue, with emphasis on international flights where length of duty is an issue, rather than workload. In this scheme, pilots and cabin crews can be asked to monitor their fatigue levels on given routes using hand-held computers.

1.6.2 Personal countermeasures

> "There is no simple and universal solution to fatigue in the workplace as different operations pose different demands and people vary widely in their reactions to these demands"
>
> **(Rosekind et al., 1996)**

In light of this statement, it is important to discuss fatigue countermeasures from the perspective of individuals and flight operations.

Due to the complex and changing patterns of sleep and circadian physiology, the following strategies could be regarded as recommendations only and more research is required in this particular area (Rosekind et al., 1996). An additional complication is that as people get older, the amplitude of their circadian rhythm reduces, the phase of their circadian rhythm becomes earlier, their natural free-running period (tau) shortens and their ability to tolerate abrupt phase shifts (jet lag and shift-work) worsens (Monk, 2005). These patterns generally make older people more vulnerable to the effects of jet lag and shirt-work.

Fatigue countermeasures can be divided into two types: preventive and operational (Rosekind et al., 1996).

Preventive strategies: those used before work and during rest periods

A variety of preventive strategies have been identified, but the 3 main ones considered relevant to this study will be discussed.

Since sleep loss is the main factor in shift-work and flight operation environments, minimizing it would be the most positive preventive strategy (Graeber, 1986; Gander et al., 1992, 1994, 1996; Rosekind et al., 1994). This strategy could generally be attained by allowing two full nights of sleep to enable recovery from the effects of cumulative sleep loss (Caldwell, 2003). From a behavioral perspective, physiological alertness is determined by the way people behave in attempting to stay awake, and therefore, they need to be encouraged to behave in order to be alert (Dinges, 1995).

Naps are another way to acutely improve alertness (Rosekind et al., 1996). A number of studies have indicated that nap opportunities of 45 minutes (a maximum limit) contribute to improved alertness because individuals undergoing such naps did not wake from deep sleep (Rosekind et al., 1994). According to the researchers, waking up from a deep sleep causes a person to feel groggy and disorientated for several minutes (known as sleep inertia).

Understanding sleep hygiene assists a person to attain good sleep habits (Zarcone, 1994). When a person is preparing for sleep, psychological stressors of the day must not interfere with this process. Therefore, sleep time needs to be given priority and kept as free as possible from other stressors and commitments (Rosekind et al., 1996). Other useful strategies advocated by the authors include various physical and mental relaxation techniques such as meditation, yoga, muscle relaxation and other similar activities.

Operational strategies: those used on the job or in flight operations

The following strategies temporarily enhance alertness and performance. However, considering the fact that fatigue has a direct impact on alertness and performance, it is worth discussing them as useful temporary strategies.

Since 1980, the NASA Fatigue Countermeasure Group has been involved in numerous studies examining the effects of fatigue, sleep loss and circadian disruption on pilot performance (Mallis, 2003). One of the focuses of the studies has been the evaluation of planned cockpit rest as a strategy in minimizing sleepiness or fatigue. This approach challenges certain aspects of the federal aviation regulations, which state that pilots must remain seated and must not nap while on duty. Nevertheless, results of the evaluation indicated that a significant percentage of pilots were able to fall asleep within at least 6 minutes even when they were strapped in their cockpit seats (Mallis, 2003).

Similarly, following the NASA cockpit napping study and supported by the NZCAA, a policy was introduced to Air New Zealand for controlled rest on the flight deck or cockpit napping (Powell et al., 1998). In this procedure, pilots who felt fatigued or tired, were allowed to nap for at most 45 minutes in their cockpit seats wearing eyeshades and ear plugs, while the other pilot(s) remain on duty. While it is a new approach in the New Zealand aviation community, it is available as a tool for reducing pilot fatigue in flight operations.

Involvement in a conversation while on duty has been recognised as a useful operational strategy. One study indicated that lack of conversation may cause physiological alertness to decline (Cabon et al., 1991 cited in Rosekind et al., 1996). Therefore, it is important that when pilots feel sleepy, that they need to converse with each other. Physical exercise and the effects of caffeine are two of many strategies that can improve alertness while on duty (Rosekind et al., 1996).

1.6.3 Regulatory approaches

A founding member of the International Civil Aviation Organisation (ICAO), New Zealand became one of thirty-five contracting states to the Chicago Convention in 1944.

Article 37 of the Convention contains established standardized and recommended practices (SARPs) that are acceptable for adoption by the contracting states. These practices aim at conformity amongst contracting states to develop a safe, economical, and orderly civil aviation system, and are issued to improve such practices.

Article 26 of the Convention sets an obligation on a contracting state to investigate accidents to aircraft. Updated changes are included as part of the appropriate annexes, for example, acceptable changes for operation of aircraft are included in Annex 6 Part I.

The prescriptive approach to managing fatigue - Flight and Duty Time Limits

Prescriptive means of managing fatigue are covered by flight and duty time limits. Internationally, Civil Aviation Authorities have recognised that these prescribed limits have been restrictive and could not be suitable for all types of operations existing in aviation industries. For example, the United States Federal Aviation Authority (FAA) recognised the importance of the opportunity for adequate rest, and has been considering a proposed rule that will clarify and simplify flight and duty time limits (Goode, 2003). The FAA sees that the current set of regulations governing flight and duty times for pilots are fundamentally sound, however, they are believed to be inflexible when responding to changes in business practices in the aviation industry (Hearing on Pilot Fatigue-Part II, 1999).

Similarly, in the United Kingdom, the general guidelines and several annexes contained in CAP 371[6] each dealing with specific types of operation, indicate that prescribed flight and duty time limitations were not sufficient and could not meet all operational demands (Lyons, 1999).

Flight and duty time limits for pilots in Australia are prescribed in Civil Aviation Order 48 as one way of managing fatigue. This prescriptive approach was considered largely inadequate as a means of ensuring safety, overly restrictive, and lacking a significant amount of the latest scientific knowledge on fatigue (McCulloch, 2003). Consequently, the Civil Aviation Safety Authority (CASA) has allowed Operators to work outside these prescribed rules by developing an accredited fatigue management scheme. A further regulatory approach for dealing with a variety of operations has been the

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[6] A supplement to the UK Air Navigation Order (2000) pertaining to the Avoidance of Fatigue in Flight Crews.

provision of exemptions. These exemptions, contained in CAO48, are variations to current prescribed flight and duty time limits, an indication that such rules have not been beneficial to all Operators and are not adequate as a sole means of managing fatigue (Commonwealth of Australia, 2005).

In New Zealand, pilot flight and duty time limits are prescribed in AC 119-2, a scheme that must be adopted in its entirety if chosen by Operators as their only means of managing fatigue. These prescriptive flight and duty times have been widely recognised to be inadequate and lacking potential factors associated with fatigue. Additionally, it is viewed as an historical approach in managing fatigue because it is largely based on industrial practices prevalent 50 years ago. With more comprehensive scientific research in the area of fatigue and aviation operations, this prescriptive means of managing fatigue has been widely recognised to be unsuitable and totally inflexible, given complex types of aviation operations and individual differences.

A concern reflecting this came from the House of Representatives Standing Committee on Communications, Transport and the Arts in Australia in their statement:

> "We are alarmed at the state of the current system of regulating flight and duty times for air crew. The current system, as provided for by Civil Aviation Order Part 48, is universally regarded as being anachronistic and deeply flawed. The Civil Aviation Safety Authority must take urgent action to ensure that the current system operates in a safe and efficient manner while the new regulatory regime is being prepared."

(*Beyond the Midnight Oil*, 2000 p. 31).

Currently in New Zealand, fatigue and its threats to aviation operations and aircrew have been recognised and have become a significant concern. Consequently, there is an increasing agreement as to the inadequacy of the current rules pertaining to flight and duty time limits. This acknowledgement is evident in NZCAA allowing Operators exemptions to work beyond these prescribed limits, and the option given to Operators to develop an approved fatigue management scheme, contained in AC 119-03. This approach indicates that current rules pertaining to flight and duty time (being a complete scheme that cannot be fragmented when applied to certain types of operation) have proven inadequate and inflexible as they cannot meet the needs of different types of operation (AC 119-2, 2000; AC 119-03, 2001).

Non-prescriptive approaches in the management of fatigue

Australia and New Zealand are the first two countries in the world to allow aviation Operators to work outside prescribed limits. In doing so, Operators are given an alternative strategy by developing an acceptable fatigue management scheme.

Ideally, a non-prescriptive approach to managing fatigue allows an accredited company to be released from the prescriptive regime of regulated hours, if they can prove that they are able to establish their own auditable fatigue management scheme (Dawson & McCullough, 2004).

Fatigue risk management is the process of managing the risks associated with fatigue which basically involves five steps:

- Identifying hazards;
- Assessing risks that may result as a result of these hazards;
- Deciding on control measures to prevent or minimise the level of risks;
- Implementing control measures and;
- Monitoring and reviewing the effectiveness of control measures.

(*Fatigue Management Guide,* Queensland Government, 2005)

Fatigue risks management systems in the Australian setting utilize the concept of risk management outlined in the Australian/New Zealand Standard (AS/NZS) 4360:1999 which basically involves the following factors:

- Establishment of the context, by means of identifying what is at risk;

- Identification of risks by means of brainstorming, followed by the use of a checklist of risks;
- Analyzing identified risks by assigning each risk a rating;
- Evaluation of risks by means of prioritizing risks according to significance and;
- Treatment of risks by means of determining necessary measures.

The above criteria were adapted and used in the development of the fatigue management concept in the Australian aviation industry, which is now termed a Fatigue Management Scheme (FMS) (McCulloch, 2003).

A fatigue management scheme is regarded as one complete accredited design which essentially takes a broader approach in considering fatigue and should aim at:

- Accounting for all possible causes of fatigue;
- Including outside work factors as potential contributors to fatigue and;
- Accepting fatigue management as a shared responsibility between Operators and individual flight crew.

(*Revised AC 119-03, 2001 p. 28*)

The NZCAA requires an Operator to adopt certain items aiming at minimising the likelihood of fatigue in flight crew. This approach makes the Operator responsible for its tailored flight and duty scheme which NZCAA approves and audits. Items required for assessment and approval are stipulated in AC 119-03 (IEM 135.803(a)(2).

Australia is currently undergoing extensive studies on fatigue management as an alternative method to replace pilot flight and duty time limits. A recent trial on fatigue management programmes carried out by the Centre for Sleep Research, University of South Australia, evaluated a sample of the first general aviation organisations that undertook the development and implementation of a FMS. Results indicated that overall, the majority of managers and flight crew members perceived the FMS to be appropriate, yet viewed that such an approach could be critical when implemented mainly due to costs involved (McCulloch et al., 2003).

1.7 A Conceptual Framework for Fatigue Management

"...........the most appropriate solution for effective fatigue management is to expand the regulatory framework from a prescriptive hours of service (HOS) approach and to permit certain organisations to use a Safety Management System (SMS) approach."

(Dawson et al., 2004)

1.7.1 The Australian Approach – A Safety Management System

The recent Australian approach to managing fatigue has culminated from the combined assessment of results from both outcome-based fatigue risk management[7] and occupational safety and health standard practices (OH&S)[8] (Dawson et al., 2004). This has lead to the development of a conceptual fatigue risk trajectory model shown in Figure 1.5 below.

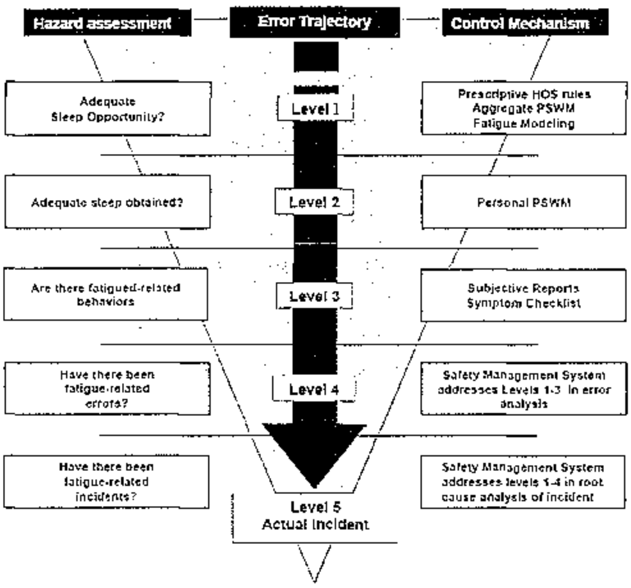

Figure 1.5 A conceptual fatigue risk trajectory model, designed by Dawson et al.(2004) and based on Reason's hazard control framework (1997)

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[7] Examples of these outcome-based fatigue-risk management systems are: the Queensland Transport, Fatigue Management Program (transitional), 2001; CASA Fatigue Risk Management System (2003) and the North American Federal Railroad Administration (2001); Fatigue Management in air traffic control: The New Zealand approach (Gander, 2000).

[8] Examples of these OH&S practices include the Canadian OH&S Act; the OHSAS 18001 and the Australian/New Zealand OH&S outlined in AS/NZS 4801:2001.

The model establishes that a series of fatigue-related errors usually results in a fatigue-related incident. It also incorporates scientifically-based findings that excessive wakefulness or insufficient sleep is directly related to fatigue-related incidents. Each hazard in each layer (left side of the model) is presented with its most appropriate control mechanisms (right side of the model). At the end of the error trajectory is an actual incident associated with four levels of antecedent that are common to any fatigue-related incidents. This approach suggests that an effective fatigue risk management system should attempt to manage each layer of risk rather than attempting to manage all risks as one whole system.

1.7.2 The Canadian Approach to fatigue management

A scientifically-based approach to fatigue management was developed by Rhodes et al. (2002) which aimed at educating marine pilots on how the body works, how to make informed decisions about good sleep and how performance is affected by fatigue. The emphasis of this approach is to have management support (in all levels of an organisation) provide the required resources. These may include provisions for napping, exercise facilities, adequate breaks according to biological and operational requirements, better health facilities and scheduling practices that encourage a healthy and productive environment.

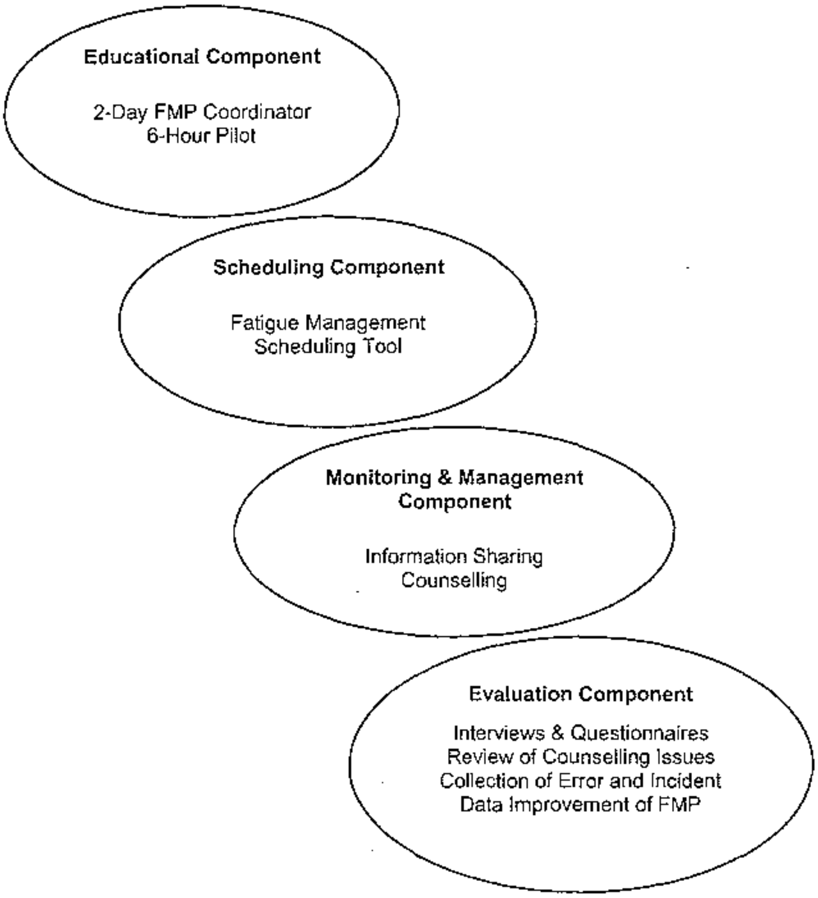


Figure 1.6 The components of the Fatigue Management Program (Rhodes et al., 2002)

The fatigue management program (FMP) as summarised in Figure 1.6, comprises four components:

- **Educational:** Individuals are informed of the process and benefits of the program so they can implement coping strategies and fatigue countermeasures both at work and home;
- **Scheduling guidelines:** By reviewing past rest/work history and fatigue levels, these contribute to the better management and identification of a fatigued pilot. This component utilizes a scheduling model designed by Fletcher and Dawson (2001a) which is based on work/rest and start time information.

- **Monitoring and management:** A designated responsible person for fatigue management is considered a resident resource specializing in fatigue, and initiating appropriate strategies in the reduction of fatigue. This person ensures ongoing assessment of the FMP and works together with other FMP experts in fine-tuning the program over time. The effectiveness of the program is highly dependant on this person's ability in counselling, assessment and monitoring.
- **Evaluation:** This process will determine whether or not the FMP requires improvement or change. It involves data provided by pilots and management to the person responsible for fatigue management. These individuals review their own participation in the FMP. Such a process has two advantages. Firstly, it provides more awareness on fatigue issues and secondly, individuals will take a positive step in valuing the important of reducing their own fatigue levels.

1.8 Aims of the Present Study

The study aims to identify the perceptions of Part 119 Operators about fatigue management schemes (FMS) and their existing flight and duty schemes.

More specifically, the aims of the present study are:

1. To examine how aircrew fatigue is being managed in the New Zealand Aviation Industry by gaining the perspectives of pilots, people in management positions, and people who work in rostering;
2. To gather information on the strategies and processes being used by the industry for managing fatigue in their organisation;
3. To examine how frequently Operators are utilizing the greater flexibility provided by their own FMS;
4. To identify barriers to implementing an FMS and resources that could better assist in implementing it;
5. To seek answers to why Operators are choosing (or not) to implement an FMS. If Operators choose to implement an FMS, they are required to tailor an acceptable FMS suitable for their operation, whereas if they chose not to, they are committed to adopt the entire AC119-2;
6. To provide feedback to the industry and the regulators on the findings and results of this study;
7. To assist Operators to identify suitable strategies that could improve their current fatigue management schemes;
8. To make recommendations to Operators as to resources which might assist in implementing their FMS.

CHAPTER TWO
METHODS

2.1 Participants

Three people from each of the 160 Part 119 organisations recorded on the NZCAA's database, were invited to participate in the study. These people were:

- a person in a management role;
- a person in rostering and;
- a line pilot.

The study package sent to the above people included the following documents:

- Three questionnaires (to be completed by respective participants) (Appendix A).
- A letter addressed to the Chief Pilot asking him/her to pass on questionnaires to these three participants (Appendix B).
- A covering letter that described the purpose of the study and the expected outcomes, how the study was conducted and who was involved (Appendix C).

2.2 The Questionnaire

The questionnaire comprised three sections, as follows:

Section A: Description and composition of organisations

This section included questions that described different aspects of the organisations in the study. Participants were asked to provide information on the rule or rules their organisations were working under, whether they engaged in scheduled, non-scheduled operations or both, the type of aircraft they operated and whether they operated under Instrument Flight Rules (IFR), Visual Flight Rules (VFR) or both. Other questions asked about the types of aerodromes they operated to and whether or not they worked outside daylight hours.

Questions on the composition of organisations were also asked, and included the role or roles participants have in their organisation, and the number of people and pilots working in their organisation.

Section B: Fatigue management strategies in your organisation

Participants were asked to provide information on fatigue management strategies they thought their organisation had and were currently using. They were presented with ten fatigue management strategies and asked to indicate which strategies they had and were using in their organisation. These strategies included the following:

- Ongoing education for pilots on fatigue management;
- Ongoing education for people in management on fatigue management;
- Ongoing education for rostering staff on fatigue management;
- Monitoring of pilots' flight and duty times;
- Monitoring of pilots' workload (other than flight and duty times);
- An occurrence reporting system that asks about fatigue;
- Identification and management of fatigued pilots;
- Ongoing review of the processes used for fatigue management;
- A system for allowing feedback from pilots on fatigue-related issues and;
- Software to assist with rostering.

For each item, participants were also asked to provide an example of the strategy or strategies they had indicated.

To ensure the study covered other fatigue management strategies, participants were asked to describe additional strategies they used in their organisation.

Further, participants were asked to rate how well they thought their organisation was managing fatigue on the visual analogue scale (anchored with "not at all well" and extremely well"). The scale was 100mm long, on which participants were asked to place a mark. The position of the mark on the scale was measured to determine participants' perception on the effectiveness of their organisations in managing fatigue. Measurement in millimetres were converted into numbers, such that, 0mm = 0 and 100mm = 100 on the VAS.

Flight and Duty Time Limits

Also included in Section B of the questionnaire was an open-ended question that asked participants how their organisation met the flight and duty time limits. A number of examples were presented; including: 'Has adopted AC119-2'; 'Has adopted AC119-2 with dispensations', 'Has an accredited Fatigue Management Scheme, and 'Don't Know'. Participants were also able to indicate if their organisation currently used another approach to meet flight and duty time limits.

Section C: How does fatigue management work in your organisation

Section C comprised open-ended questions on how fatigue management worked in different organisations. Participants were asked to provide information on who was responsible for fatigue management and where they looked for information on fatigue management. They were also asked to present their views on the positive and negative aspects of their organisations' fatigue management strategies. Participants were also asked to provide information on the problems, barriers, and obstacles their organisations have in managing fatigue. Participants were asked to provide information on help, advice and resources they required to better manage fatigue in their organisation.

Lastly, participants could provide further information and comments.

2.3 Procedure

The study was funded by the Australian Transport Bureau (ATSB) and conducted at the Sleep/Wake Research Centre, Massey University. It was reviewed and approved by the Massey University Human Ethics Committee, WGTN Application 04/37.

An Advisory Group, comprising representatives from the New Zealand Airline Pilot Association (NZALPA), the Aviation Industry Association (AIA), the New Zealand Civil Aviation Authority (NZCAA) and the Australian Civil Aviation Safety Authority (CASA) was established to give ongoing advice and input to the study. The group had a diverse membership to ensure that issues across the industry were considered and that the language and terminology used in the questionnaire was appropriate for the audience.

In August 2004, the Group met for the first time to discuss how the study could be conducted. A draft questionnaire was presented to the Group for advice and terminology consistency.

Originally, the questionnaire consisted of 40 questions and was structured more towards facets of fatigue management schemes available in the industry and how they could be improved. However, it became clear that few organisations had fatigue management schemes that were using a comprehensive approach. With the input of the Advisory Group, the questionnaire was redesigned and reduced to 22 questions.

To ensure complete anonymity of participants and participating organisations, each questionnaire was assigned a unique code number. The study packages were sent via surface mail to the Chief Pilot of each Operator. Study packages were sent in late September 2004 and contained a letter to the Chief Pilot, a cover letter to the participants, three questionnaires and return self-addressed and stamped envelopes.

With smaller organisations, the roles of a pilot, rostering staff, and management could be filled by one or two individuals and so participants were asked to indicate this by ticking the appropriate box or boxes.

Two weeks after the first mail out, reminder postcards were sent to those who had not responded (Appendix D). A follow-up letter to the Chief Pilots (Appendix E) and non-responders (Appendix F) were sent two weeks later. Follow-up phone calls were then made to all Chief Pilots in organisations where partial or no responses had been received. A number of additional questionnaires were sent, as they were often misplaced or another nominated person, other than the Chief Pilot was indicated as most appropriate to distribute questionnaires to staff.

The first group of completed questionnaires were received between the second to last week of October 2004. The second group were received between the first week of November 2004 and the first two weeks of February 2005. Questionnaires that were received up to the fourth week of March 2005 were included in the database and analysis.

To maximise participation, a description of the study was prepared and included in the New Zealand CAA News Magazine November/December 2004 issue. A copy of this promotional article is reproduced in Appendix G. Later, the media also showed interest in the study when Radio New Zealand asked to include information as part of its news report. Information about the study was delivered and the study received media coverage 3 times in a single day.

2.4 Analyses

2.4.1 Data entry procedure

Information was entered into a SPSS database (Statistical Package for the Social Sciences, Version 12.0.1). To ensure accurate data entry, each questionnaire was double entered. Double entries were compared and discrepancies corrected.

2.4.2 Choosing one response from each organisation

To provide information on the different organisations participating in the study, one response from each company was selected.

Three participants were invited to complete study questionnaires in each organisation and although there were occasions where all three participants responded, there were also other cases where only one or two people responded. In the case of more than one response, only one response per organisation was selected and that was from a person in a management position or a person who has some management role. In cases where there were no responses from people in management positions, a response from a line pilot was selected. In cases where there was no response from either person, the remaining third person was selected. This procedure ensures equal weighting of responses from individuals in summary statistics describing the organisations. In total, 99 organisations responded.

2.4.3 Perceptions of people in different positions

To determine if there were differences between the perceptions of pilots and management, a comparison of responses from the two positions was carried out. Only those organisations where two suitable responses were received, were selected and compared. A total of 41 pairs of responses were available for comparison.

CHAPTER THREE
RESULTS

3.1 Participants

A total of 480 questionnaires were sent to 160 Part 119 Air Operator Certificate Holders. These were identified from a New Zealand Civil Aviation Authority Certification database in August 2004. These certificate holders include Part 121 Operators[9] (Large aeroplanes), Part 125 (Medium Aeroplanes)[10] and Part 135 (Small Aeroplanes and Helicopters)[11].

Of the 480 questionnaires sent out, 164 completed questionnaires were received, 19 from Part 121 Operators, 17 from Part 125 Operators and 128 from Part 135 Operators. Seven organisations had closed down by the time of the first mail out.

Of the 164 respondents, 56% reported having multiple roles. The breakdown of the multiple roles can be seen in Tables 3.1 and 3.2.

Table 3.1 Breakdown of roles

Role	%
Line Pilot	26.8
Rostering	5.9
Management	11.8
All	37.3
Management and Rostering	5.9
Management and Line Pilot	8.5
Rostering and Line Pilot	3.9

[9] Part 121 Large Aeroplanes: Aircraft with >30 passenger seats or payload >3410Kg.
[10] Part 125 Medium Aeroplanes: Aircraft with >9 but <30 passenger seats or payload <3410Kg and MCTOW (Maximum certified take off weight) >5700Kg SEIFR (Single engine certified for carriage of passengers under Instrument Flying Rules) Passenger operations.
[11] Part 135 Small Aeroplanes & Helicopters: Aircraft with <10 passenger seats and all Helicopters.

Because 56% of responses were from people who had multiple roles, this effectively changed the number of potential responses (since we could not expect to receive more than one questionnaire from an organisation run by a single individual). The final denominator was calculated using the roles for which responses were received (297). This resulted in a response rate of 52%.

Table 3.2 Breakdown of roles by Operator

Operator	Organisations	Pilot	Roster	Management	Multiple roles
Part 121	10	5	5	3	6
Part 125	10	3	2	4	8
Part 135	79	35	2	14	77

Table 3.3 Breakdown of multiple roles

Multiple roles	Part 121	Part 125	Part 135
All (%)	10	6	42
Management & Rostering (%)	0	24	5
Management & Pilot (%)	21	18	8
Rostering and Pilot (%)	0	0	5

It is apparent that from the information presented in Table 3.3, most of the participants who reported having multiple roles were from Part 135 organisations whereas larger organisations (Part 121 and 125) reported having the majority of single roles (69% and 52% respectively).

3.2 Organisations

The number of people employed by the different organisations varied from 0 to 10,000 and the number of pilots varied from 0 to 700. The participant from the organisation that reported having no person employed, performed both office and flying duties. Further details are provided in Table 3.4 .

Table 3.4 **Number of people and pilots employed**

	Employees		Pilots	
	Median	Range	Median	Range
Part 121	245	5-10000	60	4-700
Part 125	36	3-300	20	1-126
Part 135	8	0-100	5	1-50

A larger number of people and pilots were employed by Part 121 Operators, while smaller numbers were employed by Part 125 Operators, with the least employed by Part 135 Operators.

3.2.1 Rules under which organisations operate

Participants were asked to indicate the rule or rules under which they operated. A number of organisations reported operating under more than one rule. This information is indicated in Table 3.5 below.

Table 3.5 **Breakdown of organisations by rule/s**

	No. of organisations	%
121 only	10	10
125 only	10	10
135 only	79	79
121 & 125	5	5
121 & 135	2	2
125 & 135	8	8

Most participants reported operating under Part 135 rules. Additionally, for organisations operating under more than one rule, most comprised Part 125 and 135 Operators.

3.2.2 Types of operation

For the purpose of this study, the type of operation was split into two: *scheduled* and *non-scheduled*. Operators reported the type of operation they carried out in their organisation. Figure 3.1-Figure 3.3 shows the proportion of Operators conducting different types of scheduled and non-scheduled operations (many Operators conducted operations under more than one category).

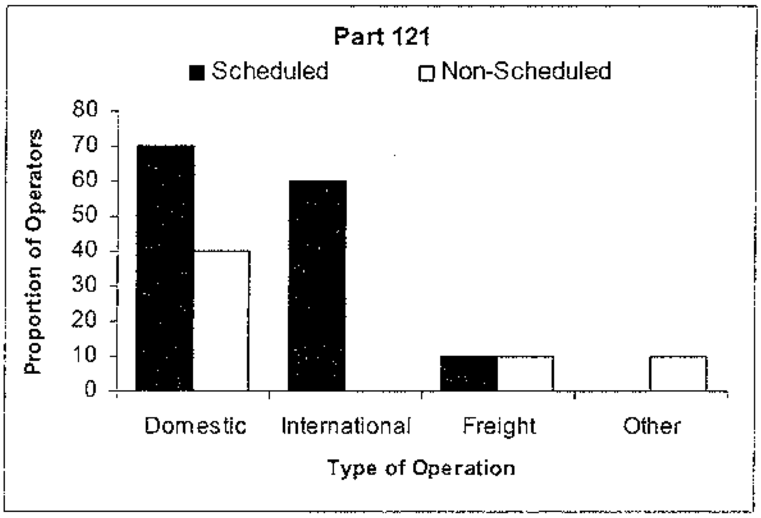


Figure 3.1 The proportion of Part 121 Operators engaged in different types of operations

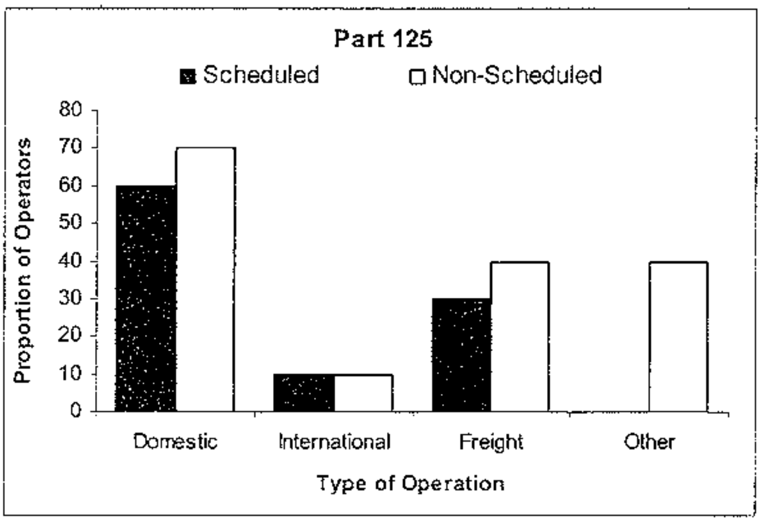


Figure 3.2 The proportion of Part 125 Operators engaged in different types of operations

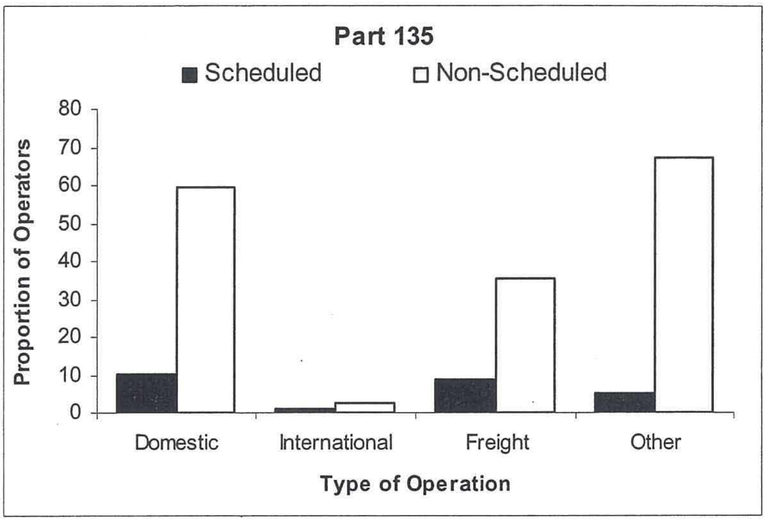


Figure 3.3 The proportion of Part 135 Operators engaged in different types of operation

Seventy percent of Part 121 Operators engaged in scheduled domestic operations, while 60% engaged in scheduled international operations. Other types of operation included non-scheduled charter reported by 10% of Part 121 Operators.

Sixty percent of Part 125 Operators engaged in scheduled domestic operations while 40% engaged in freight and other types of operation. Other types of operation included charter flights (scenics), training, and other commercial charter flights including calibration flights.

Figure 3.3 shows that 70% of Part 135 Operators were engaged in a mix of non-scheduled operations. These types of operation included a wide range of operations such as air ambulance, scenic flights, agricultural work, training, filming, aerobatics, survey work, emergency medical services (EMS), photography flight, and non-commercial flights such as company support operations. Additionally, 60% of Operators reported engaging in non-scheduled domestic operations.

3.2.3 Types of Aircraft Operated by Organisations

The types of aircraft operated by organisations are summarised in Figures 1.4 to 1.6 below. Because organisations were engaged in operating more than one type of aircraft, the data is displayed in three separate graphs. The variable labelled 'mixed' refers to operating more than one type of aircraft, while 'none' refers to organisations that did not indicate the types of aircraft operated.

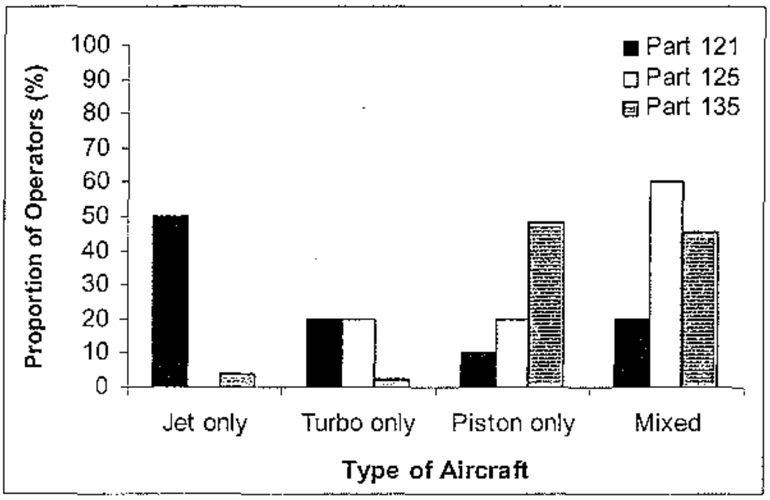


Figure 3.4 Proportion of Operators using different types of aircraft in their operation (jet, turbo, piston and all).

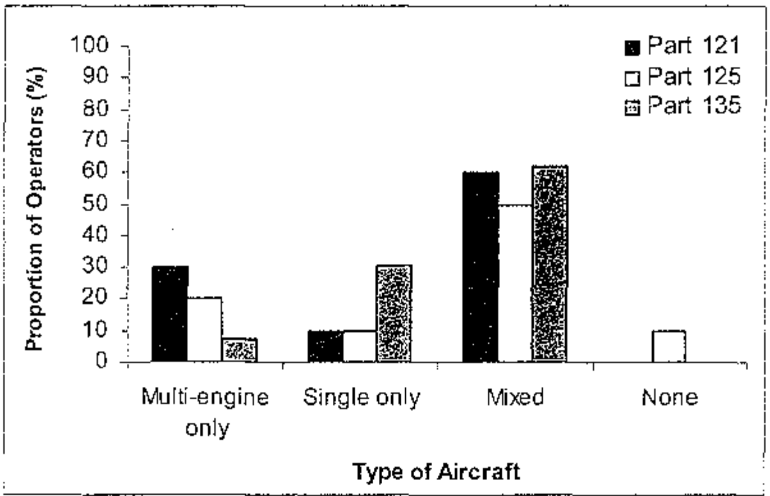


Figure 3.5 Proportion of Operators using different types of aircraft in their operation (multi-engine, single engine and all).

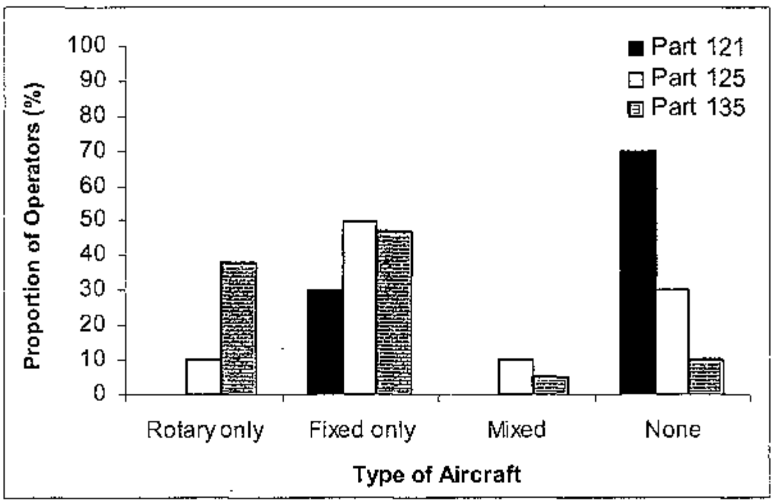


Figure 3.6 Proportion of Operators using different types of aircraft in their operation (rotary, fixed and all).

The information provided in Figure 3.4 indicates that no Part 125 Operator reported operating jet aircraft while 50% of Part 121 Operators reported this. A large number of Part 135 Operators reported operating piston and mix types of aircraft. The majority of Part 125 Operators reported operating a mix of different aircraft.

Figure 3.5 indicates that most Operators (> 60% of Part 121 and Part 135 Operators and approximately 50% of Part 125 Operators) operated a mix of multi-engine and single-engine aircraft. Ten percent of Part 121 Operators did not respond to this section of the question.

Surprisingly, larger proportions of Part 125 and 135 Operators reported operating fixed wing type of aircraft (approximately 50% and slightly fewer than 50% respectively), while only 30% of Part 121 reported this. However, 70% of Part 121 Operators did not respond to this part of the question.

3.2.4 Types of Flight Rules

Responses to the question on the type of flight rules operated under are presented in the table below.

Table 3.6 **Proportion of Operators reporting types of flight rules they operate under.**

Type of flight rules	Part 121(%)	Part 125(%)	Part 135(%)
IFR only	90	40	6
VFR only	10	40	21
IFR and VFR	0	20	73

As can be seen from 1.6, Part 121 Operators predominantly operated under IFR, Part 135 Operators under VFR and Part 125 Operators appeared to operate under IFR and VFR. Part 121 Operators did not operate under both rules while a significant number of Part 135 Operators (more than 70%), reported operating under both IFR and VFR.

3.2.5 Types of Airspace

Participants were asked to report whether they operated into controlled and/or uncontrolled airspace. Eighty percent of Part 121 Operators reported operating only in controlled airspace, while 80% of Part 125 Operators and more than 70% of Part 135 Operators reported operating in both types of airspace (Figure 3.7).

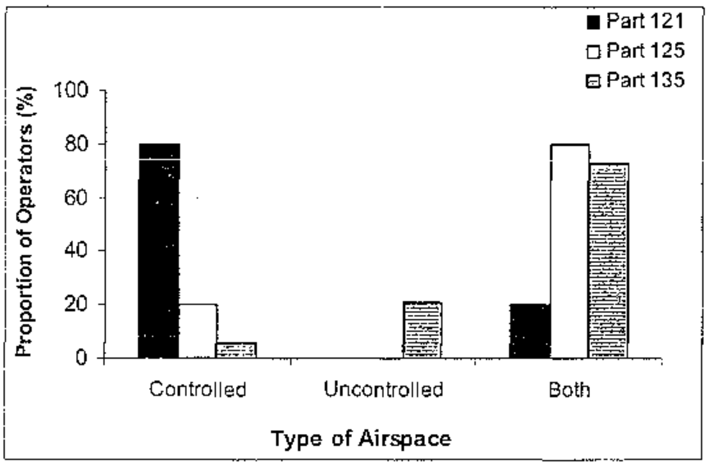


Figure 3.7 Types of Airspace

3.2.6 Types of Aerodromes

Participants were asked to provide information on the types of aerodromes used in their operations. These include certificated, uncertificated and remote aerodromes. Results are summarised in Figure 3.8 to 3.10.

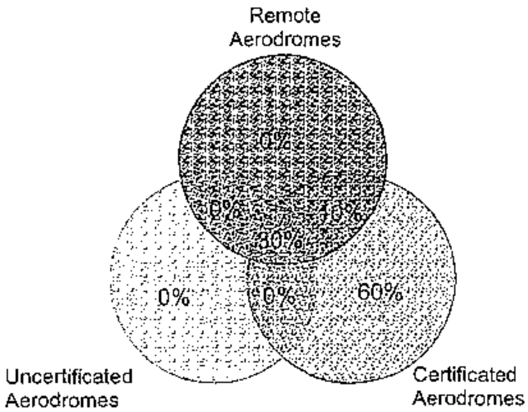


Figure 3.8 Proportion of Part 121 Operators operating to different aerodromes

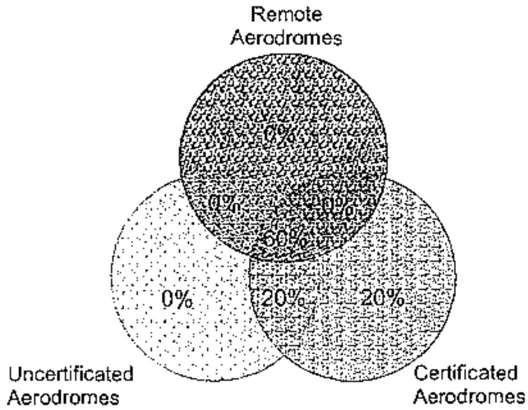


Figure 3.9 Proportion of Part 125 Operators operating to different aerodromes

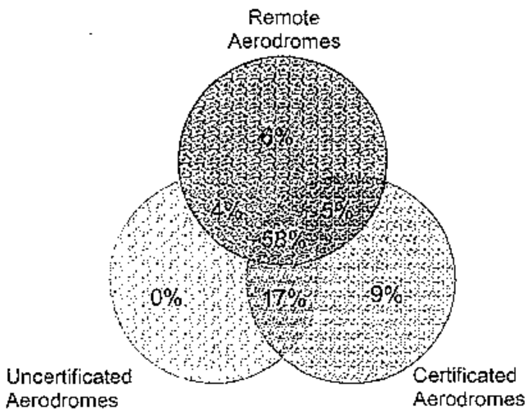


Figure 3.10 Proportion of Part 135 Operators operating to different aerodromes

The majority of Part 121 Operators operated to certificated aerodromes while a smaller proportion operated to all types of aerodromes (Figure 3.8).

Most Part 125 Operators operate to all three types of aerodromes while the remaining smaller proportions reported operating to certificated and a combination of both certificated and uncertificated aerodromes (Figure 3.9).

More than half of Part 135 Operators operate to all three types of aerodromes while smaller proportions operate to both certificated and uncertificated aerodromes (Figure 3.10).

3.2.7 Operation outside daylight hours

As expected, greater proportions of both Part 121 and 125 participants (90%) reported operating outside daylight hours, while only 60% of Part 135 Operators reported this.

3.3 Fatigue Management Strategies

The reported number of fatigue management strategies used reported by Operators is illustrated in Figure 3.8.

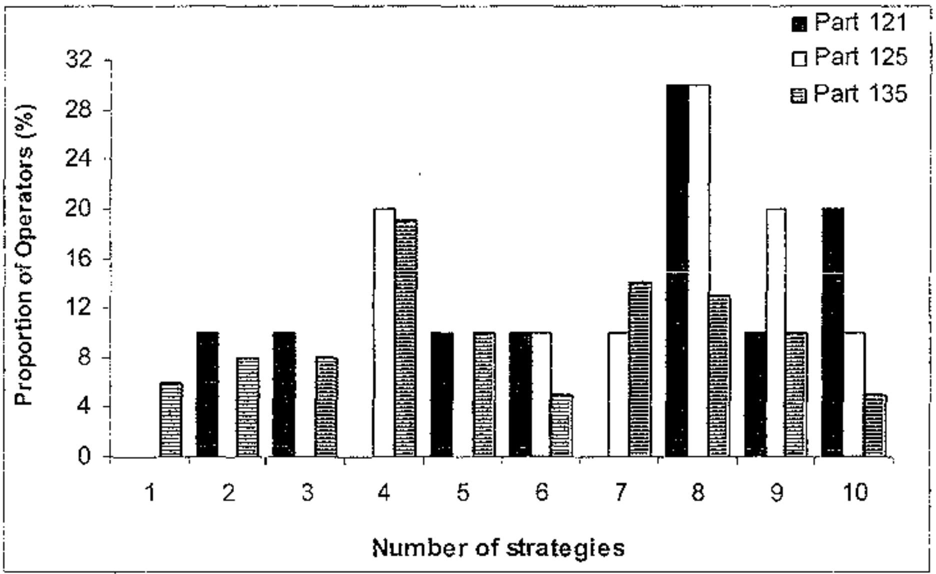


Figure 3.8 Proportion of Operators reporting number of strategies used in their organisation.

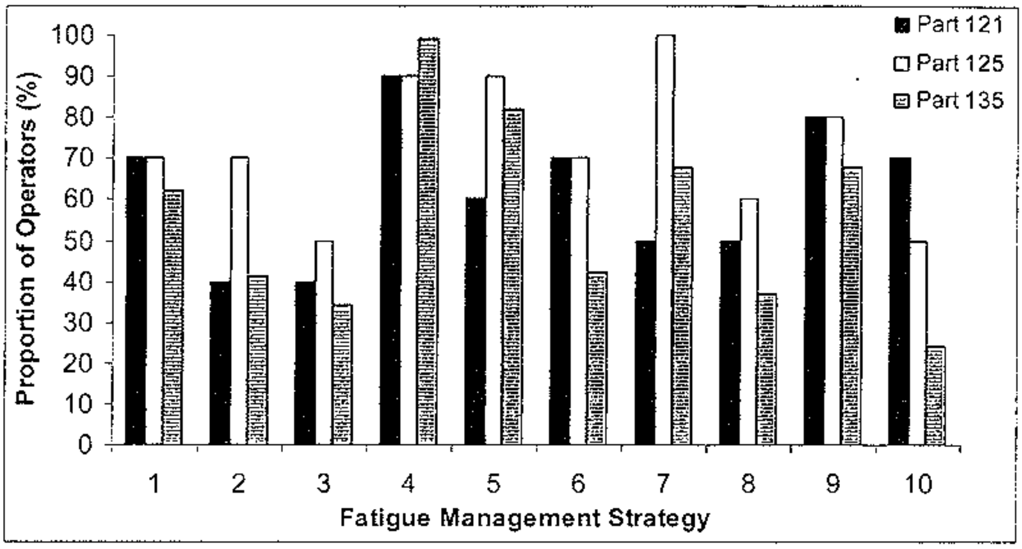
Sixty percent of participants from Part 121 Operators reported that their organisation had at least eight fatigue management strategies in place. No participant reported having fewer than two fatigue management strategies; while 10% reported that their organisation had all ten listed fatigue management strategies.

Sixty percent of Part 125 Operators reported that their organisations had eight or more fatigue management strategies. While 10% of participants indicated that their organisation had all ten fatigue management strategies, none of the participants reported having less than four strategies.

A small number of Part 135 Operators (28%) reported that their organisation had eight or more fatigue management strategies, while 6% reported having only one.

3.3.1 Fatigue management strategies used by Operators

Figure 3.9 summarises Operators' views on the most commonly used strategies they thought their organisation had in place.



Key: 1 = Ongoing education for pilots on fatigue management. 2 = Ongoing education for people in management on fatigue management. 3 = Ongoing education for rostering staff on fatigue management. 4 = Monitoring of pilots' flight and duty times. 5 = Monitoring of pilots' workload (other than flight and duty times). 6 = Occurrence reporting system that asks about fatigue. 7 = Identification and management of fatigued pilots. 8 = Ongoing review of the processes used for fatigue management. 9 = A system for allowing feedback from pilots on fatigue-related issues. 10 = Software to assist with rostering.

Figure 3.9 The proportion of Operators reporting each fatigue management strategy

A large proportion of Operators (90% of Part 121 and Part 125; 99 % of Part 135) reported that they monitored pilots' flight and duty times as one way of managing fatigue in their organisation. The graph also indicates that all Part 125 Operators reported using a strategy that identified and managed fatigued pilots, while half of Part 121 and more than 60% of 135 Operators reported this.

Examples of fatigue management strategies used by organisations (as shown in Figure 3.9) were provided by participants and are summarised in Appendix H.

Ongoing education for pilots, rostering staff and management

A large proportion of Operators reported arranging ongoing education for pilots, rostering staff and management through existing company training programmes and scheduled activities in their organisation. Some of these activities included programmes such as Crew Resource Management (CRM) training, pilot induction, annual refresher course, seminars and meetings. The majority of Part 135 Operators (99%) on the other hand, mentioned monitoring flight and duty schemes as a means of educating their pilots on fatigue management. Other more informal methods such as open discussions and awareness on fatigue management were also reported by a large number of Part 135 Operators.

Monitoring of Pilots' Flight and Duty Times

Examples of how Operators monitored pilots' flight and duty times were mostly related to how and where they kept such records. This was as reported by all Part 121 Operators, 60% of Part 125 and more than half of Part 135 Operators. In the case of Part 121 and 125 Operators, such records were stored in computer systems in most cases, while for most of Part 135 Operators, these records were stored in non-computerized systems.

Monitoring of Pilots' Workload

Half of Part 121 participants monitored pilots' workload by accounting for extra duties in their roster system. In general, Part 125 and 135 Operators reported that they monitored pilot workload by conducting open discussions between management and pilots. Additionally, a large proportion of Part 135 Operators reported monitoring pilot workload by monitoring existing flight and duty time schemes.

Occurrence Reporting System

With the exception of Part 135 organisations, more than 50% of Operators reported that occurrence reporting was part of other general reporting systems which also included the QSRS. Nevertheless, a significant number of participants from Part 121 and 125 organisations (33% and 50% respectively) reported having the system but that it was either ineffective or did not specifically ask about fatigue.

Identification and Management of Fatigued Pilots

In general, Operators reported that fatigued pilots were identified and managed by reviewing systems that specifically addressed flight and duty times, such as rostering and fatigue reporting systems.

Ongoing Review of the Processes used for Fatigue Management

Greater proportions of Operators reported that in general, ongoing review for the processes used for fatigue management was incorporated and carried out as part of existing activities and systems within their organisation. Some of these arrangements and systems were Quality Assurance (QA), Annual Refresher Courses, management meetings and recurrent updates on company manuals.

A system for Allowing Feedback from Pilots

Half of Part 121 Operators reported that they allowed pilots to provide feedback through a quality and fatigue reporting system. Unexpectedly, half of Part 125 Operators reported that their system for allowing feedback from pilots was carried out through personal interactions, while more than 40% of Part 135 also reported that such a system was informally based, that is, through open discussions.

Software used by Operators to Assist with Rostering

As expected, greater proportions of Part 121 and 125 participants (50% of both groups) indicated using specialized software to assist with rostering such as Geneva and a program that computes flight and duty times respectively. In general, Part 135 Operators indicated using simpler methods such as Microsoft Access programs and databases.

3.3.2 How different are the views of pilots and management people in relation to the fatigue management strategies used in their organisation?

There were only four Part 121 Operators where responses were received from both a pilot and a management person and only three Part 125 Operators where two responses were received. A total of 34 Part 135 organisations had responses from the two positions. The views of these people on the use of different fatigue management strategies are summarised in Figure 3.10 and Figure 3.11.

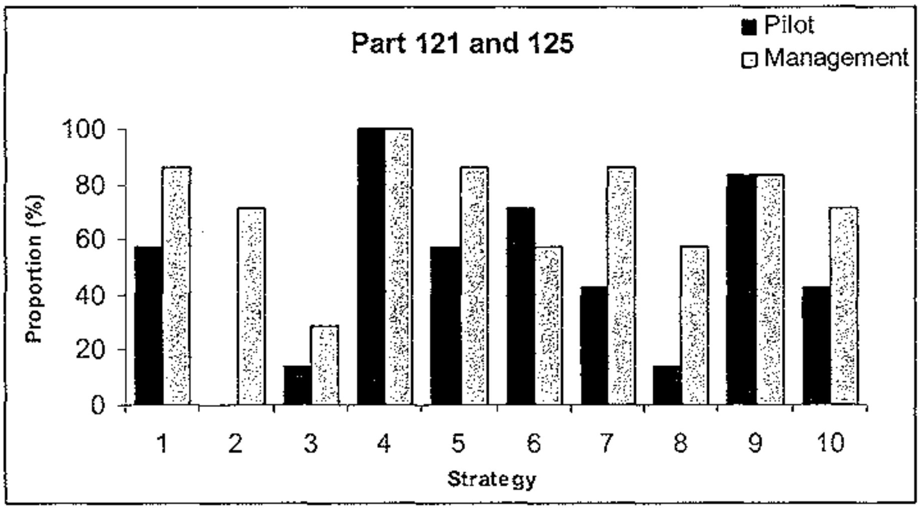
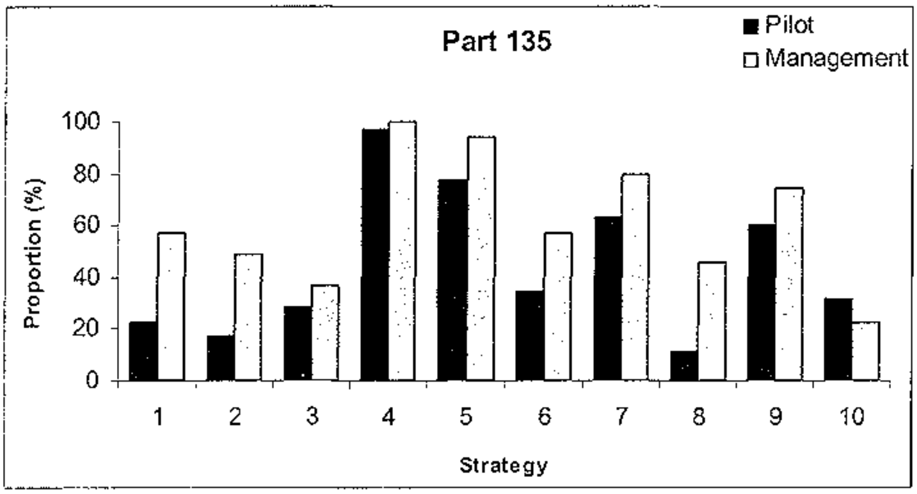


Figure 3.10 Proportion of Part 121 and 125 Operators showing difference in views in relation to fatigue management strategies used in their organisation.

Key: **1** = Ongoing education for pilots on fatigue management. **2** = Ongoing education for people in management on fatigue management. **3** = Ongoing education for rostering staff on fatigue management. **4** = Monitoring of pilots' flight and duty times. **5** = Monitoring of pilots' workload (other than flight and duty times). **6** = Occurrence reporting system that asks about fatigue. **7** = Identification and management of fatigued pilots. **8** = Ongoing review of the processes used for fatigue management. **9** = A system for allowing feedback from pilots on fatigue-related issues. **10** = Software to assist with rostering.

The information in Figure 3.10 shows that pilots and management differed significantly in their perceptions over education on fatigue management in their organisation. Pilots indicated that management did not receive education on fatigue management, whereas 85% of management reported that this occurred. Another significant difference in the two views is related to the identification and management of fatigued pilots and the ongoing review of the processes used in the management of fatigue. As can be seen from the graph, there is approximately 40% fewer pilots reporting these strategies compared to those in management.



Key: **1** = Ongoing education for pilots on fatigue management. **2** = Ongoing education for people in management on fatigue management. **3** = Ongoing education for rostering staff on fatigue management. **4** = Monitoring of pilots' flight and duty times. **5** = Monitoring of pilots' workload (other than flight and duty times). **6** = Occurrence reporting system that asks about fatigue. **7** = Identification and management of fatigued pilots. **8** = Ongoing review of the processes used for fatigue management. **9** = A system for allowing feedback from pilots on fatigue-related issues. **10** = Software to assist with rostering.

Figure 3.11 Proportion of Part 135 Operators showing difference in views in relation to fatigue management strategies used in their organisation.

Figure 3.11 indicates that the views of pilots and management from Part 135 organisations differed across all ten fatigue management strategies. With the exception of participants' perceptions over software used to assist in rostering, a smaller proportion of pilots than management reported that the remaining 9 fatigue management strategies were used in their organisation.

3.3.3 How different are the views of pilots and management people on fatigue management strategies used in their organisation?

The views of pilots and people in management positions working in the same organisation were compared to determine if there were differences in the perception of the number of fatigue management strategies used by their organisations are summarised in Table 3.7.

Table 3.7 Comparison of pilot and management views on the number of fatigue management strategies their organisations are using.

	PART 121		PART 125		PART 135	
	Pilot	*Management*	*Pilot*	*Management*	*Pilot*	*Management*
Range	3-7	5-10	4-6	4-8	1-8	2-10
Median	5	7	5	6	5	8

There were differences in the views from pilots and management working in the same organisations as shown in Table 3.7. Overall, people in management reported having more fatigue management strategies than pilots. The results also show that the range for the number of strategies reported by Part 125 Operators (pilots and management) is smaller in comparison to the other two Operators.

3.3.4 What other fatigue management strategies are used in organisations?

Other fatigue management strategies used in organisations in addition to the ten specific strategies are summarized in the following tables. The 'not applicable' group refers to and those categorized as 'Nil' who reported having no 'other' fatigue management strategies in their organisation, apart from those strategies they had already mentioned.

Table 3.8 Other fatigue management strategies reported by Part 121 participants

Other fatigue management strategies used	%
Follow-up training programmes	33
Not applicable	33
Common Sense	17
Nil	17

More than 30% of Part 121 participants reported using follow-up training programmes as other strategies to manage fatigue (Table 3.8).

Table 3.9 Other fatigue management strategies reported by Part 125 participants

Other fatigue management strategies used	%
Promoting increased awareness of fatigue	**25**
Open door policy	**25**
Common sense	**25**
Nil	**13**
Not applicable	**13**

Half of Part 125 participants reported using other fatigue management strategies such as increasing staff awareness of fatigue and open door policies (Table 3.9).

Table 3.10 Other fatigue management strategies reported by Part 135 participants

Other fatigue management strategies used	%
Scheme to suit nature of operation	9
Open door policy	41
Better rest facilities	7
Self-assessment	9
Common sense	9
Not applicable	9
Nil	16

The information in Table 3.10 reveals four other types of fatigue management strategies reported by 65% of Part 135 Operators, of which 41% reported using open door policies.

3.3.5 How well participants think their organisations are currently managing fatigue

Participants were asked to place a mark on a line (100mm long) indicating how well they thought their organisation was managing fatigue. As shown in Table 3.11, on average, participants reported that their organisation manages fatigue moderately well. Part 121 participants had slightly lower scores on average compared to Part 125 and 135 Operators.

Table 3.11 Participants' ratings on how well they thought their organisation manages fatigue, where 0=0mm (not at all well) and 100=100mm (extremely well)

Operator	Range	Median
Part 121	3-73	59
Part 125	36-100	71.5
Part 135	6-100	68

3.3.6 Comparison of the views of pilots and management people in relation to how well they think their organisation manages fatigue

The perceptions of pilots and people in management positions on how well fatigue was being managed in their organisation were compared. The views varied largely between the two positions in Part 121 and 125 organisations, while surprisingly, the views of pilots and management people in Part 135 organisations were similar. These comparisons are summarised in Table 3.12.

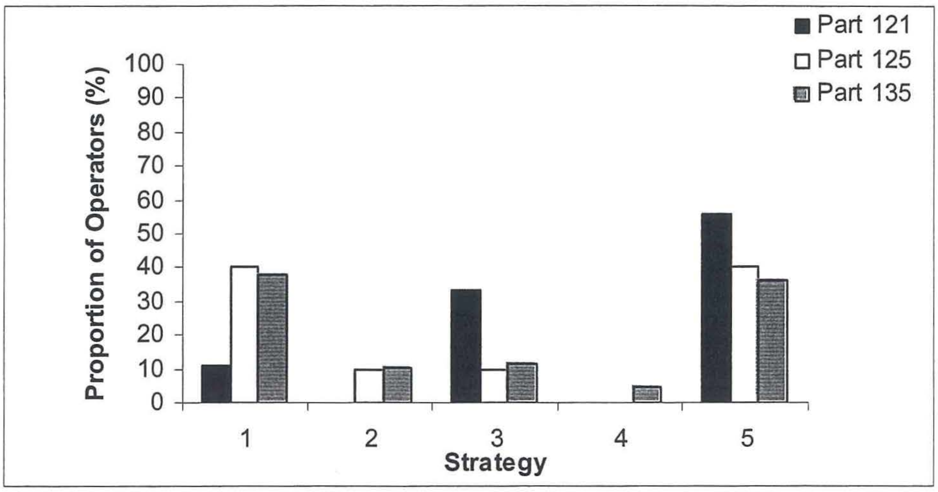
Table 3.12 Median reported for pilots and management on how well they thought their organisation manages fatigue, where 0=0mm (not at all well) and 100=100mm (extremely well).

	Part 121		Part 125		Part 135	
	Pilot	Management	Pilot	Management	Pilot	Management
Range	3-58	59-63	22-78	45-78	17-100	36-100
Median	31	61.5	50	61.5	66	66

The median values for pilots' perceptions of how well fatigue was being managed from Part 121 and Part 125 organisations were lower than those for people in management positions, while the median value for pilots and management from Part 135 organisations were the same, and higher than Part 121 or Part 125 organisations.

3.3.7 How organisations meet their Flight and Duty Time Limits

Participants were asked to provide information on how their organisation meets the flight and duty time limits (FDTL) (Figure 3.12).



Key: **1**=AC-119-2; **2**=AC119-2 with dispensations; **3**=Accredited Fatigue Management Scheme; **4**=Don't know; **5**=Other.

Figure 3.12 Operators reporting how their organisation meets the flight and duty time limits.

As can been seen in the bar graph above, a significant number of Part 121 Operators (> 30%) reported having an accredited fatigue management scheme to meet the FDTL. The majority of Part 125 Operators reported adopting AC 119-2 or additional means as methods for meeting their FDTL, while the largest proportion of Part 135 Operators reported adopting AC 119-2.

3.3.8 Other strategies used by Operators in meeting Flight and Duty Time Limits

In general, participants from Part 121 Operators reported establishing their own flight and duty time schemes. One example of an alternative scheme was using the principles of CAP371, which is the UK flight and duty time limits.

The information reported by Part 125 Operators in relation to other strategies included tailored schemes to suit extreme weather-dependant operations, and approved flight and duty monitoring and recording systems.

Part 135 Operators reported other strategies in meeting their FDTL are summarised as follows:

- 58% of Part 135 participants reported fatigue is not a problem or issue due to the very low number of hours flown and adequate staff levels;
- 25% reported monitor rosters and flight and duty time limits manually by pilots and other staff;
- 8% reported using computerized flight and duty time information and;
- the remaining 8% indicated that they comply with Part 135 requirements.

3.3.9 How different are the views of pilots and people in management positions in relation to strategies used in meeting Flight and Duty Time Limits.

There were few similarities between the perceptions of pilots and management from Part 121 and 125 organisations in how their organisation met the FDTL. A review of responses from the two positions in Part 135 organisations indicated that 48% of these responses were different. The remaining 52% showed similar views and more than half of them ticked 'Other', (Option 5 in Figure 1.15).

3.3.10 How does fatigue management work in organisations?

In order to address how fatigue management worked in an organisation, participants were asked a number of questions on different aspects of fatigue management.

Who is responsible for fatigue management?

Overall, responses from Part 125 and 135 participants generally indicated that there was more than one person responsible for fatigue management in their organisation. Generally, these people form part of their Operations Management.[12] The responses from Part 121 Operators were more specific and reported that the Flight Operations Manager had the responsibility for managing fatigue in their organisation. The results are summarised in the Tables 3.13-3.15 below:

Table 3.13 A summary of responses from Part 121 participants in relation to who is responsible for fatigue management in their organisation.

Who is responsible for fatigue management?	%
Flight Operations Manager or Operations Controller	44
Operations Management	22
Committee	11
Quality & Safety Manager	11
Individual Department Manager	11

[12] Operations Management refers to a group of people inclusive of the Flight Operations Manager, the Operations Controller, the Chief Pilot and other people assigned definitive responsibilities directly related to operational activities within organisations.

The information in Table 3.13 indicates that almost half of the Part 121 participants report that the Flight Operations Manager is responsible for fatigue management in their organisation.

Table 3.14 A summary of responses from Part 125 participants on who is responsible for fatigue management in their organisation

Who is responsible for fatigue management?	%
Operations Management	88
Flight Operations Manager & pilots	12

More than 80% of Part 125 participants reported that members of Operations Management are responsible for fatigue management in their organisation, while the remaining participants indicated that the Flight Operations Manager, along with pilots, are responsible (Table 3.14).

Table 3.15 A summary of responses from Part 135 participants in relation to who is responsible for fatigue management in their organisation.

Who is responsible for fatigue management?	%
Operations Management	54
Chief Pilot only	20
Chief Executive Officer	8
Chief Flying Instructor only	3
Quality Manager	2
OSH Officer	2
Pilots	5
Committee	5
Everyone	2

As can be seen from Table 3.15, more than 50% of Part 135 participants reported that Operations Management was responsible for fatigue management in their organisation, while the remaining participants indicated a number of responsible persons. These remaining responses covered a number of different titles and included 'pilots' and 'everyone' as people responsible for fatigue management.

Comparison of views of pilot and management people on who is responsible for fatigue management

Part 121 Pilot/Management views: A review of the data indicated that 25% of participants from Part 121 organisations had different perceptions as to who was responsible for fatigue management in their organisation while the remaining 75% gave similar responses. Of the 25% whose views differed, overall responses provided by both people showed at least one similar aspect, for example, a typical response from a management person indicated *"Individual managers"* such as the *Flight Operations Manager and Manager Customer Services for Flight Attendants* whereas a response from a pilot stated *"OSH Committee (chaired by the Flight Operations Manager) and the Roster Review Committee"*.

Part 125 Pilot/Management views: A review of responses provided by pilots and people in management in Part 125 Operators showed great similarities. Overall, a typical feature of management responses was that they were more descriptive and explanatory than those of pilots. For example, in one company, a management response stated, *"Operations Manager (CEO), Chief Pilot and individual self-monitoring and responsibility"* and a pilot response indicated *"Chief Pilot, CEO, Operations Manager and pilots"*. Another feature of the data was that a pilots' responses inferred pilot inclusion in the system whereas managements' responses excluded others. For example, the pilot view indicated, "*Operations Manager and pilots*" whereas a management view stated," *Operations Manager*" only.

Part 135 Pilot/Management views: The responses from pilots and management from Part 135 Operators were compared to identify the differences. Fifty nine percent of the participants' perceptions were similar. Of the pilots' responses, 32% indicated a combination of a *management person and a pilot* responsible for fatigue management. The remaining 68% was distributed amongst '*Operations Management*', '*Everyone*' and *single roles*. Of the management responses, 23% indicated that fatigue management was the responsibility of a *management person and a pilot* while the remaining percentage represented a combination of two management roles, '*Operations Management*' or '*Administration Management*' and *single roles*.

Where do organisations look for and get information on fatigue management?

The responses indicated a variety of sources from which Operators looked for and got information on fatigue management. Overall, the responses showed that most of the information sought was from outside the organisation as opposed to having readily available information within organisations. The results are described in Tables 3.16 to 3.18.

Table 3.16 A summary of responses from Part 121 participants on the sources of information on fatigue management

Source of information	%
Other organisations and other sources outside organisations	60
Organisations do not provide any information	20
Within organisations	10
Not aware of any research or information gathering	10

More than half of Part 121 participants indicated seeking information from other organisations, while a smaller proportion of participants reported getting information from within their organisation. Other sources included NZALPA and specific sources from within organisations as well as other regional airlines and the NZCAA.

Table 3.17 A summary of responses from Part 125 participants on the sources of information on fatigue management

Source of information	%
Other sources from outside the organisations	50
Resources and training programmes within organisations	30
Pilot and roster feedback from within organisations	20

Half of Part 125 participants reported getting information on fatigue management from other sources from outside their organisations. Sources outside their organisation included expert advice and resources from an Aviation Medical Doctor, NZCAA and publications from other aviation organisations.

The remaining half of Part 125 participants reported getting information on fatigue management from within their organisation.

Table 3.18 A summary of responses from Part 135 participants on the sources of information on fatigue management

Source of information	%
Other organisations, CAA, publication, articles, experts	47
Within organisations	17
We don't look for information	10
Own experience and commonsense	9
Feedback from flight and duty time records	9
Not applicable	7
Don't know	2

More than 20% of Part 135 participants reported getting information on fatigue management from the aviation industry and CAA, while the remaining participants indicated a wide variety of sources.

Comparison of the views of pilots and management people on the sources of information on fatigue management

Part 121 Pilot/Management views: The views of pilots and people in management positions from Part 121 Operators were compared to determine the differences in sources of information on fatigue management. The results showed that two thirds of the responses were different. Generally, responses from pilots indicated "*Don't know*" and "*Not aware of*", whereas management responses indicated getting information on fatigue management from within and outside the organisation (by being provided with more specific information, for example via a CRM training package). A typical feature of the similar views reported by people in these 2 positions was that a pilot response was confined to one source whereas a management response included more than one source. For example, a pilot response stated, "*A Medical Doctor*" and a management response reported, for example from a larger organisation, *NZALPA and Safety Publications*".

Part 125 Pilot/Management views: A third of the responses from pilots and management people indicated a difference in perceptions of where information was obtained from while the remaining two thirds of the participants showed similarities. The pilot response indicated sources readily available within their organisation such as "*Internet, CAA Rules*", whereas a management response was more elaborative and included personal experience, for example, "*A wide range of study materials, on the job experience and seminars*". Another typical scenario showing the difference in views between these two positions was indicated by a pilot response stating, "*Don't know*" and a management response stating, "*Yet to be done*".

Part 135 Pilot/Management views: More than 50% of the responses from pilots and management people were different. Of the responses with different views, a general feature of management responses reflected acquiring information on fatigue management by consulting *flight and duty time records, observing pilots and adhering to pilot feedback*. On the other hand, pilot responses were more oriented to information available from *CAA, relevant books, publications and articles*. Further, of the views that were similar, responses from management people were generally more concise and included details of the source, for example, "*CAA articles/circulars and using own experience from previous jobs*", while, pilot responses were broader and included brief descriptions, such as, "*CAA website*", or "*CAA Rules*".

Positive benefits of organisations' fatigue management strategies

Participants were asked to present their views on the positive aspects of their organisations fatigue management strategies. These views are summarised in Tables 3.19 – 3.21.

Table 3.19 A summary of responses from Part 121 participants on positive benefits of their organisations' fatigue management strategies

Positive benefits	%
Factors leading to motivation and well-being of pilots	70
No ongoing pilot fatigue problem	10
No positive benefits	10
Too soon to report	10

The largest proportion of Part 121 participants (70%) reported that the positive benefits of their organisations' fatigue management strategies were 'factors leading to improved motivation and well-being of pilots'.

Table 3.20 A summary of responses from Part 125 participants on to the positive benefits of their organisations' fatigue management strategies

Positive benefits	%
Better schemes and activities motivating aircrew and contribute to better work environment	67
Awareness of fatigue reduces fatigue levels and incidents	22
No positive benefits	11

More than 60% of Part 125 participants indicated improved aircrew motivation and better work environment as positive benefits of their organisations' fatigue management strategies. Additionally, more than 20% stated that positive aspects of fatigue management as being a greater awareness of fatigue, thereby reducing fatigue levels and incidents.

Table 3.21 A summary of responses from Part 135 participants on the positive aspects of their organisations' fatigue management strategies

Positive aspects	%
Factors leading to the well-being of workers	33
Awareness of fatigue and safety measures	26
Fatigue has never been a major issue	20
Better roster management	11
Incident and Accident free operations	9
Don't know	2

More than 33% of Part 135 participants stated that a positive aspect of their organisations' fatigue management strategies was improved well-being of workers. Other positive aspects reported by smaller proportions of participants included improved awareness of fatigue and safety measures, and better roster management.

Comparison of views from pilots and management people on positive aspects of their organisations' fatigue management strategies

Part 121 Pilot/Management views: One third of the responses were different and of these responses, a typical example is shown below:

Pilot:	*"Don't know"*
Management:	*"Responsibility and shared liability. The overall and biggest benefit is safety"*

Of the views that were similar, a typical example is shown below:

Pilot:	*"Happier pilot workforce. Less health problems amongst pilot group. Less "sickies" and sick day leave usage."*
Management:	*Safety of the operation. Aircrews who remain motivated and sharp."*

Overall, management responses were generally more organisationally focussed, whereas pilot responses generally indicated less information and were more focussed on the individual.

Part 125 Pilot/Management views: Responses from pilots and management people showed many similarities. However, pilot responses described positive aspects in terms of the practicality of their tasks as pilots whereas management responses were more organisation oriented. For example, a typical response from a pilot indicated that *flexible time management* was a positive aspect of their organisation's fatigue management strategies. On the other hand, a management response was geared more to *participation of staff, a tailored time and duty scheme suitable for the organisation and a wide range of activities to enhance staff physical and mental performance.*

Part 135 Pilot/Management views: The results of the comparison of the two positions indicated that 46% of the views differed. Of the 46% that differed, responses from pilots indicated that they *have not seen any positive benefits* of their organisations' fatigue management strategies, while management responses were more specific and generally covered *improved systems for the well-being of pilots.* Of these responses that were similar, less than half stated that *fatigue was not a problem* while more than half stated positive benefits such as a *reduction in incidents, a better working environment that could contribute to sustainability.* In general, pilot responses were more focused on improved systems and procedures that contributed to their work as pilots while management responses were more focused on the organisation as a whole.

Negative aspects of organisations' fatigue management strategies

Responses from Operators are summarised in Table 3.22-Table 3.24.

Table 3.22 A summary of responses from Part 121 participants on the negative aspects of their organisations' fatigue management strategies

Negative aspects	%
Considered not practical	43
Present system waits for pilots to complain	14
Time consuming; Difficult to maintain	14
No negative aspects	29

More than 40% of Part 121 Operators considered their present fatigue management strategies not practical. While other participants perceived their present strategies to be time consuming, difficult to maintain and hard on pilots, a higher percentage of the participants stated that there were no negative aspects.

Table 3.23 A summary of responses from Part 125 participants on the negative aspects of their organisations' fatigue management strategies

Negative aspects	%
Can be limiting and inflexible	33
Not aware of any negative aspects	33
Fatigue yet to be formally managed	17
Not applicable	17

Table 3.23 indicates that more than 30% of Part 125 participants reported that their organisation's fatigue management strategies could be limiting and inflexible. The same percentage of participants were not aware of any negative aspects and a smaller proportion indicated that fatigue was yet to be formally managed.

Table 3.24 A summary of responses from Part 135 participants on the negative benefits of their organisations' fatigue management strategies

Negative aspects	%
No negative aspects	39
Fatigue management strategies limited by flight time	17
Not applicable	13
Very informally based	8
Poor planning	6
Considered time consuming	3
External factors not accounted for	3
Lack of staff	6
Negative responses from pilots	3
Difficult to identify fatigue	3

Approximately one third of Part 135 participants reported that there were 'no negative aspects' of their fatigue management strategies. A smaller proportion of participants indicated that the strategies were considered limiting in terms of flight time (Table 3.24).

Comparison of views from pilots and management people on the negative aspects of organisations' fatigue management strategies

Part 121 Pilot/Management Views: Two thirds of Part 121 participants showed great differences in their responses. Of the responses with differing views, a typical pilot response stated, "*the strategies do not reduce fatigue levels*", while a management response reported the "*inconsistency in attempts to structure rosters without breaching current rules relating to fatigue management schemes*". Another typical example of a pilot and a management response that differed is given below:

Pilot:	*"Don't know"*.
Management:	*"Time consuming. Difficult to assess sometimes"*.

Part 125 Pilot/Management Views: Responses from pilots and management people indicated significant differences. For example, a response from a pilot indicated that there were *no negative aspects* to their organisations' fatigue management strategies, while a response from a person in a management position reported that *lack of staff* was a negative aspect. Another typical example of the difference in views is indicated by a pilot response reporting, "*can be too flexible – too many people away or not flying increases pressure on flying pilots to fly*", while a management response stated, "*seen to be looking well. A significant factor often overlooked is the obligation for outside of work activities, sleep, etc......*"

Part 135 Pilots/Management Views: Comparisons indicated that 67% of the responses were different. Responses from pilots were generally more reflective of problems associated with flying, for example, *inadequate number of pilots to fly schedules*, while management responses generally mentioned problems associated with the organisation as a whole, for example, *lack of staff to monitor fatigue management strategies.* A typical example of views that were different indicated a pilot response reporting, "*a lot is left to the individual, so more management input would be valued*", while a management person reported, "*nil*".

Problems, barriers or obstacles to managing fatigue (for example, costs, operational factors or staffing)

Participants were asked to provide information on problems, barriers and obstacles they thought their organisation had in managing fatigue. The responses are summarised in Tables 3.25–3.27.

Table 3.25 A summary of responses from Part 121 participants on the problems, barriers and obstacles to managing fatigue in their organisation

Problems, barriers, obstacles to managing fatigue	%
Costs	37
No problems	25
Fatigue issues are not identifiable	25
Fatigue is a problem to everyone which needs to be understood by pilots	13

Table 3.25 indicates that among other problems provided, cost was reported by more than 30% of Part 121 participants to be the main obstacle in fatigue management.

Table 3.26 A summary of responses from Part 125 participants on problems, barriers and obstacles to managing fatigue in their organisation

Problems, barriers, obstacles to managing fatigue	%
No problems	62
Inconsistency between reported fatigue and records in system	13
Costs	13
Pressure on pilots	12

More than 60% of Part 125 participants reported that their organisation did not have any problems, obstacles or barriers to managing fatigue. Costs and other problems were reported by smaller proportions of participants (Table 3.26).

Table 3.27 A summary of responses from Part 135 participants on problems, barriers and obstacles to managing fatigue in their organisation

Problems, barriers, obstacles to managing fatigue	%
No problems	41
Staffing	22
Costs	16
Operational factors	4
No cooperation between management and pilots	4
Fatigue underreported	4
Loss in production	4
Not applicable	4
Lack of education in managing fatigue	2
Barriers between Regulator and Operator	2

More than 40% of Part 135 participants indicated that their organisation did not have any problems in managing fatigue. However, despite this feedback, a number of other problems were reported, such as staffing and costs, identified by significant numbers of participants (Table 3.27).

Comparison of views from pilots and management people on the problems, barriers or obstacles to managing fatigue

Part 121 Pilot/Management views: Two thirds of responses from Part 121 participants indicated great differences in their views. A typical example showing the difference in views, includes a pilot response stating, '*Nil*' and a management response reporting, '*Costs, staffing adhoc nature of charter business and night freight operations*'.

Part 125 Pilot/Management views: Two thirds of responses from Part 125 participants were different and revealed large disparities in opinions. For example, for all responses; where pilots indicated having *no problems*, people in management positions specified having problems such as *lack of staff to monitor*. Similarly, where a management response indicated having *no problems*, pilots on the contrary stated having problems such as *'can be too flexible – too many people away not flying increases pressure on flying pilots'*.

Part 135 Pilot/Management Views: Results of the comparison revealed that 50% of the responses were different. A typical example indicating this difference included a pilot response reporting '*expertise is lacking*' and a management response stating '*no great barrier, management people feel the barrier when designing schedules for pilots*'.

Another example indicating the difference in the views of the 2 positions includes a pilot response stating, "*Nil*", while a management response reported, *"In weather dependant scenic operations, there is always the challenge of low flight hrs, down time, morale and extended duty time with a wide variation of flight requirements."*

Help, advice or resources that would assist in managing fatigue

Responses from Operators are outlined in Tables 3.28-3.30.

Table 3.28 A summary of responses from Part 121 participants on the help, advice and resources that would assist in managing fatigue in their organisation

Help, advice & resources	%
Expert advice and training on fatigue	33
Current system is sufficiently resourced, need help in implementing systems	33
Objective tools and standardised processes	17
Expert advice with rostering	17

More than 30% of Part 121 participants reported that their organisations were sufficiently resourced, while the same proportion stated that they required help with implementing fatigue management schemes. The remaining proportion of participants reported requiring other types of assistance to manage fatigue in their organisation.

Table 3.29 A summary of responses from Part 125 participants on the help, advice and resources that would assist in managing fatigue in their organisation

Help, advice & resources	%
Assistance with rostering	40
More awareness training programmes	20
More information and articles	20
All other available assistance welcome	20

A higher percentage of Part 125 participants (40%) reported requiring assistance with rostering while smaller proportions of participants sought other types of help, advice and resources such as those shown in Table 3.29

Table 3.30 A summary of responses from Part 135 participants on help, advice and resources that would assist in managing fatigue in their organisation

Help, advice & resources	%
More education, resources, feedback and intercommunication	59
None	21
Simple, efficient and low cost system	9
More audits and fatigue manual guidelines	9
Not applicable	6

More than half of Part 135 participants reported that more education, resources, feedback and communication were required by their organisation to manage fatigue. The data revealed that some of the resources required were human factors training programmes, a network to enable communication between Operators on fatigue issues, more positive interactions between Regulator and Operators, more productive articles and other similar types of resources. More than 20% of the participants reported requiring no assistance in managing fatigue in their organisation (Table 3.30).

Comparison of views from pilots and management people on the help, advice and resources that would assist in managing fatigue

Part 121 Pilot/Management Views: The views of pilots were different from those of management people. Pilots indicated that their organisation required help, advice and resources in relation to *rostering. However, implementing such schemes was complex given the large differences in opinions from within organisations.* On the other hand, management views indicated that their organisation was *sufficiently resourced and well audited.* However, the persisting problem was *time* in implementing a scheme for managing fatigue.

Part 125 Pilot/Management Views: A comparison of views for pilots and management people from Part 125 Operators was not possible given no responses from people in the two positions available for comparison.

Part 135 Pilot/Management Views: Responses from the two positions in Part 135 organisations revealed more differences than similarities. Overall, pilot responses were related more to *not knowing, requiring a guide on fatigue management, and the need to arrange seminars and training programmes* on fatigue management, while the majority of management responses indicated having *no major problems* with current procedures in managing fatigue. Of the views that were the same, the two people agreed that their organisation required more resources. One particular response from a management person indicated that *expert advice on setting up a flight and duty time system suitable for weather dependant operations* was required.

3.4 Other Comments

Comments provided by Part 121 Operators included fatigue being identified as a hazard and consequently, that more advice on issues causing fatigue was required than is in current fatigue management guidelines. Comments also included the critical nature of their operation in that 'days off' did not include recovery time. Furthermore, one of the comments indicated that because pilots were working on rosters; their knowledge on fatigue was generally relied on the construction of such rosters.

No significant comments were provided by Part 125 participants.

Comments provided by Part 135 Operators were broader and included their views on current systems for managing fatigue. Additionally, their comments included issues concerning present regulations. Their comments are summarised in Table 3.31.

Table 3.31 A summary of responses from Part 135 participants on the help, advice and resources that would assist in managing fatigue in their organisation

Other Comments	%
Fatigue is not a problem due to the size of organisations	40
Views pertaining to the nature of their operations	30
Views pertaining to current systems	10
Views in relation to current rules on fatigue management	10
Views in relation to the importance of fatigue	10

A large number of Part 135 participants (40%), reported that fatigue was not a problem generally due to the size of their organisation. Also, more than 30% of the participants made comments on the difficulties associated with their operation, including difficulties in adhering to rosters in a '24/7' operation, in particular, helicopter services. Comments also related to the workload involved in more specific operations such as aerobatic flights which was typically intensive flying for shorter periods. There were also comments on weather-dependant operations, which meant having to complete schedules while the weather was favourable. Other participants commented on the problems resulting from continuous amendments to the roster system.

Some participants commented that, because of lack of resources (in particular information and expertise on fatigue management), their fatigue management strategies were of a *'poor standard'*. Additionally, some participants reported that, with the available knowledge on fatigue and with pilot input, such systems were *'just surviving'*.

In relation to 'current rules that pertain to fatigue management', the majority of participants commented that CAA's views were too narrow, a reason given that '*every person is different*'. Despite this view, other participants reported that their organisation ensured that current procedures were within legal limits.

CHAPTER FOUR
DISCUSSION

The present study examined the perceptions of pilots, rostering staff and management personnel in Part 119 certificated organisations on how fatigue is currently being managed within their organisation. This study is unique as it is the first of its kind to be carried out both in New Zealand or elsewhere.

The regulatory changes from the late 1980s through to the 1990s in the New Zealand aviation industry signified a move away from a prescriptive approach based on flight and duty time limits (FDTL), to a more holistic fatigue management approach (whereby the safety regulator has oversight rather than participatory responsibility in Operator practices). This has allowed Operators to operate under alternative compliance regimes, to tailor FDTL to be more suitable to their operation. In 1990, the new Civil Aviation Act was passed into law which included this new approach as a means of enhancing safety. Internationally, the move to operate beyond prescribed FDTL and allow a more holistic approach to managing fatigue has been recognised.

4.1 Limitations of the Present Study

<u>Information Bias</u>

The primary limitation of this study is that all data were self-reported. Self-reported data introduces the possibility of bias because information received from participants was purely based on their own perceptions. However, in this present project, a questionnaire was considered to be the most inexpensive means of gathering a large amount of data across the entire industry. While face-to-face interviews may have been more ideal, this was not feasible in terms of cost. Fewer Part 119 certificated organisations would have been sampled, although possibly in greater detail. In terms of representation, the present study received responses from 91% of Part 121 organisations, 83% of Part 125 and only 53% of Part 135 organisations. Therefore, the greatest potential for bias comes from Part 135 organisations.

Fatigue could not be effectively managed if fatigue itself was not understood and its causes not determined. Given that little is known about fatigue management in the New Zealand aviation industry, it is possible that information received on fatigue management was incomplete, due to participants' limited knowledge. However, strategies unknown to the key individuals who participated would be unlikely to be implemented effectively in their organisations.

<u>Non-Response</u>

More than 60% of the follow-up phone calls were unsuccessful. This was because appropriate persons were either not available or did not want to accept the calls. Further, it was difficult to conduct follow-up phone calls to some non-responders as contact information was not available. Although the most up-to-date list of Part 119 Operators as provided by the CAA was used, some Operators were found to be working under slightly or completely different names, while others had supposedly closed down. Consequently, this study did not receive responses from the potential participants in these organisations.

The estimated 52% response rate is conservative, because there may have been people with multiple roles among the non-responders.

4.2 Strengths of the Study

This study is considered timely to the introduction of this new approach, that is, a move away from a prescriptive approach based on FDTL towards a non-prescriptive fatigue management approach.

The present study utilized both closed and open-ended questions. Many questions asked for examples to support participants' responses. These examples have been helpful to better understand the level of fatigue management knowledge available in the industry.

A double-entry procedure was used to ensure data accuracy.

4.3 Overview of Findings

The move from prescriptive flight and duty time rules to more flexible and tailored fatigue management schemes acceptable to the Regulator and suitable for the Operator is slowly emerging as a known and acceptable feature in the New Zealand aviation industry. However, given the current level of knowledge on fatigue management and on the present rules governing flight and duty time limits and fatigue management schemes (alternatives), it is difficult to predict the time when the industry could be ready to adopt this new approach more widely.

Operators have three alternatives for meeting their obligation to manage flight crew fatigue: 1) complying with the prescribed FDTL based on AC 119-2 in its entirety; 2) applying for dispensations to operate outside specific aspects of the FDTL; or 3) developing an accredited fatigue management programme.

As expected, all Operators currently have a system whereby pilot flight and duty time limits (FDTL) were monitored as one way of managing fatigue. However, the extent to which fatigue was understood and managed varied broadly amongst participants and organisations.

Some Part 125 and 135 organisations sought dispensation to the prescribed FDTL (Figure 3.15). This is an indication that these organisations have found AC119-2 to be inadequate or unsuitable for their operations. On the other hand, no Part 121 organisation chose to seek a dispensation. Overall, they developed an accredited fatigue management scheme or complied solely with AC119-2 to meet their obligation to manage flight crew fatigue. The greater number choosing to develop an FMS suggests that on the whole, Part 121 organisations have more resources available within their organisations. This could be due to the size of their organisation and that they are engaged in more complex types of operations. However, this assumption is not consistent with other more specific findings as discussed below.

Part 121 and 125 Operators (being larger organisations compared to Part 135 organisations) seemed more formal in their approach to fatigue management than Part 135 Operators. This is supported by the finding that Part 121 and 125 Operators reported having more fatigue management strategies than Part 135 Operators. Further, there was a general consensus between pilots and management on the number of fatigue management strategies used in Part 121 and 125 organisations, while this was not the case for Part 135 Operators (Figures 3.11 and 3.12). A theoretical principal of formalization advocates that "the larger the organisation, the more formalized it should be" (Donaldson, 2004 p. 295).

Part 135 Operators, on the other hand, appeared informal in their approach to fatigue management because they reported fewer fatigue management strategies, indicating that minimal fatigue management process was occurring in their organisation.

When participants' perceptions were sought on how well their organisation was managing fatigue, the scores reported did not seem to relate to the number of fatigue management strategies reported in place. The average score for Part 121 Operators was 59.5, for Part 125 Operators' score was 71.5, while for Part 135 Operators, it was 68. A possible reason for this result could have been that Part 135 participants overestimated how well their organisations were managing fatigue. Evidence supporting this assumption comes from the proportion of participants from Part 135 organisations not knowing how their organisations met FDTL (Figure 1.19). On the other hand, because none of Part 121 and 125 participants ticked Option 4 ("Don't Know") on how their organisation met FDTL, this suggests that people in these larger organisations had better knowledge on how their organisations are meeting FDTL.

However, when comparing ratings (on how well fatigue was being managed) for pilots and management in Part 135 organisations, the results were identical. This was not the case for Part 121 and 125 organisations. The scores for pilots and management in Part 135 organisations were above the middle point of the continuum and were higher than scores for Part 121 Operators. This result was unexpected, and it is suggested that it could be due in part to more 'open door' policies in Part 135 organisations, because more discussions between pilots and managers can occur on a one-to-one/face-to-face basis. Smaller organisations are often regarded as more personal organisations because they require less planned routines, non-formalized structures, decentralized meetings and communications (Clegg, Kornberber and Pitsis, 2005 p. 119).

4.4 Specific Findings

The Importance of Ongoing Education

Ongoing education on fatigue management appeared minimal across all organisations. This could have implications for the development of fatigue management schemes long term. Because education has been stated to be the only legitimate way of improving activities or processes, it must continue to develop so that knowledge on fatigue management is continually updated and revised.

An education program was advocated as one of the methods effective in accomplishing flexibility of operations beyond current FDTL (Rosekind, Neri and Dinges, 1996). One of the main components of a Fatigue Management Programme (FMP) is education (Millar & Signal, 2001).

Fatigue management education is arguably an important issue in maintaining the safety of an operation. As stated, current rules place the "responsibility on the *flight crew member and the operator* not to permit *any person* to fly an aircraft as a flight crew member if they know that this person is suffering from fatigue or is likely to suffer from fatigue" (CAA, 2001). Therefore, pilots, management, rostering staff and anyone who has direct or indirect influence on work and rest patterns of operational personnel must be provided with education on fatigue management on an ongoing basis.

Management has a pivotal role in ensuring that transparent fatigue management processes are established and maintained (Millar & Signal, 2001). After all, active management involvement in fatigue management has been reported as a critical requirement in reducing fatigue (Swedavia-McGregor Report, 1988). Therefore, ongoing education for management on fatigue management is essential.

The importance of educating pilots on the causes and consequences of fatigue has been stated to be the only genuine way of addressing activities performed outside normal hours (Gander, 1998). Therefore, on the basis of this argument, fatigue education needs to be provided to pilots and their family members.

Although participants reported using ongoing education on fatigue management for pilots, management and rostering staff, the examples provided often were not true educational opportunities. Rather, most of these examples were describing participants' future intentions on how education programmes could be improved, how were they used, or their current status. A typical example provided by most participants for ongoing education on fatigue management for pilots, rostering staff and management, was flight and duty time limits. This response appears to be a poor strategy for providing education on fatigue management and could mean that participants were not aware of what their organisation was advocating as a means of educating its staff, or that organisations provided no ongoing education on fatigue management. Another typical response in relation to ongoing education was arranged training or recurrent training programmes such as annual refresher courses. This appears to be a good strategy in managing fatigue. However, it could be assumed that no specific arrangements or processes existed for education on fatigue management in most organisations. Further, the vague descriptions of most of the examples provided imply that most education was not taken very seriously or was not particularly organized.

Roster management

The key to effective roster management is good communication between the people designing the roster and those working the roster (Gander, 2003). In this way, a participatory approach is fostered, combining inputs from both sides. This approach is thought to facilitate needs of both parties allowing active participation in all aspects of fatigue management (Millar & Signal, 2001). Therefore, effective communication and understanding of potential fatigue-related risks are two most important components of good roster design.

If an Operator chooses to develop an alternative FDTL as a means for managing fatigue, this approach warrants "evidence-based critical factors" that need to be accommodated in good roster design principles (Millar & Signal, 2001).

Despite this approach, there will always be inadequate scientific evidence to set precise lower and higher limits in determining fatigue-related risks (Millar & Signal, 2001; DP 0404OS, 2004). Widely recognised factors contributing to this circumstance are individual variability, operational variation, and numerous influences that may contribute to fatigue, other than just hours spent on work (Millar & Signal, 2001; Gander, 2003; DP 0404OS, 2004).

Part 121 and 125 participants reported that they required assistance in rostering. This could be related to the size of their organisation. In general, the scope of a Part 135 operation is not as complex as those found in Part 121 and 125 organisations, hence, a simple roster system is adequate. Larger organisations appeared to require assistance with rostering on the basis that they lacked available resources within their organisation to effectively develop such a system, while cost was not disclosed. For example, Part

121 and 125 organisations reported using more recent software packages to assist with their roster system, such as the Geneva programme.

Regardless of who is involved in the designing of the roster, people directly or indirectly involved in this process must be provided with education on fatigue management. One of the key elements to effective fatigue management scheme is a good roster design that encompasses the latest scientific knowledge on fatigue (Allen, 2004).

Occurrence Reporting

There is a requirement for greater awareness about fatigue so that Operators routinely and adequately report fatigue-related occurrences. Insufficiently or incorrectly reporting occurrences relating to fatigue may have a considerable negative impact on fatigue management schemes, which could render them futile. For example, if fatigue was not recognised, it could not be sufficiently reported. The failure to recognise fatigue effectively cancels out the purpose of a fatigue occurrence reporting system.

As stated in AC 119-3 Subpart K of the Part 135 rules, one of the components required for a systematic fatigue management scheme is an incident/accident reporting and investigation system (CAA, 2001). This system allows pilots to report incidents they encountered while on duty, so that the consequences of fatigue-related operations may be assessed through analyzing these reports (Millar & Signal, 2001). It is therefore important that an acceptable and formal method of reporting such occurrences is established.

CAR Part 12 prescribes the requirement for Operators to provide details of incident types. This rule highlights the importance of active occurrence investigation to be carried out by organisations with available consultation from the authority, making a positive contribution to their internal quality assurance system (AC 12-2, 1999). This system should incorporate details of both investigation and reporting requirements to adequately address fatigue-related occurrences.

However, self-reporting could be an obstacle to an effective occurrence reporting system. One of the reasons contributing to this circumstance is that bias in reporting is unavoidable due to human nature (Maurino, 2003). For example, some pilots do not see fatigue as a cause of an incident because it has never been a recognised factor, whereas others perceive fatigue as a normal part of a flying career. In addition, if a person does not know what causes fatigue and what the symptoms are, it is difficult for them to report it (Gander, 1998). Consequently, pilots reporting these occurrences should have a substantial level of knowledge on fatigue.

Overall, participants reported that occurrence reporting was organized through their quality safety system, but some reported that such systems did not reflect or identify fatigue. The prime purpose of a quality safety system is to institute policies and guidelines to fulfil safety objectives and responsibilities, with less direct CAA involvement (AC 119-1, 1999). It appears that, generally, Part 121 and 125 organisations have been more formal in their approach to occurrence reporting than Part 135 organisations. Most of them reported using current quality safety systems and having specific forms for reporting fatigue. This indicates that an effective fatigue management strategy may be in place. This finding is in agreement with feedback from the New Zealand Aviation Community stating that, "large aircraft Operators routinely report occurrences" (CAA, 2005).

On the other hand, this was not the case for Part 135 organisations, as they appeared less formal in their approach to occurrence reporting. A typical example indicated that fatigue-related occurrences were reported verbally. In addition, and to a larger extent, participants indicated that their occurrence reporting systems either did not specifically involve fatigue-related incidents, or such incidents were only included if fatigue was suspected to be a factor.

This finding correlates with the general consensus amongst representatives of the New Zealand Aviation Community that "small Operators rarely report occurrences" (CAA, 2005). It could be assumed that if small Operators have difficulties in reporting ordinary occurrences, they could be expected to have even greater problems in reporting fatigue-related occurrences.

Understanding of AC 119-2 and AC 119-03

The prescriptive limits specified in AC 119-2 are based on the old CASO 3[13]. These limits have been stated to be adequate as one ***sole*** means of managing fatigue (AC 119-03, 2001). Other components of a fatigue management scheme, such as those outlined in AC 119-03, Subpart K, IEM 135.801, form the basis of an acceptable and alternative approach to managing fatigue.

Participants' knowledge on the flight and duty rules indicated that, to a certain degree, Operators have not understood the purpose of AC 119-2 and the appropriate applications of AC 119-03. This is demonstrated by a broad range of feedback being provided in response to how FDTL was being met (Figure 3.15). Also indicative of the lack of knowledge pertaining to the two Advisory Circulars, was the significant numbers of participants indicating other methods of meeting FDTL besides the 4 strategies presented. The vagueness in responses received could be related to the following:

1. Since information pertaining to the two different approaches (i.e. AC 119-2 and AC 119-03) is currently located in different Advisory Circulars (ACs), it is possible that these different locations could have impeded participants in clearly understanding the purposes of such approaches. Further, it is a possibility that participants rarely 'visit' these rules unless it is an absolute necessity, which may contribute to participants' lack of confidence in choosing a given strategy in describing how their organisations were meeting FDTL.

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[13] CASO is Civil Aviation Safety Order. (AC 119-03, 2001).

2. AC 119-03, Subpart K, contained in Part 135 rules has been considered to be more comprehensive and informative document than those of other Civil Aviation Authorities such as CASA or FAA in providing assistance to Operators to manage fatigue (Millar & Signal, 2001). Basically, as it stands, this AC refers only to Part 135 operations, however, description of its purpose relates also to Part 121 and 125 operations as stipulated below:

"The intent of this rule is to require an Operator to establish a flight-and-duty scheme for the management of fatigue in flight crew. It provides general considerations for ***air transport operators*** *and specific limitations for* ***commercial transport operators****".*

AMC 135.803 – Fatigue of Flight Crew

Because the information is located in AC 119-03, it could be interpreted by Part 121 and 125 Operators as not relevant to their operation. On the basis of this interpretation, Part 121 and 125 Operators may have been further constrained when seeking a dispensation because two different ACs guide their decisions. For example, the primary purpose of AC 119-2 is to provide information on the compulsory components of a flight and duty scheme suitable for operations working under Part 121, 125 and 135 rules. Operating beyond these limits prescribed in AC 119-2 requires a dispensation. AC 119-3, on the other hand, also provides information for Part 121 and 125 organisations; however, such information is compiled and located separately under a different title.

Positivism and Negativism

Overall, participants reported that they are committed to developing an alternative approach to managing fatigue, hence the following typical comments:

Part 121	*"No particular problems – culture of the organisation is to have a fatigue management scheme".* *"Current system is well resourced with advisory group maintaining effective oversight and advice".*
Part 125	*"Helps prevent fatigue amongst aircrew".* *"Reduction in incidents and awareness of fatigue related issues".*
Part 135	*"Early capture; able to better deal with issue".* *"Awareness of fatigue which is often accepted and overlooked".*

Despite these positive responses in relation to fatigue management, there were other negative reports which indicated uncertainties about this new approach:

Part 121	*"While rostering meets the requirements of our FMS, there is no regard for the actual fatigue levels amongst pilots (or cabin crew)".*
Part 125	*"Seen to be working well. A significant factor often overlooked is the obligations for outside of work activities, sleep etc. Our staff take a responsible approach and we expect an honest declaration of any fatigue or fitness problems."*
Part 135	*"Lose flexibility when operating on specific rosters when commercial needs change".*

In general, although participants reported having no problems with current fatigue management strategies, it is believed that knowledge of fatigue management is poor and not translated into practical and effective fatigue management schemes.

Consequently, this situation culminates in ineffective internal fatigue management strategies.

The main advantages of operating beyond AC 119-2 were reported by organisations as follows:

Part 121

- Able to derive fatigue countermeasures.
- Perceived to be productive because organisations ensured that pilots were not fatigued.
- Fatigue was accepted as a shared responsibility and liability.

The above reports appear to imply that Part 121 organisations have taken a positive step in the management of fatigue. Identification of fatigue, and the realization that it is indeed a shared responsibility, are important factors leading to effective fatigue management.

Part 125

- Participation of staff in developing a tailored scheme suitable for a wider range of activity.
- Safer environments; help prevent fatigue.
- Greater awareness of fatigue.

Comments from participants in Part 125 organisations reflected that fatigue management strategies helped them to raise employees' awareness of fatigue, thus allowing them to participate in the development of fatigue management schemes suitable for various types of operations. The end result of such a process was the prevention of fatigue, which was perceived to be linked with a safer environment.

Part 135

Some of the specific comments were:

- Allows flexibility in pilot use, therefore requires close personal monitoring.

- Allows maximum flight and duty to run the operation commercially and viably but to account for lifestyle, rest and relaxation time. Also, the importance of giving pilots good amount of time off between rotational shifts.

- Safer work place. Understanding the body clock better.

It appeared that a reasonable level of knowledge of fatigue management existed amongst some Part 135 participants because they have linked the positive aspects of their organisations' fatigue management strategies to important fatigue factors.

The main disadvantages of an organisation's fatigue management strategies appeared to be related to:

- Cost in the development of fatigue management schemes especially amongst larger organisations, while for smaller organisations the main disadvantage was logistical, such as the lack of computer packages to assist with rostering.

- Staffing and Operational factors were regularly mentioned by Part 135 participants. This was due to the nature of their operation that they depended largely on weather. For example, during times of adverse weather, pilots' work tends to be limited by duty time rather than flight time. On the other hand, staffing problems were more related to expert personnel being required to develop and assist in fatigue management schemes amongst Part 121 and 125 organisations.

- Difference in opinions amongst pilots and management indicated that certain areas of fatigue management were not fully understood. This was indicated by disagreement amongst pilots and management over the number of fatigue management strategies existing in their organisation. This could be due to inadequate and informal education on fatigue management provided to staff. A typical comment highlighting difference in opinions relates to the following:

> *"Organisation believes that operation within approved FMS will ensure adequate FM. Not the case. Differences in opinion on what FMS actually means and how to apply it. FM is seen unimportant, barrier to efficient operation by company personnel setting policies".*

Part 121 Line Pilot

4.5 Summary

Due to increased demand for air travel, the aviation industry is producing faster aircraft capable of travelling longer distances. This is a common factor in larger organisations, in particular Part 121. On the other hand, commercial industry demand has escalated, resulting in more "24/7" operations, which are often found in medium and smaller organisations. Aircrews remain physiologically affected by the adverse effects of fatigue as a result of these demands.

The aims of this study were to create a picture of the current level of knowledge on fatigue management in the New Zealand aviation industry and attain a greater understanding of what processes or strategies were currently being used for the management of fatigue. This process involved assessing the views of pilots, rostering staff, and management, of Part 119 air operator certificated holders. The present study was successful in obtaining responses from a significant proportion of the industry.

Prescriptive FDTL, as one sole means of managing fatigue, have been shown to be inadequate for managing fatigue as they do not address other factors such as those relating to circadian rhythms and sleep. Because it is not possible to have prescribed rules that suit all complex types of operation, a more appropriate approach would be to allow Operators to design their own strategies for managing fatigue. Such an approach includes the latest scientific knowledge on fatigue, allowing Operators to work outside prescribed limits but within the parameters of practices that are acceptable (to the authority) and suitable (for the Operator and pilots).

To obtain information on the level of knowledge on fatigue management in the industry, and what strategies exist in managing fatigue, the study used a number of questions. Firstly, fatigue management strategies (stipulated under AC 119-03 Subpart K - Fatigue of Flight Crew for developing a fatigue management scheme) were investigated as to whether or not they existed in organisations. To further determine what strategies were in place, participants were also asked to provide examples of these strategies. Participants were also asked to indicate how their organisations met their FDTL and to rate how well their organisation was managing fatigue. Finally, participants were asked to provide information on how fatigue management worked in their organisation.

Results from this study clearly identified that the level of knowledge on fatigue management, across the board, was minimal. This finding is exacerbated by results indicating that overall, participants indicated poor understanding of the applications of both AC119-2 and AC119-03.

4.6 Future Recommendations

This study is the first of its kind to be carried out nationwide. Presently, little is known about fatigue management in the New Zealand aviation industry, and therefore, the study represents a first step. The following recommendations are based on study findings about participants' perceptions.

1. More informed training sessions to Operators on CAA rules, in particular those pertaining to flight and duty time limitations could be initiated as a starting point and as the first step in the management of fatigue. Fatigue management training programmes could then be encouraged, to improve the level of knowledge required for operating beyond current prescribed flight and duty time limits. One suggested means of providing information would be via industry forums whereby people are brought together to share, and enhance their knowledge to improve the management of fatigue at the industry level.

2. AC 119-2 and AC 119-03 could be transferred to one AC to provide easier access. This transfer could alleviate some of the problems suspected to exist amongst Operators when seeking dispensations, such as AC 119-03 referring only to Part 135 operations when such information refers also to other larger

Operators (Part 121 and 125). Information on further recommendations relating to the two ACs has been previously reported (Millar & Signal, 2001).

3. More training and education on fatigue management is required for individuals who have a direct responsibility for the management of fatigue in their organisation. This process should further enhance fatigue management knowledge and thereby strengthen fatigue management schemes. Additionally, training programmes and education to establish better review processes used in the management of fatigue could be considered, to ensure such activities are evolving with recent scientific findings.

4. An evaluation of processes used in fatigue management training programmes must be part of an ongoing activity to ensure the review system is effective, and that knowledge on fatigue management is evolving and recurrent. A recent study conducted amongst New Zealand heavy vehicle drivers evaluated the effectiveness of driver training as a fatigue countermeasure. Results indicated that the participants largely retained the knowledge attained from the training. It was also evident that about half the participants had implemented some of the strategies suggested, while others showed that they gained some benefit as a result of the fatigue management training (Gander et al., 2005).

5. Resources, such as expertise and useful information on fatigue management, are essential for effective fatigue management.

6. A participatory approach must be undertaken when designing fatigue management systems, for example a rostering system. Such an approach allows participation for those designing and those working such systems.

This study provides guidance for future work in fatigue management, which could be useful for the New Zealand Civil Aviation Authority and the New Zealand Aviation Industry.

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APPENDIX A

THE QUESTIONNAIRE

HOW IS AIRCREW FATIGUE MANAGED IN THE NEW ZEALAND AVIATION INDUSTRY?

Section A: Description of Your Organisation.

1. The title of your position(s) ....

2. What is your role(s) within the organisation you work for?

   ☐ Management ☐ Rostering ☐ Line Pilot *(if you have multiple roles please tick all the boxes that apply)*

3. How many people are employed by your organisation? ....

4. How many pilots are employed by your organisation? ....

5. What rule does your organisation operate under? ☐ Part 121 ☐ Part 125 ☐ Part 135

6. What type(s) of operation(s) does your organisation conduct? (*please tick appropriate box or boxes*)

☐ <u>Scheduled</u>	☐ <u>Non-scheduled</u>
☐ Domestic passenger services	☐ Domestic passenger service
☐ International passenger services	☐ International passenger service
☐ Freight operations	☐ Freight operations
☐ Other (please specify)	☐ Other (please specify)
....	....

7. What type of aircraft does your organisation operate? (*please tick appropriate boxes*)

   ☐ Jet aircraft ☐ Turbo-prop aircraft ☐ Piston-engine aircraft

   ☐ Multi-engine aircraft ☐ Single-engine aircraft ☐ Rotary-wing aircraft ☐ Fixed-wing aircraft

8. What flight rules does your organisation <u>predominantly</u> operate under? (*please tick appropriate box*)

   ☐ Instrument flight rules ☐ Visual flight rules

9. What type of airspace does your organisation operate in? (*please tick appropriate box or boxes*)

   ☐ Controlled airspace ☐ Uncontrolled airspace

10. What type of aerodromes does your organisation operate to? (*please tick appropriate box or boxes*)

    ☐ Certificated aerodromes ☐ Uncertificated aerodromes ☐ Remote aerodromes

11. Does your organisation operate outside daylight hours? ☐ Yes ☐ No

Section B: Fatigue Management Strategies in Your Organisation

12. Which of the following fatigue management strategies does your organisation use? (*If possible, please give an example of how this strategy is carried out or used in your organisation)*

- Ongoing education for pilots on fatigue management ☐ Yes ☐ No ☐ Don't know ☐ Not applicable

  e.g. ....

- Ongoing education for people in management on fatigue management ☐ Yes ☐ No ☐ Don't know ☐ Not applicable

  e.g. ....

- Ongoing education for rostering staff on fatigue management ☐ Yes ☐ No ☐ Don't know ☐ Not applicable

  e.g. ....

- Monitoring of pilots' flight and duty times ☐ Yes ☐ No ☐ Don't know ☐ Not applicable

  e.g. ....

- Monitoring of pilots' workload (other than flight and duty times) ☐ Yes ☐ No ☐ Don't know ☐ Not applicable

  e.g. ....

- Occurrence reporting system that asks about fatigue ☐ Yes ☐ No ☐ Don't know ☐ Not applicable

  e.g. ....

- Identification and management of fatigued pilots ☐ Yes ☐ No ☐ Don't know ☐ Not applicable

  e.g. ....

- Ongoing review of the processes used for fatigue management ☐ Yes ☐ No ☐ Don't know ☐ Not applicable

  e.g. ....

- A system for allowing feedback from pilots on fatigue-related issues ☐ Yes ☐ No ☐ Don't know ☐ Not applicable

  e.g. ....

- Software to assist with rostering ☐ Yes ☐ No ☐ Don't know ☐ Not applicable

  e.g. ....

13. What other fatigue management strategies does your organisation use?

....

....

14. How does your organisation meet the Flight-and-Duty time limits? (*for example: Has adopted AC 119-2, Has adopted AC 119-2 with dispensations, Has an accredited Fatigue Management Scheme, Don't know*).

....

....

15. How well do you think your organisation currently manages the fatigue of pilots? (*Please place a mark on the line*).

not at all well |————————————————————| extremely well

Section C: How does Fatigue Management Work in Your Organisation?

16. Who is responsible for fatigue management in your organisation? *(titles or group)*

....

....

17. Where does your organisation look for and get information on fatigue management?

....

....

18. From your experience, what are the positive benefits of your organisation's fatigue management strategies?

....

....

19. From your experience, what are the negative aspects of your organisation's fatigue management strategies?

....

....

20. Are there problems, barriers, obstacles to managing fatigue in your organisation? (e.g.; costs, operational factors, staffing)

....

....

21. What help/advice/resources would assist in managing fatigue in your organisation?

....

....

22. Other comments ....

....

....

....

....

APPENDIX B
1ST LETTER TO CHIEF PILOT

<u>HOW IS AIRCREW FATIGUE MANAGED IN THE NEW ZEALAND AVIATION INDUSTRY?</u>

To The Chief Pilot (insert name of Air Transport Operator),

The Sleep/Wake Research Centre (SWRC) at Massey University is conducting a study on how aircrew fatigue is being managed in the New Zealand aviation industry. We would greatly appreciate it if you could distribute these questionnaires. Please pass one to:

- A person in a management position in your organisation, preferably someone in a quality assurance role;
- A person involved in rostering in your organisation, preferably someone who is actively involved in putting the roster together;
- A line pilot, preferably someone who has been with your organisation for at least 6 months.

Why study aircrew fatigue?
Presently, we know very little about how fatigue is being managed in the New Zealand aviation industry. The aim of this project is to gather information on the different strategies Air Transport Operators (referred to as 'operators') are using to manage aircrew fatigue, the positive and negative aspects of different approaches to fatigue management, and the information or resources that would assist operators in managing fatigue.

What are the outcomes of the study?
Findings of the study will be provided to all study participants and all operators in New Zealand. The operators will be able to see what different organisations are doing to manage fatigue, what strategies are perceived to be working, and what strategies are perceived not to be working. We hope the results will provide operators with ideas to help them manage fatigue and lead to better fatigue management resources.

Who has been asked to participate in the study?
The 158 operators in New Zealand working under Rule 135.803(a)(2) or AC119-2 will be invited to participate in this study. Three people from each organisation will be asked to complete the questionnaire.

How is the study being conducted?

- We have sent a study pack to the Chief Pilot of each organisation. We would appreciate it if you could pass a questionnaire on to three people in your organisation. These people should be:
  - A person in a management position in your organisation, preferably someone in a quality assurance role;
  - A person involved in rostering in your organisation, preferably someone who is involved in developing the roster;
  - A line pilot, preferably someone who has been with your organisation for at least 6 months.

- We understand that for smaller organisations some of these positions may overlap. If this is the case, then, we ask that the person completing the questionnaire indicate on the questionnaire their multiple roles (this is question 1).
- Once each person has completed their questionnaire, which should take no more than 20 minutes, they are asked to return it in the self-addressed and stamped envelope provided.
- None of the data collected has the name recorded on it. Instead it has a code number. No material which could identify the people who complete the questionnaire or the organisation they work for will be used in any reports on the study.
- Data from the questionnaire will be analysed by researchers at the SWRC, Massey University. The data will be kept for a minimum of 5 years after the study has been completed. It will then be archived.
- Findings of the study will be published in a thesis, an industry report and a summary of the findings will be presented in a pamphlet. You will receive a summary of the findings of the study and a copy of the final report.

Who is involved in this study?
The project is funded by the Australian Transport Safety Bureau. It is being conducted as part of a Masters Thesis project and involves the following people from the SWRC at Massey University:-

- Ms Denise Kuraem Ratieta (Masters student), telephone 8015799 extn 6032, email D.T.Ratietamassey@.ac.nz
- Dr. T. Leigh Signal (Senior Research Fellow and Project Supervisor), telephone 8015799 extn 6034, email T.L.Signal@massey.ac.nz
- Professor Philippa Gander (Director, SWRC), telephone 8015799 extn 6033, email P.H.Gander@massey.ac.nz

The study also involves input and advice from an industry group which is comprised of representatives from the New Zealand Civil Aviation Authority (NZCAA), the New Zealand Airline Pilot Association (NZALPA) and the Aviation Industry Association (AIA).

What are the rights of study participants?
Completion and return of the attached questionnaire implies consent. They have the right to decline to answer any particular question.

We very much appreciate your time and consideration of this study.

Denise Kuraem Ratieta	Dr. T. Leigh Signal	Professor Philippa Gander
Master of Aviation student	Senior Research Fellow	Director
Massey University	SWRC	SWRC

Research Team
Aircrew Fatigue Management
Sleep/Wake Research Centre
Massey University
Private Box 756
Wellington

APPENDIX C

1ST LETTER TO PARTICIPANTS

HOW IS AIRCREW FATIGUE MANAGED IN THE NEW ZEALAND AVIATION INDUSTRY?

Dear Sir/Madam,

The Sleep/Wake Research Centre (SWRC) at Massey University is conducting a study on how aircrew fatigue is being managed in the New Zealand aviation industry. We would greatly appreciate you taking a few minutes to complete the attached questionnaire and returning it in the stamped-return envelope provided.

Why study aircrew fatigue?

Presently, we know very little about how fatigue is being managed in the New Zealand aviation industry. The aim of this project is to gather information on the different strategies Operators are using to manage aircrew fatigue, the positive and negative aspects of different approaches to fatigue management, and the information or resources that would assist operators in managing fatigue.

What are the expected outcomes of the study?

Findings of the study will be provided to all study participants and all Operators in New Zealand. Operators will be able to see what different organisations are doing to manage fatigue, what strategies are perceived to be working, and what strategies are perceived not to be working. We hope the results will provide Operators with ideas to help them manage fatigue and lead to better fatigue management resources.

Who has been asked to participate in the study?

The 160 Operators in New Zealand operating under Part 119 will be invited to participate in this study. Three people from each organisation will be asked to complete the questionnaire.

How is the study being conducted?

- The Chief Pilot from each organisation has been asked to select three volunteers to complete the questionnaire (a person from management, a person from rostering, and a line pilot).
- In smaller organisations these 3 positions might be filled by one or two people. This can be indicated on the questionnaire. In this instance 3 questionnaires do not need to be completed.
- Once you have completed your questionnaire, which should take no more than 20 minutes, please return it in the self-addressed and stamped envelope provided.
- None of the data collected has your name recorded on it. Instead it has a code number. All data collected is kept confidential and no material which could personally identify you or the organisation you work for will be used in any reports on the study.
- Data from the questionnaire will be analysed by researchers at the SWRC, Massey University. The data will be kept for a minimum of 5 years after the study has been completed. It will then be archived.
- Findings of the study will be published in a Masters in Aviation thesis and will also be available in a pamphlet. You will also have access to a copy of the final report.

Who is involved in this study?

The project is funded by the Australian Transport Safety Bureau. It is being conducted as part of a Masters Thesis project and involves the following people from the SWRC at Massey University:-

- Ms Denise Kuraem Ratieta (Masters student), telephone 801 5799 extn 6085, email D.T.Ratieta@massey.ac.nz
- Dr. T. Leigh Signal (Senior Research Fellow and Project Supervisor), telephone 801 5799 extn 6034, email T.L.Signal@massey.ac.nz
- Professor Philippa Gander (Director, SWRC), telephone 801 5799 extn 6033, email P.H.Gander@massey.ac.nz

The study also involves input and advice from an industry group which is comprised of representatives from the New Zealand Civil Aviation Authority (NZCAA), the New Zealand Airline Pilot Association (NZALPA) and the Aviation Industry Association (AIA).

What are the rights of study participants?

Completion and return of the attached questionnaire implies consent. You have the right to decline to answer any particular question.

This project has been reviewed and approved by the Massey University Human Ethics Committee, WGTN Protocol 04/37. If you have any concerns about the conduct of this research, please contact Mr Jeremy Hubbard, Acting Chair, Massey University Campus Human Ethics Committee: Wellington, telephone 04 801 5799 ext 6358, email J.J.Hubbard@massey.ac.nz

We very much appreciate your time and consideration of this study.

Denise Kuraem Ratieta
Master of Aviation student
Massey University

Dr. T. Leigh Signal
Senior Research Fellow
SWRC

Professor Philippa Gander
Director
SWRC

Research Team
Aircrew Fatigue Management
Sleep/Wake Research Centre
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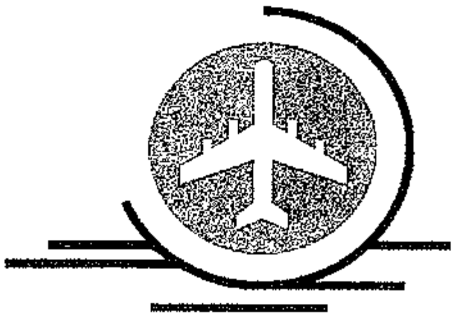
Wellington

APPENDIX D
REMINDER POSTCARD

Front of Postcard



A friendly reminder
about the
Aircrew Fatigue Study
questionnaire...

Back of Postcard

You may recall receiving a two-page questionnaire entitled
'How is Aircrew Fatigue Managed in the New Zealand Aviation Industry?'

We would greatly appreciate you taking the time to look at the questionnaire again, complete it and return it in the brown freepost return envelope provided.

If you prefer, call the free phone
0800 445 988
to give your answers over the phone.

We greatly value your help in giving us a better understanding of how fatigue is being managed in the New Zealand aviation industry.

APPENDIX E

2ND LETTER TO CHIEF PILOT

HOW IS AIRCREW FATIGUE MANAGED IN THE NEW ZEALAND AVIATION INDUSTRY?

The Chief Pilot, (name of Operator),
You may remember receiving a package a few weeks ago containing 3 questionnaires on how Aircrew fatigue is being managed in the New Zealand Aviation Industry. We have invited the 160 Operators in New Zealand operating under Part 119 to participate in this study.

We had asked if you could pass the questionnaires onto three volunteers in your organisation for completion. We have received a questionnaire (or have received questionnaires) from........ and very much appreciate the time and involvement of this person (or these people) in the study. However, to date we have not received completed questionnaires from .....

(or if no questionnaires have been received) To date, we have not received any completed questionnaires from:

- a person in a management position;
- a person in a rostering position; or
- a line pilot.

Some Operators have contacted us and said that their questionnaires had been misplaced, so we are sending a new package of questionnaires to all whose replies have not reached us yet. If individuals completing the questionnaires prefer, we can receive answers to the questionnaire over the phone by calling our toll free number 0800 445 988.

Presently, we know very little about how fatigue is being managed in the New Zealand aviation industry. The aim of this project is to gather information on the different strategies Operators are using to manage aircrew fatigue. Findings of the study will be provided to all study participants and all Operators in New Zealand. We hope the results will provide Operators with ideas to help them manage fatigue and lead to better fatigue management resources.

We would greatly appreciate your help in passing the questionnaires on to the volunteer(s) in your organisation. If you would like any further information or have any queries about the survey, please feel free to contact us.

Merry Christmas and Happy New Year.

Denise Kuraem Ratieta	Dr. T. Leigh Signal	Professor Philippa Gander
Master of Aviation student	Senior Research Fellow	Director
SWRC	SWRC	SWRC
Massey University	Massey University	Massey University

APPENDIX F
2ND LETTER TO PARTICIPANTS

HOW IS AIRCREW FATIGUE MANAGED IN THE NEW ZEALAND AVIATION INDUSTRY?

Dear Sir/Madam,

You may remember receiving an envelope a few weeks ago containing a questionnaire on how Aircrew fatigue is being managed in the New Zealand Aviation Industry. We would greatly appreciate your help in answering the questionnaire and sending it back to us. Your information is very important to us.

Some people have contacted us and said that their questionnaire had been misplaced, so we are sending new questionnaires to all Operators whose replies have not reached us yet.

If you prefer, we can receive answers to the questionnaire over the phone by calling our toll free number (0800 445 998).

Presently, we know very little about how fatigue is being managed in the New Zealand aviation industry. The aim of this project is to gather information on the different strategies Operators are using to manage aircrew fatigue. Findings of the study will be provided to all study participants and all Operators in New Zealand. We hope the results will help Operators better manage fatigue and lead to improved fatigue management resources.

We would greatly appreciate your help in completing the questionnaire and returning it to us in the brown freepost envelope. If you would like any further information or have any queries about the survey, please feel free to contact us.

Merry Christmas and Happy New Year.

Denise Kuraem Ratieta
Master of Aviation student
SWRC

Dr. T. Leigh Signal
Senior Research Fellow
SWRC

Professor Philippa Gander
Director
SWRC

APPENDIX G
PROMOTIONAL ARTICLE

How is Aircrew Fatigue Managed in the New Zealand Aviation Industry?

The Sleep/Wake Research Centre at Massey University in Wellington is conducting a study on how aircrew fatigue is being managed in the New Zealand aviation industry.

The research is funded by the Australian Transport Safety Bureau. Representatives from the New Zealand Civil Aviation Authority, New Zealand Air Line Pilots' Association and the Aviation Industry Association have been involved in the design of the study and have been providing advice to the research team.

Presently, there is very little information on how aircrew fatigue is being managed in the New Zealand aviation industry and concurrently, we know little on how to improve the current strategies and approaches the organisations are using to manage aircrew fatigue.

The aim of the study is to gather information on how Operators are managing fatigue, the strategies they are using, the positive and the negative aspects of these approaches and how they could be used to better manage fatigue in their organisations.

As a result of the study, 160 Operators working under Part 119 have been invited to participate in the study. The Chief Pilot of each organisation has recently been sent a package containing 3 questionnaires. The questionnaires are to be filled out by three volunteers: a person in a management position, a person in rostering, and a line pilot. If these positions are filled by only 1 or 2 individuals, such as in smaller organisations, this can be indicated on the questionnaire. If you have been handed a questionnaire

APPENDIX G
PROMOTIONAL ARTICLE

How is Aircrew Fatigue Managed in the New Zealand Aviation Industry?

The Sleep/Wake Research Centre at Massey University in Wellington is conducting a study on how aircrew fatigue is being managed in the New Zealand aviation industry.

The research is funded by the Australian Transport Safety Bureau. Representatives from the New Zealand Civil Aviation Authority, New Zealand Air Line Pilots' Association and the Aviation Industry Association have been involved in the design of the study and have been providing advice to the research team.

Presently, there is very little information on how aircrew fatigue is being managed in the New Zealand aviation industry and concurrently, we know little on how to improve the current strategies and approaches the organisations are using to manage aircrew fatigue.

The aim of the study is to gather information on how Operators are managing fatigue, the strategies they are using, the positive and the negative aspects of these approaches and how they could be used to better manage fatigue in their organisations.

As a result of the study, 160 Operators working under Part 119 have been invited to participate in the study. The Chief Pilot of each organisation has recently been sent a package containing 3 questionnaires. The questionnaires are to be filled out by three volunteers: a person in a management position, a person in rostering, and a line pilot. If these positions are filled by only 1 or 2 individuals, such as in smaller organisations, this can be indicated on the questionnaire. If you have been handed a questionnaire and have not yet returned it, the research team would greatly appreciate you taking the time to complete it and return it in a brown freepost return envelope provided.

The findings of the study will be reported in a Master of Aviation thesis and will also be available in a pamphlet. The participants will also have access to a copy of the final report should they wish to view it.

If you would like to complete your questionnaire over the phone please contact Denise Ratieta on 0800 445 988. For further information about this research please contact Ms Denise Ratieta or Dr. Leigh Signal on (04) 8015799.

APPENDIX H
ADDITIONAL RESULTS

Ongoing education for pilots on fatigue management provided from all Operators

Table 4.1 Ongoing education for pilots provided from Part 121 participants

Description	%
Arranged as part of scheduled arrangements and training programmes	67
Pilots supplied with fatigue-related magazines, journals and articles	17
Nil	17

Table 4.2 Ongoing education for pilots provided from Part 125 participants

Description	%
Arranged as part of existing systems and training programmes	50
Discussions and awareness on fatigue management	25
Time management principal	25

Table 4.3 Ongoing education for pilots provided from Part 135 participants

Description	%
Arranged as part of existing operating systems and training programmes	54
Discussions and awareness on fatigue management	22
Pilots supplied with fatigue-related magazines, journals and articles	8
Practical preventive measures	8
Formal meetings	8

Ongoing education for people in management on fatigue management provided from all Operators

Table 4.4 Ongoing education for people in management provided from Part 121 participants

Description	%
Arranged as part of existing operating systems and training programmes	60
Availability of fatigue-related journals or articles	20
Very informal	20

Table 4.5 Ongoing education for people in management provided from Part 125 participants.

Description	%
Arranged as part of existing operating systems and trainings	50
Specific fatigue training programmes	25
Availability of fatigue-related journals or articles	25

Table 4.6 Ongoing education for management provided from Part 135 participants

Description	%
Arranged as part of existing systems and training programmes	55
Availability of fatigue-related journals or articles	27
Review of time management	9
Constant monitoring of existing flight and duty time limits	9

Examples of ongoing education for rostering staff on fatigue management provided from all Operators

Table 4.7 Ongoing education for rostering staff on fatigue management provided from Part 121 participants

Description	%
Trainings/Seminars/Meetings	60
Arranged as part of existing systems and training programmes	20
Continuous review of present system	20

Table 4.8 Ongoing education for rostering staff on fatigue management provided from Part 125 participants

Description	%
Arranged as part of annual refresher course	50
Appeared minor, or is being developed	50

Table 4.9 Ongoing education for rostering staff on fatigue management provided from Part 135 participants

E Description	%
Monitoring of existing flight & duty time limitations	33
Discussions	22
Trainings/Seminars/Meetings	22
Late start/Early finish the next day principle	11
Availability of fatigue-related journals, articles	11

Examples of monitoring of pilots' flight and duty times provided from all Operators

An example provided by Part 121 Operators on monitoring of pilots' flight and duty times was the processed information on flight and duty records stored in their organisations' computer systems.

Table 4.10 Monitoring of pilots' flight and duty times provided from Part 125 participants

Description	%
Monitoring of processed flight & duty records in computer system	60
Flight & duty information entered on sheets & stored in computer	40

Table 4.11 Monitoring of pilots' flight and duty times provided from Part 135 participants

Description	%
Monitoring of current CAA approved flight & duty time limits	20
Monitoring of records entered on database but not computerized	51
Formal duty and flight time management system	3
Discussions	3
Monitoring of computerized flight & duty records	23

Examples of monitoring of pilots' workload other than flight and duty times provided from all Operators

Table 4.12 Monitoring of pilots' workload provided from Part 121 participants

Description	%
Information from roster converted to decisions about leave, etc..	50
Extra duties performed by pilots are accounted for in roster	50

Table 4.13 Monitoring of pilots' workload provided from Part 125 participants

Description	%
Management discretion	50
Information from roster converted to decision	50

Table 4.14 Monitoring of pilots' workload provided from Part 135 participants

Description	%
General monitoring of existing flight & duty time limits	37
Open discussions between management and pilots	33
Assessing work habits of pilots	15
Review of computerized information	4
Monitoring of pilots' workload is minor due to very little workload	4

Examples of occurrence reporting system that asks about fatigue provided from all Operators

Table 4.15 The occurrence reporting system that asks about fatigue provided from Part 121 participants

Description	%
Built in the Quality safety reporting system	33
Specific fatigue reporting system	33
Have system but is not effective	33

Table 4.16 The occurrence reporting system that asks about fatigue provided from Part 125 participants

Description	%
Built in the Quality safety reporting system	50
Have system but does not specifically ask about fatigue	50

Table 4.17 The occurrence reporting system that asks about fatigue provided from Part 135 participants

Description	%
Built in existing systems that generally ask about fatigue	57
Completion of fatigue form	14
Verbal reporting	14
Have system, but does not include fatigue	7
Discussed in safety meetings	7

Examples of identification and management of fatigued pilots provided from all Operators

Table 4.18 Identification and management of fatigued pilots provided from Part 121 participants

Description	%
Review of existing systems such as rostering and fatigue reporting	40
Via reporting system or self-monitoring	20
No proactive system in place	20
Fatigue has not been felt by pilots so no system in place	20

Table 4.19 Identification and management of fatigued pilots provided from Part 125 participants

Description	%
Review of existing systems such as flight & duty and rostering systems	25
Development of a culture where openness about fatigue is encouraged	25
Operations Management monitors fatigue	25
No system in place	25

Table 4.20 Identification and management of fatigued pilots provided from Part 135 participants

Description	%
Small company so fatigue is easy to be managed (case by case)	25
Constant monitoring of flight & duty limits and rostering system	32
Open door policy	18
Operations Management monitors fatigue	14
Not procedure but proactive about fatigue	4
Pilots monitor identification and management of fatigue	4
Relevant information reviewed at safety meeting	4

Examples of ongoing review of the processes used for fatigue management provided from all Operators

Table 4.21 Ongoing review of the processes used for fatigue management provided from Part 121 participants

Description	%
Carried out as part of existing systems and trainings	60
Carried out by responsible committee comprised of aircrew and medical doctor	20
No review carried out	20

Table 4.22 Ongoing review of the processes used for fatigue management provided from Part 125 participants

Description	%
Carried out as part of audit and quality systems	67
Carried out as part of scheduled meetings, courses, trainings	33

Table 4.23 Ongoing review of the processes used for fatigue management provided from Part 131 participants

Description	%
Carried out as part of existing systems, trainings and meetings	53
Review of fatigue-related issues and flight & duty scheme	40
Review carried only if flight & duty times increase over busy periods	7

Examples of a system for allowing feedback from pilots provided from All Operators

Table 4.24 A system allowing feedback from pilots on fatigue-related issues provided from Part 121 participants

Description	%
Reporting system such as quality reporting and fatigue reporting	50
Feedback goes to responsible personnel or group	34
Informal reporting by pilots	17

Table 4.25 A system allowing feedback from pilots on fatigue-related issues provided from Part 125 participants

Description	%
Informal feedback	50
Quality safety reporting system	25
Scheduled meetings	25

Table 4.26 Examples for a system allowing feedback from pilots on fatigue-related issues provided from Part 135 participants

Description	%
Informal reporting/Open door policy	42
Scheduled meetings where feedback is reviewed	30
More formal internal reporting face to face	12
Quality safety reporting system	9
Quality system but pilots don't use it	3
Feedback received but not specifically on fatigue	3

2

Examples of software used to assist with rostering

Table 4.27 Software used to assist with rostering provided from Part 121 participants

Description	%
Software such as Geneva, Sabre	50
No software	17
Have program that computes flight & duty time & limits	17
Spreadsheet only	17

Table 4.28 Software used to assist with rostering provided from Part 125 participants

Description	%
Have program that computes flight & duty time & limitations	50
Software such as Geneva	25
Spreadsheet only	25

Table 4.29 Software used to assist with rostering provided from Part 135 participants

Description	%
Have program that computes flight & duty time & limitations	50
Record flight & duty time on database/Microsoft access program	33
Simple display method such as roster, whiteboard	17