Australian Government
Australian Transport Safety Bureau

Fatigue experiences and culture in Australian commercial air transport pilots

Research

ATSB Transport Safety Report
Aviation Research Investigation
AR-2015-095
Final – 22 January 2019

Publishing information

Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

Addendum

Page	Change	Date

Safety summary

Why the ATSB did the research

Fatigue is an inevitable risk in aviation. As it cannot be completely eliminated, it must be managed. Data on fatigue and its impact on air transport safety is generally only obtained if there is an incident or accident. As a result, there is generally a lack of understanding of the baseline level of fatigue in day-to-day Australian air transport across operators.

To provide the air transport industry, regulators and policy makers with further insights into industry perceptions of fatigue, the ATSB conducted a survey of commercial pilots engaged in passenger, freight, and aeromedical operations in the second half of 2016. To understand the reported level of fatigue during normal operations, the survey aimed to discover the amount of sleep and rest obtained by pilots, as well as their perceptions on the length of rests and duty times. The survey also aimed to capture data on the organisational aspects of fatigue, including how pilots feel about removing themselves from duty because of fatigue experienced and how they think management perceive this behaviour.

What the ATSB found

The majority of survey respondents reported they were sufficiently well rested by the end of their last duty. Over half of pilots reported having 7 hours of sleep or more in the previous 24 hours, and over 60 per cent reported having more than 14 hours in the previous 48 hours, at the end of the last flight. The survey also found a small but significant number of pilots, 10 per cent and 17 per cent, who reported obtaining less than 5 hours of sleep in the previous 24 hours, or less than 12 hours in the previous 48 hours, respectively, at the end of their last flight. These sleep thresholds have been shown to be associated with impaired performance.

Less sleep on duty was more prevalent for international and domestic jet airline pilots than other air transport pilots (regional, charter and aeromedical). While around one third of the respondents reported obtaining the same amount of sleep at home as they did while on duty, around half of international and domestic pilots reported obtaining less hours of sleep on duty than at home. About 15 per cent of international pilots responded they had no rest during their last international flight.

Domestic pilots completed duties on a stand-by day more often than other pilots. Some believed the rest period between duties was too short, duty periods were too long, and access to food during duties was more difficult compared with other pilots, indicating some pilots within this group have negative perceptions of rest opportunities provided by their employers.

Over 90 per cent of pilots indicated their employer offered a formal process for removing themselves from duty due to fatigue. About one third of respondents indicated they removed themselves from duty at least once in the past year, mostly between one and three days. The pilots who removed themselves from duty generally perceived their actions left a negative impression with management (with the exception of aeromedical pilots), and did not feel comfortable doing so.

Safety message

Responsibility to manage the risk of fatigue lies with both the individual pilot and organisation. It is the individual pilot’s responsibility to use rest periods to obtain adequate sleep and to remove themselves from duty if they feel fatigued. It is important for operators to implement policies to reduce the likelihood of fatigue-related issues through rostering practices and by providing an organisational culture where crew can report fatigue in a supportive environment. The results of this research suggest that operating in circumstances conducive to fatigue is an ongoing challenge for a proportion of Australian air transport pilots.

Contents

Executive summary

Background

Fatigue is an inevitable risk in aviation where operations are conducted through all hours of the day and sometimes through multiple time zones. As fatigue cannot be completely eliminated, it must be appropriately managed.

Fatigue is defined by the International Civil Aviation Organization (2016) as:

> …a physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a person's alertness and ability to perform safety related duties.

Three broad aspects of fatigue relevant to aviation include rest obtained, rest opportunity provided, and organisational support.

Rest obtained includes hours of sleep, hours awake, hours of rest, and layover length. There is a body of literature that describes the ideal hours of sleep and wake for optimum performance, as well the effects of obtaining less than the optimal hours of sleep. In summary, most people need between 7 to 9 hours of sleep to obtain maximum levels of alertness and performance (Hirshkowitz and others 2015). Obtaining less than 5 to 6 hours of sleep in the prior 24 hours, and less than 12 hours sleep in the prior 48 hours, would be inconsistent with a safe system of work (Dawson and McCulloch 2005). In addition, after 19 hours of being awake, significant performance decrements in visual perceptual, complex motor, and simple reaction time impairments have been found in the literature (Russo and others 2005; Transportation Safety Board 2014).

Rest opportunity takes into account length of duty period, perceptions of rest period adequacy, and access to food. The topic of organisational support includes examining the fatigue risk management systems in place at the organisation level. This includes provisions for removing one's self from duty and organisational processes. The culture of the organisation is relevant, such as whether pilots feel comfortable in removing themselves from duty without negative consequences.

Objectives

This ATSB survey research was designed to understand the level and perceptions of fatigue in normal operations in the airline environment among a sample of volunteer Australian commercial air transport pilots. The objectives of this research were to:

- measure fatigue-related indicators such as amount of sleep, hours awake, and length of layover
- evaluate pilots' perceptions of length of rest and duty, and perceptions of how removing one's self from duty because of fatigue was viewed in their organisation.

The data collected was related to experiences based on the last duty completed or within the previous 12 months, while data on perceptions related to the previous 12 months, from the time the survey was completed (June to November 2016).

Methodology

The ATSB developed an online survey examining fatigue issues, as well as other areas such as safety culture—to be published in a separate report. Letters were emailed to chief pilots and safety officers of passenger, freight, and aeromedical operators in Australia requesting they distribute the survey link to pilots in their organisation. The survey was also advertised on the ATSB website and Facebook page.

The questions in the survey about fatigue centred on three themes: rest obtained, rest opportunity provided, and organisational support. The questions relating to rest obtained asked participants about:

- the hours of sleep normally obtained at home
- hours of sleep obtained in the previous 24 and 48 hours prior to the end of their last duty
- number of hours awake at the end of last duty
- length of their last layover and rest obtained
- rest obtained on their last long-haul flight
- their ratings of alertness at the end of their last duty.

Questions on rest opportunity provided asked pilots to rate their:

- frequency of being asked to complete a duty on a stand-by day
- perceptions of whether rest periods were sufficient to obtain adequate rest and duty periods too long to manage fatigue
- opportunities to accessing food on duty.

Questions on organisational support asked pilots to rate their:

- frequency of removing themselves from duty
- perceptions of the impression they left with management when removing themselves from duty
- how comfortable they felt removing themselves from duty.

Demographic data

There were 625 valid respondents. Pilots were grouped by the categories in Table 1 for analysis.

Table 1: Operation types of pilots

Operation type	Frequency	Per cent[1]
Long-haul (international)	133	21.3
Short-haul (domestic jet)	230	36.8
Regional (turboprop and piston regular public transport)	86	13.8
Charter	100	16.0
Aeromedical (aeroplane and helicopter)	66	10.6
Helicopter (excluding aeromedical)	10	2.6
Total	625	100

The number of respondents represented a sample of at least 4 per cent of pilots with an Air Transport Pilot Licence (ATPL)[2] or Commercial Pilot Licence[3] (aeroplane and helicopter) in Australia. Although it is a small sample size, the number of respondents broadly correspond to the number of licence holders per type.

1 Percentages were rounded to the one decimal place, so the total percentage may be more than 100 per cent.

2 A pilot licence with authorisation to conduct private and commercial operations and be the pilot-in-command or the copilot of any operation.

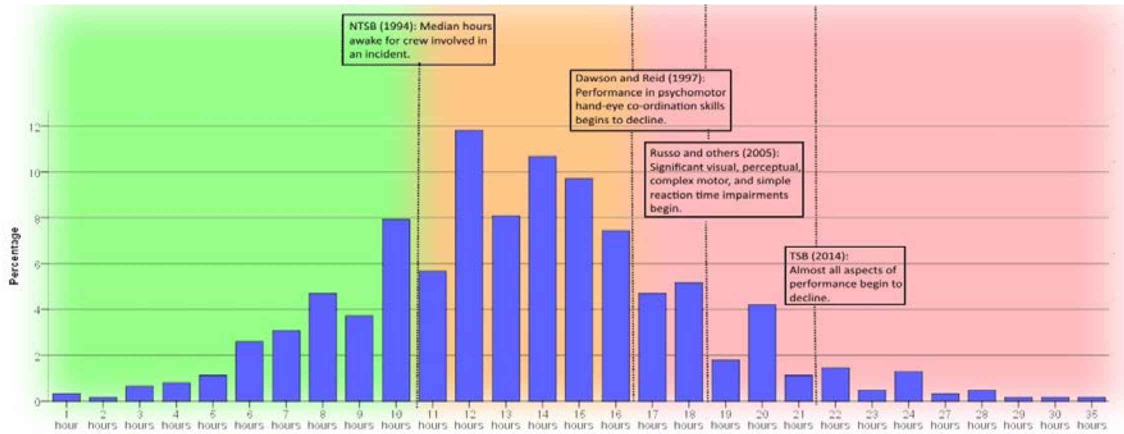
3 A pilot licence with authorisation to conduct private and commercial operations and be the copilot and pilot-in-command of any operation except multi-crew aircraft in charter or regular public transport operations, an aeroplane certified for single-pilot operations with a maximum take-off weight (MTOW) of more than 5,700kg in regular public transport operations, and turbojet aeroplanes with a MTOW of more than 3,500kg in regular public transport operations.

Results and discussion

Rest obtained

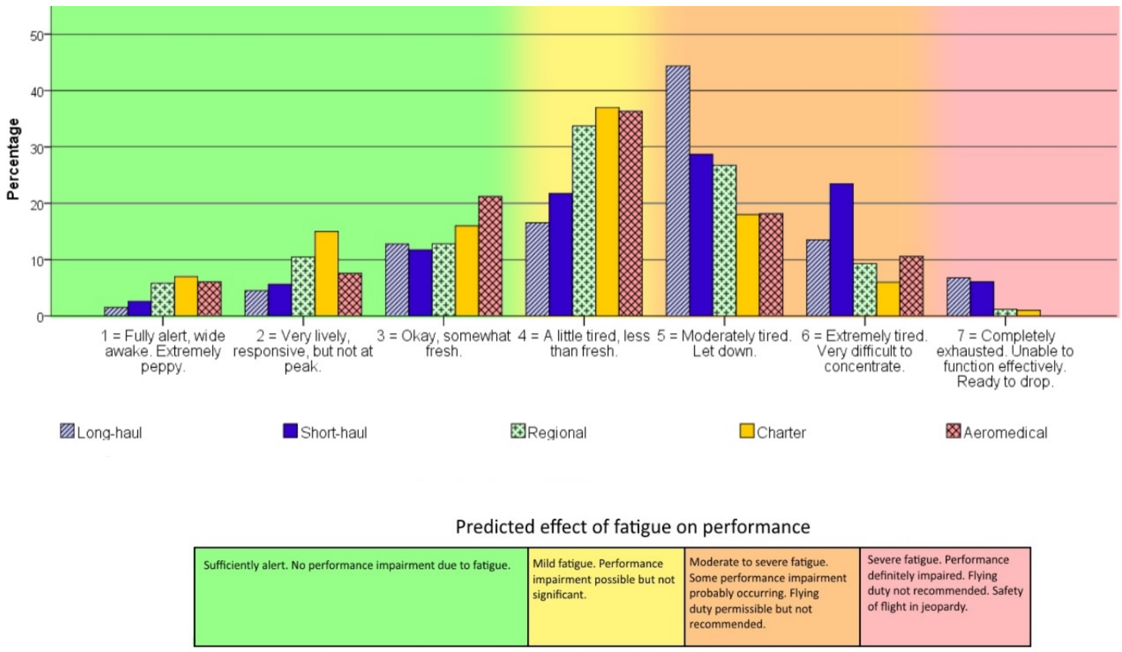
The majority of pilots, almost 90 per cent, reported their hours awake at the end of their last duty being under the thresholds identified in fatigue research. Around 11 per cent of pilots reported they were awake 19 hours or more and around 4 per cent of pilots reported they were awake 22 hours or more (Figure 1). These are thresholds associated with impairments in performance (Russo and others 2005; Transportation Safety Board 2014). Long-haul pilots reported being awake the longest compared with the other pilots with around half reporting being awake 16 hours or more. This reflects the nature of long-haul operations where duty times can be almost a day.

Figure 1: Distribution of hours awake at the end of their last duty



Around one quarter of pilots perceived they were sufficiently alert at the end of their duty, however nearly half of the pilots perceived they were experiencing moderate to severe fatigue at the end of their last duty (reported feeling 'Moderately tired. Let down' or 'Extremely tired. Very difficult to concentrate'). Long-haul and short-haul pilots reported feeling more tired at the end of duty than the other groups (Figure 2). Around 50 per cent of short-haul and 60 per cent of long-haul pilots indicated they were experiencing moderate to severe fatigue at the end of their last duty.

Figure 2: Self-rated alertness at the end of last flight by operation type



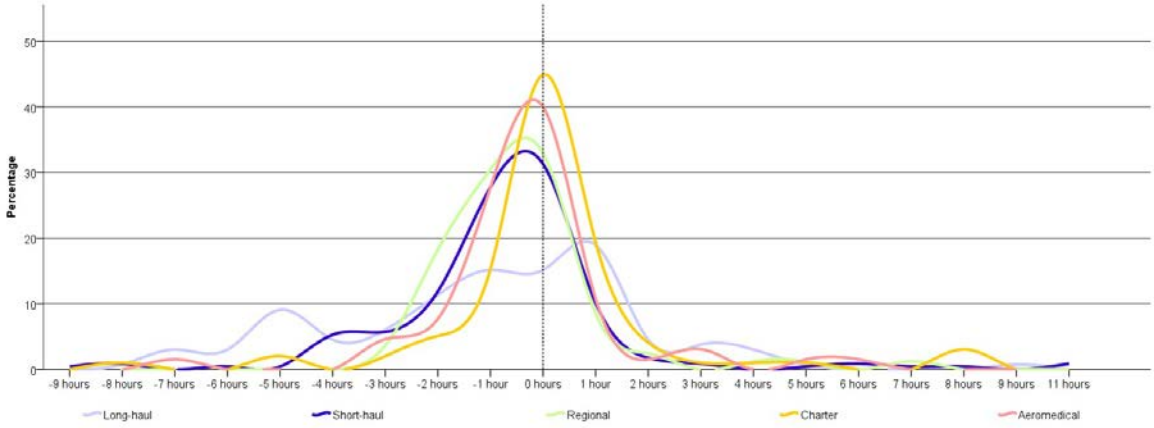
For short-haul operations, results indicate the more sectors flown in a month, the more pilots reported feeling tired. Pilots who undertake many sectors will have many take-offs and landings, both high workload phases of flight (Lee and Liu 2006), which can increase feelings of fatigue.

Around 90 per cent of pilots reported obtaining between 7 and 9 hours of sleep at home, with 50 per cent of pilots reported obtaining these hours of sleep in the previous 24 hours at the end of their last duty. Ten per cent of pilots reported obtaining less than 5 hours of sleep in the previous 24 hours at the end of duty. In contrast, less than 1 per cent of pilots reported obtaining less than 5 hours of sleep at home. Seventeen per cent of pilots reported they obtained less than 12 hours of sleep in the previous 48 hours, whereas less than five per cent reported obtaining these hours of sleep at home.

Similar to hours' awake, nearly one quarter of long-haul pilots reported obtaining less than five hours of sleep in the previous 24 hours (prior to the end of their last duty). Around 10 per cent of short-haul pilots reported obtaining less than five hours of sleep in the previous 24 hours at the end of duty and around 20 per cent reported less than 12 hours of sleep in the previous 48 hours. Pilots from other operation types (regional, charter, aeromedical) rarely reported less than 5 hours sleep.

Around 30 per cent of pilots reported the same amount of sleep at home and in the previous 24 hours at the end of their duty. These were mainly charter pilots and aeromedical pilots (Figure 3). Around half of long-haul and short-haul pilots reported obtaining fewer hours of sleep in the 24 hours prior to the end of duty than at home. Acute sleep disruptions are reductions in the quality or quantity of sleep that have occurred within the prior 3 days (Transportation Safety Board 2014). Losing as little as two hours of sleep can induce fatigue and degrade subsequent waking performance and alertness (Dinges and others 1996).

Figure 3: Distribution of differences in sleep obtained at home compared with the previous 24 hours at the end of their last duty by operation group



Of the long-haul pilots who responded to the survey, nearly 80 per cent reported their last layover had less than 40 hours of non-duty time. Research has found that long-haul flight crew who had a layover less than 40 hours self-reported a higher level of fatigue and recorded slower reaction times in a vigilance task than flight crew who had a longer layover of an average of 62 hours. This indicates that the shorter layover did not provide sufficient opportunity for recovery from the outbound flight (Lamond and others 2006). However, note the direction of travel (east-bound or west-bound) was not gathered in the ATSB survey. It has been found that adding an additional day to an east-bound flight had no effect on fatigue (Powell and others 2010).

Approximately 7 per cent of short-haul pilots reported having less than 8 hours' non-duty time during their last layover. The Civil Aviation Safety Authority (2017) states flight crews should get the required sleep opportunity (8 hours), plus sufficient time to address personal requirements, and to travel to and from accommodation, meaning layovers should ideally be around 10 hours minimum. The majority (80%) of short-haul pilots reported having at least 10 hours' non-duty time during their last layover.

While most long-haul pilots had some sleep during their last flight, around 15 per cent of long-haul pilots reported they had no hours of rest during their last long-haul flight. Pilots on long-haul flights who napped have been found to have a higher level of alertness and performed better on vigilance and reaction time tasks compared with those who did not nap (Rosekind and others 1994). However, from the survey, it is unknown whether the pilots who did not nap attempted to nap or if there was a scheduled rest break during the flight.

Rest opportunity provided

Of the pilots who completed a duty on a stand-by day, around half reported they completed these duties 'often' or 'most of the time', particularly aeromedical and short-haul pilots. First officers reported they completed duties more often than captains from both multi-crew and single pilot operations.

Approximately one third of pilots reported their rest period was sufficient as they indicated their rest period between duties was 'never' or 'rarely' too short. However, around 30 per cent perceived their rest period was too short between duties either 'often' or 'most of the time'. This was particularly so for short-haul pilots, who accounted for half of these responses.

Around 40 per cent of pilots perceived their duty period was 'never' or 'rarely' too long. One third of pilots who perceived their duty period was too long indicated this was 'often' or 'most of the time' the case. Access to food during duty was perceived as difficult by half of the respondents; in particular, for short-haul pilots, with 50 per cent reporting access to adequate food as 'often' or 'always' difficult.

Organisational support

Over 90 per cent of pilots indicated their employer offered a formal process for removing themselves from duty due to fatigue.

One third of pilots reported removing themselves from duty because of fatigue in the previous 12 months for '1 to 3 days', with around 60 per cent indicating they had not taken time off, due to fatigue, in the previous 12 months. Of the pilots who removed themselves from duty, long-haul and short-haul pilots reported removing themselves from duty more often than other pilots.

The pilots who removed themselves from duty felt they left a 'slightly negative' or 'very negative' impression with management. The exception was aeromedical pilots, who indicated they felt they left a 'very positive' or 'slightly positive' impression. Overall, pilots did not feel comfortable in removing themselves from duty, particularly first officers compared with captains. Of the pilots who reported removing themselves from duty, around half felt 'not comfortable' or 'rarely comfortable'.

Findings

Safety factors

- A small proportion of pilots reported conditions consistent with thresholds that have been shown to be associated with impaired performance due to fatigue at the end of their last duty. These included:
  - 11 per cent of pilots reported they were awake 19 hours or more, and around 4 per cent of pilots reported they were awake 22 hours or more
  - 10 per cent of pilots overall (and 25 per cent of long-haul pilots) reported obtaining less than 5 five hours of sleep in the previous 24 hours
  - 17 per cent overall (and 30 per cent of long-haul pilots) reported obtaining less than 12 hours of sleep in the previous 48 hours.
- Pilots who removed themselves from duty due to fatigue generally did not feel comfortable doing so and perceived they left a negative impression with management.

Other findings

- Half of short-haul (domestic) pilots reported completing duties on a stand-by day. They also believe the rest period between duties is too short, duty periods are too long, and indicated access to food during duties is difficult compared with pilots from other operation groups (long-haul, regional, charter, and aeromedical).
- Over 90 per cent of pilots indicated their employer offered a formal process for removing themselves from duty due to fatigue. Overall pilots do not remove themselves from duty often due to fatigue, but one third had removed themselves at least once in the past 12 months.
- Aeromedical pilots that removed themselves from duty due to fatigue perceived they left a positive impression with management.

Context

The continuation of Australia's good aviation safety record requires ongoing active management of safety hazards. Fatigue is a well-known factor hazard that degrades human performance. Fatigue is inevitable in the 24/7 aviation industry, where flight crew travel across time zones. As the hazard of fatigue cannot be eliminated completely, it must be managed.

The International Civil Aviation Organization (2016) has defined fatigue as:

> …a physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a person's alertness and ability to perform safety related duties.

The effects fatigue can have on human performance include (Battelle Memorial Institute 1998):

- decreased vigilance
- slowed reaction time
- decreased work efficiency
- increased variability in work performance
- lapses or errors of omission.

Fatigue can have a number of causes and can affect flight safety in various ways. The science of fatigue's effect on safety has advanced greatly in recent years (see *Fatigue literature* below) and is still progressing. Relating fatigue to accident and incident outcomes can be difficult (see *Fatigue in ATSB investigations* below), and its relative prevalence in everyday operations is not apparent. Pilot fatigue is often only recorded when things go wrong. This ATSB research was therefore designed to establish the level and perception of fatigue in normal operations in the air transport environment.

Fatigue literature

Rest obtained

Most people need between 7 and 9 hours of sleep each day to achieve maximum levels of alertness and performance (Hirshkowitz and others 2015). A review of highly cited, peer-reviewed, research on fatigue has found that obtaining less than 5 to 6 hours of sleep in the prior 24 hours, and less than 12 hours sleep in the prior 48 hours, would be inconsistent with a safe system of work (Dawson and McCulloch 2005). In road safety research, it has been found that drivers obtaining around 5 hours of sleep in the previous 24 hours increased the risk of a car crash (Williamson and others 2011). This research also found drivers obtaining 9 hours of sleep in the previous 48 hours had double the risk of a road accident compared with a driver who had obtained 12 hours of sleep.

Similarly, observations during normal airline flight operations demonstrated that, when the crew had obtained 5 to 6 hours of sleep or less in the previous 24 hours, their performance was associated with poorer management of threats and an increased occurrence of errors (Thomas and Ferguson 2010). The results also demonstrated that the relationship between fatigue and performance of multi-crew operations was complex. For example, the performance of the crew was more sensitive to restricted sleep of the captain. Specifically, crews' threat management was poorer and errors increased if the captains had obtained less than 6 hours sleep in the prior 24 hours, whereas the threshold for the first officer appeared to be at less than 5 hours sleep in the past 24 hours.

Petrilli and others (2006) also found that long-haul pilots' higher rating of self-reported fatigue and slower response time was associated with obtaining fewer hours of sleep in the previous 24 hours. A similar result was found with short-haul pilots (Roach, Sargent, Darwent, and Dawson 2012) where pilots who obtained fewer hours of sleep in the 12 hours prior to the start of duty self-reported higher fatigue scores.

Although the exact threshold of performance decrements is debated, the National Transportation Safety Board (1994) review of incidents found that first officers awake for more than 11 hours and captains awake for more than 12 hours made more errors. Furthermore, experimental research has found that after 17 hours of being awake, performance in psychomotor hand-eye co-ordination tasks begins to decrease and continues to decrease as hours awake increase (Dawson and Reid 1997). Russo and others (2005) found significant visual perceptual, complex motor, and simple reaction time impairments began in the 19th hour of continuous wakefulness. In its guide to investigating fatigue, the Transportation Safety Board of Canada (2014) uses 22 hours of continuous wakefulness as a threshold where almost all aspects of performance begin to decline. Previous research has demonstrated that duty periods and number of sectors flown affect the risk of fatigue. A review of fatigue in aviation accidents found that 20 per cent of accidents occurred in the 10th hour of duty (Goode 2003).

Rest opportunity provided

A French survey of pilots across four airlines, found that short-haul pilots described a roster that increased fatigue was one that involved long duty periods that included 4 to 5 sectors per day with successive early wake-ups over a sequence of days (Bourgeois-Bourgrine and others 2003). Powell and others (2007) also found that, when short-haul flight crew were asked to rate their levels of fatigue prior to the descent phase of flight, the score increased as the number of sectors flown and length of duty time increased.

In the *Civil Aviation Order 48.1 Instrument 2013 and the associated* Civil Aviation Advisory Publication (CAAP) 48-01, the Civil Aviation Safety Authority (2017) states operators must provide crew with an off-duty period that is long enough to cover the required sleep opportunity (8 hours), plus sufficient time to address personal requirements, and to travel to and from accommodation. In total, the time free of duty should be about 10 to12 hours, but can be as low as 9 hours in some cases.

The effect of layover time on short-haul pilots has also been studied. Gander and others (1998) found during duty periods that included layovers, short-haul pilots rated their fatigue to be highest at post-trip and during sectors. Pilots also reported during trips they slept less, awoke earlier, and reported having more difficulty falling asleep and obtaining poorer quality sleep. It has also been found that crew schedules on trans-Tasman flights that included a layover, compared to those without, resulted in reduced self-reported levels of fatigue (Powell and others 2010).

Pilots on long-haul flights identified schedules involving flights on two successive nights with a sleep during a short layover day as fatiguing (Bourgeois-Bourgrine and others 2003). Flight crews who had a shorter layover, less than 40 hours, between outbound and inbound on trans-Atlantic long-haul flights self-reported a higher level of fatigue and recorded slower reaction times in a vigilance task than crews who had a longer layover of an average of 62 hours. This indicates the shorter layover did not provide sufficient opportunity for recovery from the outbound flight (Lamond and others 2006). Powell and others (2010) found the effect of layover and fatigue, when crossing time zones, is dependent on the direction of travel as pilots on east-bound flights report higher levels of fatigue.

On long-haul flights, sleep opportunity may be limited. At times when sleep is possible, but time available for sleep is limited, one countermeasure is napping (Bonnet 1991). Pilots on long-haul flights who napped have been found to have a higher level of alertness and performed better on vigilance and reaction time tasks than those who did not nap (Rosekind and others 1994). Another countermeasure for fatigue is food consumption (Caldwell and others 2009).

Organisational support

Operators are required to comply with *Civil Aviation Order 48.1 Instrument 2013*. There were two sections relating to operator (section 14.1) and pilots' responsibilities (section 16.1) in regards to experiences of fatigue.

> …an air operator's certificate holder must not require a flight crew member (FCM) to operate an aircraft if, considering the circumstances of the flight to be undertaken, the holder has reason to believe that the FCM is suffering from, or is likely to suffer from, fatigue which may so impair the FCM's performance that the safety of the operation may be affected.
>
> It is a condition on each flight crew licence that the licence holder must not operate an aircraft if, considering the circumstances of the flight to be undertaken, he or she has reason to believe that he or she is suffering from, or is likely to suffer from, fatigue which may so impair performance that the safety of the operation may be affected.

Management of fatigue is moving from prescriptive rules to an operator-based management of fatigue risk through fatigue risk management systems. The International Civil Aviation Organization (2016) defined a fatigue risk management system as:

> A data-driven means of continuously monitoring and managing fatigue related safety risks, based upon scientific principles, knowledge and operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness.

An organisation's safety culture is individuals' shared underlying beliefs in the importance of safety within their organisation (Reason 1997). It is reflected in the consistent way an organisation manages safety issues (Wiegmann and others 2004). The development of a mature safety culture is important for successful implementation of safety management systems, including fatigue risk management systems (Gander and others 2011). Hazard identification, safety assurance, and continuous improvement rely on safety issues being reported and analysed for learning. Organisations with a mature reporting culture encourage employees to report issues without fear of disciplinary action (Reason 1997). This includes submitting incident reports as well as crew being comfortable removing themselves from duty when unfit to fly, and management's supportive attitudes towards crew removing one's self from duty.

A workshop conducted by Anund and others (2015) among a range of transport modes including aviation has found the presence of a just culture, where crew's self-reporting of fatigue does not lead to blame or punishment, was identified as an effective countermeasure to fatigue. Organisations with a mature safety culture approach view any report from crew, including those events with safety lapses, errors and unintended violations, as opportunities to learn safety lessons.

Organisational support for managing fatigue also includes countermeasures such as prescribing maximum duty periods, provisions of breaks during duty, suitable accommodation during breaks, and breaks between shifts, which are based on the physiological basis of fatigue (Caldwell and others 2009). An organisation's culture can be evident through company support of the discussion and addressing of fatigue-related issues (Rosekind and others 1996).

Fatigue in ATSB investigations

In safety investigations, fatigue can be difficult to identify as a safety factor. It can also be difficult to collect evidence supporting its contribution to an accident or incident. There can be many explanations why an error occurred, such as a pilot experiencing high workload concurrently with circumstances indicative of insufficient rest. In these situations, fatigue may not be able to be isolated as the factor that contributed to the error.

To assist in collecting standard evidence for the presence of fatigue in investigations, the ATSB has developed fatigue evidence collection guidelines relating to sleep obtained, sleep opportunity, and organisational support.

In the investigations where evidence of flight crew experiencing fatigue has been found, it was usually related to the number of hours of sleep obtained in the previous 24 and 48 hours prior to the incident or accident. The investigations indicate the factors present affecting the amount of sleep obtained, such as:

- sleep interruptions (AO-2010-035)
- obtaining sleep outside of the normal circadian[4] lows (AO-2013-047)
- experiencing life stressors (AO-2007-036 and AO-2008-064)
- conducting other employment on rostered days off (AO-2013-049).

Extended wakefulness has also been found to contribute to experiences of fatigue (AO-2013-130).

Another factor influencing sleep obtained is the rest opportunity provided. Some operators' rostering systems did not to allow enough time between duties for crew to obtain adequate rest (AO-2013-010 and AO-2014-189), subsequently influencing sleep hours obtained. Rostering issues also include the number of early morning duty start times in a week. Organisational practices, such as guidance for crew to self-assess their level of fatigue (AO-2014-189) or guidance on managing early start times (AO-2011-033) have also been found to influence the level of fatigue.

Other sources of fatigue that are not necessarily linked to sleep obtained were poor nutrition and illness (AO-2013-047).

Objectives

The objective of this research was to estimate:

- fatigue-related indicators such as amount of sleep, hours awake, and length of layover
- pilots' perceptions of length of rest and duty relating to fatigue, and
- practices and organisation perceptions of removing one's self from duty due to fatigue for normal operations among a sample of Australian commercial air transport pilots.

4 Sleep/wake cycle over a 24 hour period.

Method

The ATSB survey asked Australian commercial pilots about their perceptions of, and experiences with, fatigue and safety issues, safety and reporting cultures, and operational experiences. This report specifically focuses on responses to questions about pilots' experiences and perceptions of fatigue in the previous 12 months.

The list of survey questions was developed based on literature reviewed above, common ATSB *SafetyWatch* priorities, measures of fatigue used in ATSB investigations, and an earlier ATSB survey (ATSB 2004; ATSB 2005). The list of questions was assessed by aviation and human factors experts internal and external to the ATSB.

Before distribution, the survey was tested on a small sample of former commercial pilots and questions were revised, based on their feedback, to aid understanding.

The online survey was open to pilots conducting air transport operations such as passenger, including aeromedical, and freight operations employed by Australian operators. The survey was advertised by a letter to chief pilots of airlines and charter operators, as well as Australian pilot unions informing them of the purpose of the survey. They were asked to distribute the survey link to pilots within their organisation. A follow-up letter was sent two weeks later to the safety manager of these organisations, informing them of the survey and requesting the survey link be distributed within the organisation. A link to the survey was also published on the ATSB website and Facebook page.

One limitation to this survey methodology used is it was reliant on the operators distributing the survey among its pilots. As such, the ATSB did not have control over who received a link to the survey. Although many operators did promote the survey to their pilots, the ATSB is aware that at least one regional operator did not distribute the survey to their pilots.

The survey was open between June and October 2016.

Survey design

The questions applicable for this analysis appear in *Appendix A – Survey questions*. There were 16 questions (questions 15 – 29; questions 30 and 36) about fatigue in the survey.

Fatigue

Questions were asked on three factors affecting fatigue: rest obtained, rest opportunity, and organisational support.

Rest obtained

Rest obtained (questions 21–29) measured a snapshot in time based on the pilot's last flight/trip before completing the survey. Rest obtained before and during the last flight/trip was compared with a baseline measure of usual sleep obtained at home.

Rest obtained included questions on the following:

- alertness felt at the end of last duty
- usual hours of sleep at home (baseline measure)
- hours of sleep at the end of last duty in the previous duty in 24 hours
- hours of sleep at the end of last duty in the previous duty in 48 hours
- hours awake at the end of previous duty
- last layover non-duty hours
- last layover hours of sleep
- last long-haul flight time
- last long-haul flight hours of rest during the flight.

All answers required pilots to enter the length of time in digits except alertness, which was a scale from one to seven. Self-reporting hours of sleep has been found to be a valid measure of actual sleep as it has been correlated with activigraphy data; a physiological measure (Signal and others 2005). The scale used for the question on alertness at the end of last duty was the seven-point Samn-Perelli scale (Samn and Perelli 1982):

1. Fully alert, wide awake. Extremely peppy.
2. Very lively, responsive, but not at peak.
3. Okay, somewhat fresh.
4. A little tired, less than fresh.
5. Moderately tired. Let down.
6. Extremely tired. Very difficult to concentrate.
7. Completely exhausted. Unable to function effectively. Ready to drop.

Rest opportunity

Rest opportunity (questions 18–20, and 36) asked pilots to rate on a scale, based on the previous 12 months:

- frequency of being asked to complete a duty on a standby day
- whether rest periods were too short to obtain adequate rest
- whether duty periods were too long to manage fatigue
- difficulty in accessing adequate food during duty.
- The responses were on a five-point Likert scale with:
    1. never
    2. rarely
    3. sometimes
    4. often
    5. most of the time.

Organisational support

Organisational support (question 15–17) asked pilots to rate on a scale:

- How comfortable they felt removing themselves from duty. Responses were:
    1. not comfortable – I would always choose to fly
    2. rarely comfortable
    3. sometimes comfortable
    4. mostly comfortable
    5. always comfortable – it would be unacceptable to fly.
- Frequency of removing self from duty. Responses were:
    1. not an option
    2. never
    3. 1 to 3 days
    4. 4 to 12 days – up to once per month
    5. more than 12 days (more than once per month).
- Their impression left with management when they removed them self from duty. Responses were:
    1. very positive
    2. slightly positive

3. neutral
4. slightly negative
5. very negative
6. N/A – Did not take any time off for fatigue.

Demographic information

To analyse the data by groups, demographic information on aircraft flown, operation type, role, and sectors was asked.

- Possible aircraft flown responses included:
  - wide-body jet
  - narrow-body jet
  - turboprop aeroplane
  - piston aeroplane
  - helicopter.
- Possible operation type responses included:
  - scheduled passenger
  - scheduled freight
  - non-scheduled passenger
  - non-scheduled freight
  - aeromedical
  - other (please specify).
- Possible role responses included:
  - captain (multi-crew)
  - captain (single pilot)
  - first officer
  - second officer
  - other (please specify).

For ease of analysis, the above categories were used to formulate a new operation type category:

- long-haul
- short-haul
- regional
- charter
- aeromedical (aeroplane and helicopter)
- helicopter (excluding aeromedical).

For sectors flown, pilots were required to enter the number of sectors flown per month. These numbers were aggregated into the following groups:

- 0–24 sectors
- 25–49 sectors
- 50–74 sectors
- 75–99 sectors
- 100 + sectors.

Data analysis

Responses to the questions on fatigue were analysed by operation type, role, and sectors flown.

Responses from pilots who specified operation types outside of air transport, such as military or aerial application were excluded from the sample.

Descriptive statistics were used to examine the distribution of responses per question. Inferential statistics were used to determine any statistically significant differences between groups. As the data was not normally distributed, the inferential statistics chosen were Kruskal-Wallis H Test for comparisons between groups (*Appendix B: Data analysis*). The sign test was used for comparing sleep at home and sleep prior to duty as it related to the data from the same pilot for two time periods. Statistical significance testing was conducted using a type one error rate of five per cent, which is the standard level for behavioural sciences.

Demographic information

Representation of operation types

Overall, 625 pilot respondents answered one or more questions in this section (fatigue) and were included in the analysis. For the purpose of analysis, the data was grouped as per Table 2 below.

Table 2: Responses by revised operation types

Operation type	Frequency	Per cent[5]
Long-haul	133	21.3
Short-haul	230	36.8
Regional	86	13.8
Charter	100	16.0
Aeromedical (aeroplane and helicopter)	66	10.6
Helicopter (excluding aeromedical)	10	2.6
Total	**625**	**100**

Due to the small sample size, 'helicopter' was removed from between-group analyses using operation types.

For the purposes of the survey, long-haul refers to pilots who fly internationally on either wide or narrow-body aircraft. Short-haul refers to pilots who fly domestically with jet aircraft, either wide-body or narrow-body jets, on multi-crew operations. Regional refers to pilots who also fly domestically on multi-crew operations, but with turboprop aeroplanes or piston aeroplanes. Charter refers to single pilot operations on any aircraft type. Aeromedical refers to pilots who fly for the purposes of medical transport on all aircraft types. Helicopter includes both multi-crew and single pilot operations.

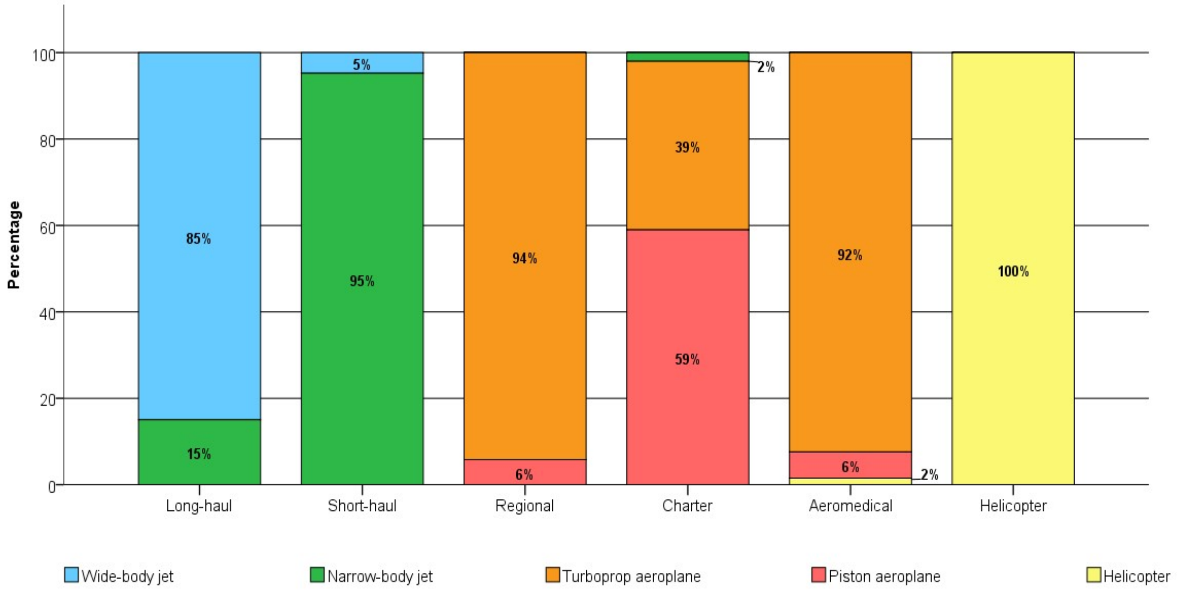
According to the CASA annual report, there were 14,709 pilots who possessed either an Air Transport Commercial Licence[6] or Commercial Pilot Licence[7] for aeroplane or helicopter in the year 2015-16.[8] This means that the pilots who responded to the survey comprise at least 4 per cent of this population. This sample is smaller than other surveys conducted where respondents received the surveys individually. Although it is a small sample size, the numbers broadly correspond to the populations within each licence type. In addition, the distribution of respondents across operation types shown in Table 2 broadly reflects the expected distribution of pilot population of working in those operations based on the activity levels.

5 Percentages were rounded to the one decimal place, so the total percentage may be more than 100 per cent.
6 A pilot licence with authorisation to conduct private and commercial operations and be the pilot-in-command or the copilot of any operation.
7 A pilot licence with authorisation to conduct private and commercial operations and be the co-pilot and pilot-in-command of any operation except multi-crew aircraft in charter or regular public transport operations, an aeroplane certifed for single-pilot operations with a maximum take-off weight (MTOW) of more than 5700kg in regular public transport operations, and turbojet aeroplanes with a MTOW of more than 3500kg in regular public transport operations.
8 The 14,709 pilots also includes CPL holders who are engaged in non-transport sectors such as aerial agriculture, aerial survey, mustering as it is unable to ascertain how many are engaged in air transport.

Aircraft flown with operation type

Figure 4 below shows the types of aircraft flown by pilots within operation types.

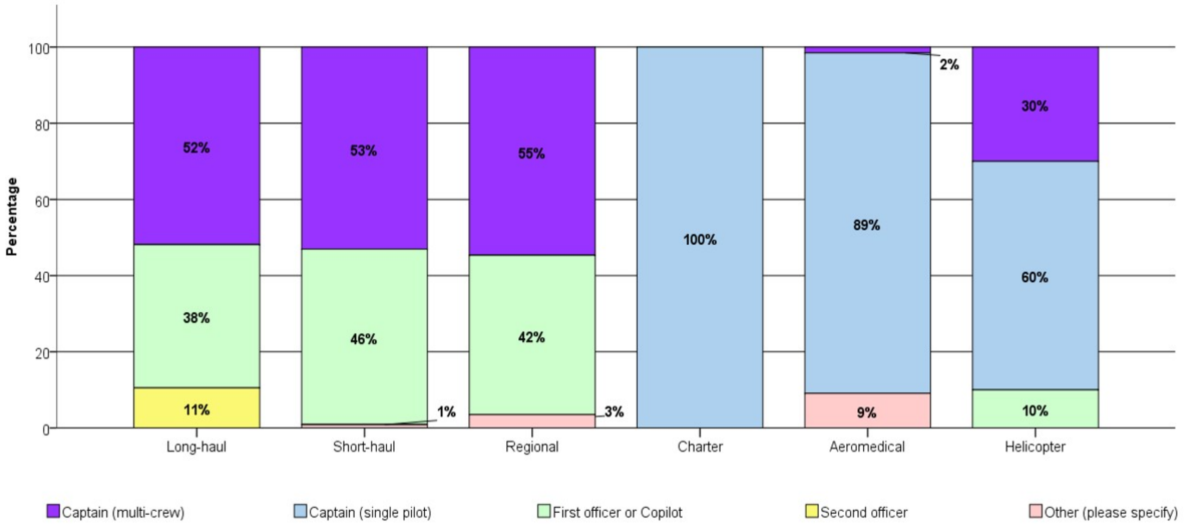
Figure 4: Aircraft flown by operation type



Role within operation type

Figure 5 shows the role of pilots within each operation type.

Figure 5: Role within each operation type



Flying hours

The hours flown on average by pilots preceding the survey are shown in Table 3. The number of flying hours ranged from 147 to 26,000 hours (Avg = 9,071, SD[9] = 6,284).

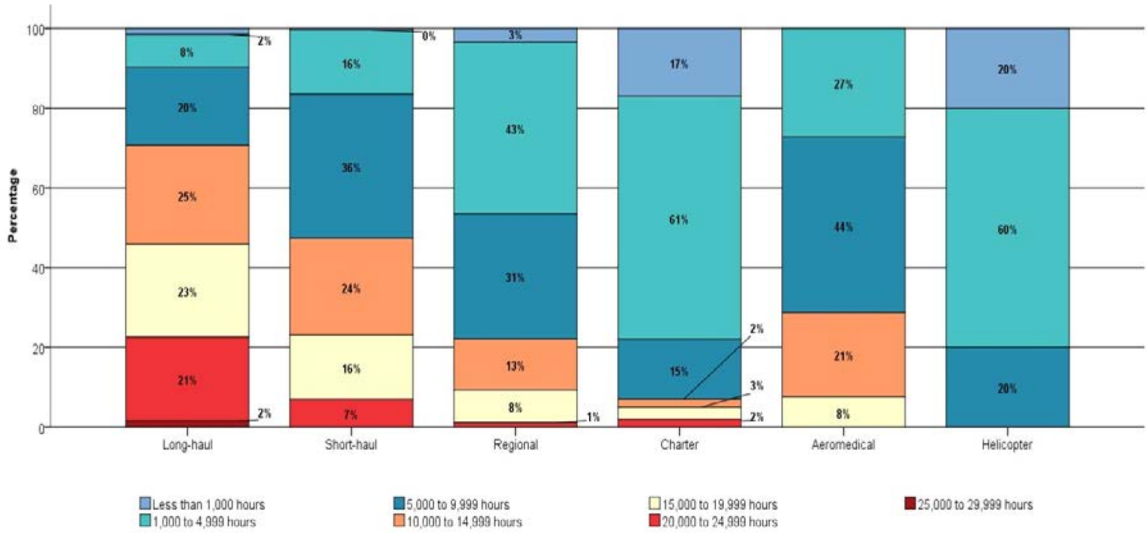
Table 3: Responses by operation type

Operation type	Average	Median	Standard deviation
Long-haul	13,864	14,000	6,372
Short-haul	10,231	9,000	5,533
Regional	6,512	5,000	4,947
Charter	3,703	2,100	4,286
Aeromedical	7,734	7,000	3,913
Helicopter	3,170	2,900	2,409

Flying hours within operation types

Figure 6 shows the distribution of the number of flying hours across the operation types.

Figure 6: Distribution of flying hours by operation type



9 SD is the abbreviation of standard deviation. It refers to the measures of the spread of data around the mean (average).

Sectors flown

The number of sectors flown (as both pilot flying and pilot monitoring[10]) per month in the last 12 months ranged from 0 to 200 sectors (Avg = 41.5, SD = 29.1). More than one third of pilots flew 25 to 49 sectors (37.4%) (Table 4).

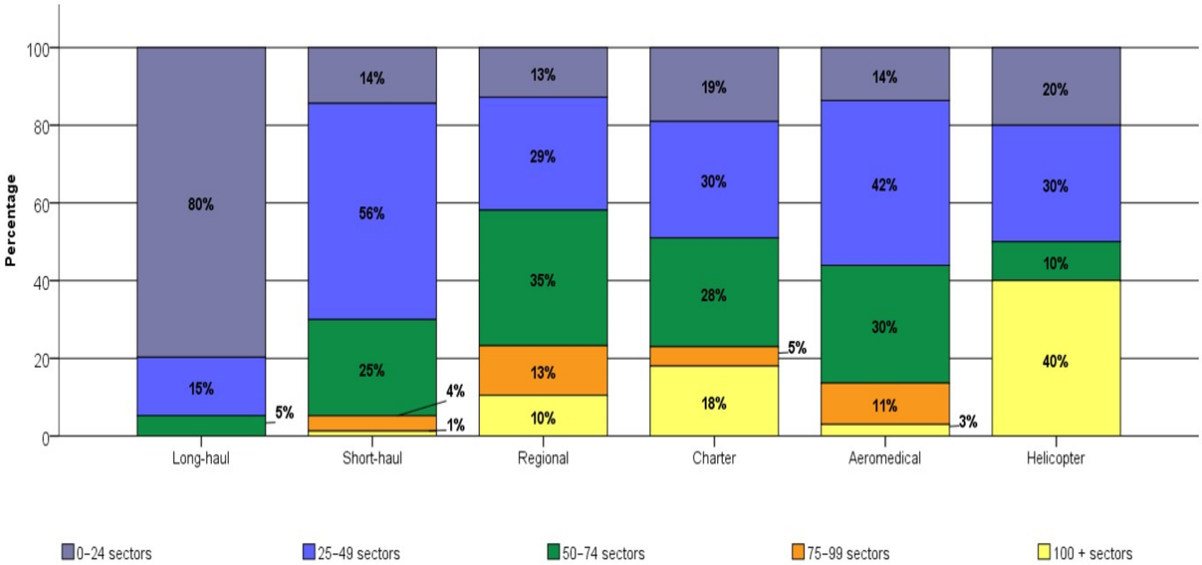
Table 4: Total sectors flown

Sectors	Frequency	Per cent
0–24 sectors	180	28.8
25–49 sectors	234	37.4
50–74 sectors	143	22.8
75–99 sectors	32	5.1
100 + sectors	36	5.8
Total	625	100

Sectors flown within operation type

Figure 7 shows the distribution of the number of sectors flown each month across operation type.

Figure 7: Number of sectors flown by operation type



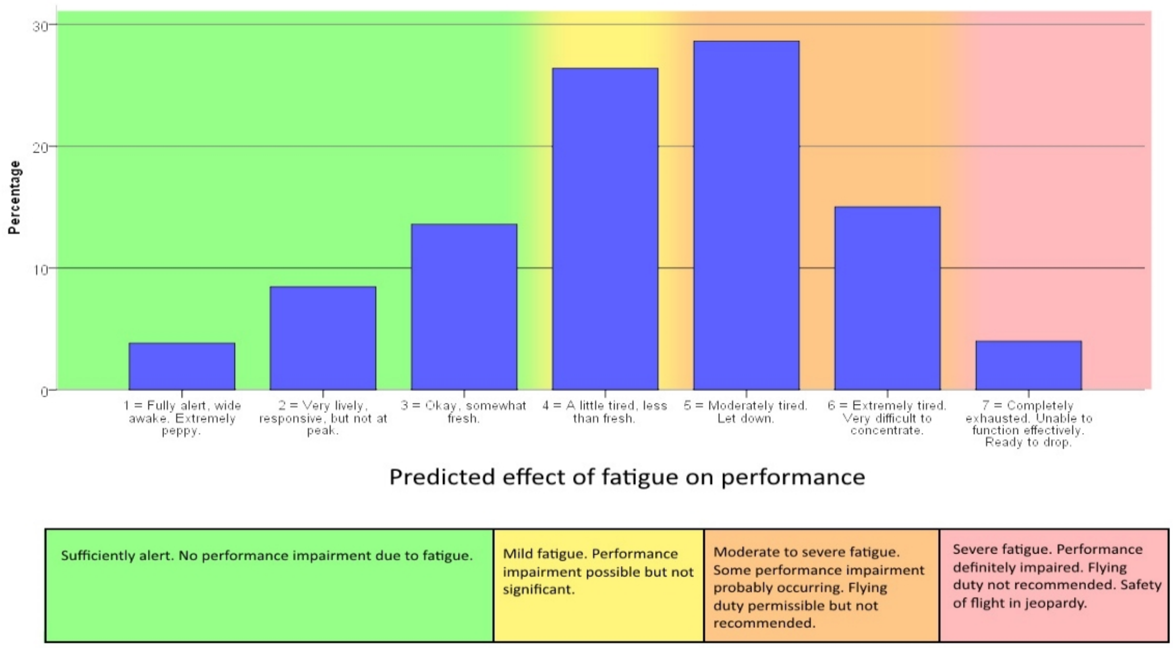
[10] Pilot Flying (PF) and Pilot Monitoring (PM) are procedurally assigned roles with specifically assigned duties at specific stages of a flight. The PF does most of the flying, except in defined circumstances; such as planning for descent, approach and landing. The PM carries out support duties and monitors the PF's actions and aircraft flight path.

Rest obtained

Perceived alertness at the end of the last flight

Around a quarter of pilots indicated they felt sufficiently alert at the end of the last flight. However, using Samn and Perelli (1982) benchmarks, another one quarter (26.4%) of pilots perceived they were experiencing mild fatigue at the end of their last duty, selecting ‘A little tired, less than fresh’. Nearly half (43.6%) perceived they were experiencing moderate to severe fatigue, selecting ‘Moderately tired. Let down’ or ‘Extremely tired. Very difficult to concentrate’, at the end of their duty. Only around five per cent perceived they were experiencing severe fatigue, selecting ‘Completely exhausted. Unable to function effectively. Ready to drop’ at the end of their duty (Figure 8).

Figure 8: Overall self-rated alertness at the end of last flight



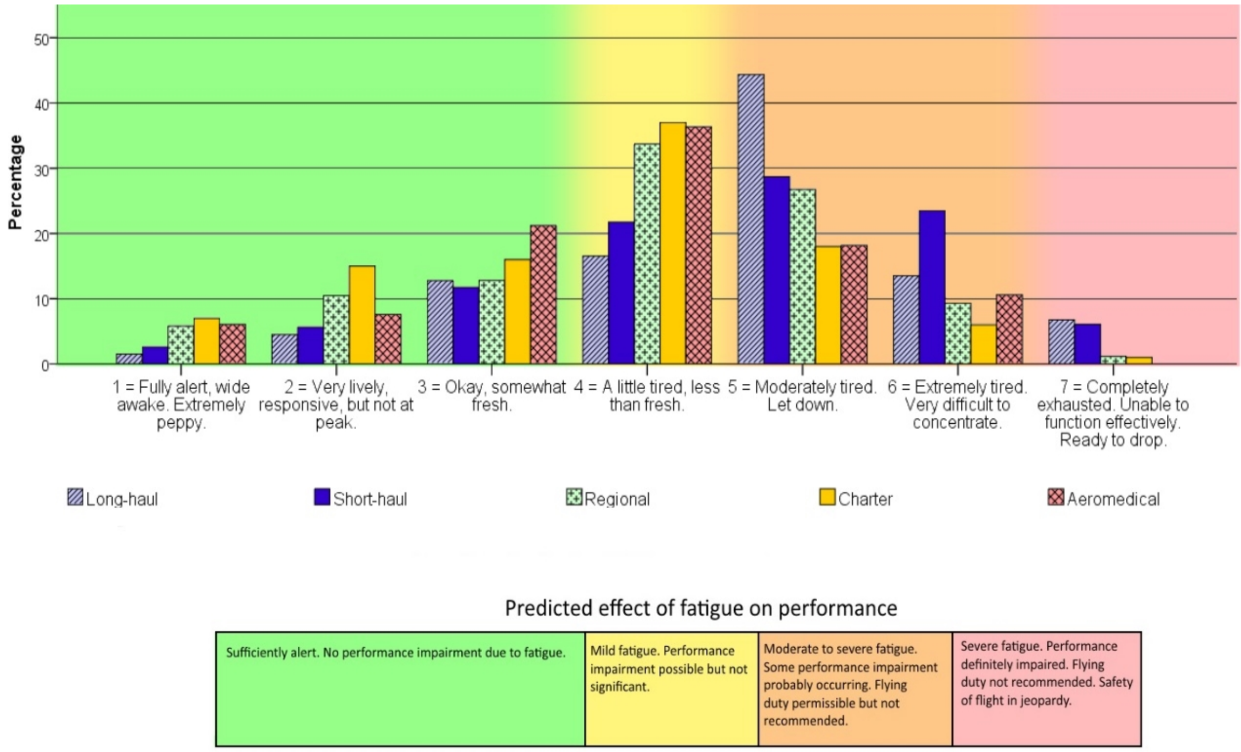
Ratings of alertness distributed by operation type

Around 20 per cent of short-haul and long-haul pilots indicated they were feeling sufficiently alert. Furthermore, around 50 per cent of short-haul and 60 per cent of long-haul pilots indicated they were feeling ‘Moderately tired. Let down’ or ‘Extremely tired. Very difficult to concentrate’ at the end of their last duty. This indicated the pilots were experiencing moderate to severe fatigue (Figure 9). These results were similar to ratings of alertness at the end of duty in Petrilli and others (2006) research on subjective fatigue long-haul pilots where pilots perceived they were feeling ‘moderately tired. Let down’ at the end of their duty.

While around one third of regional, charter and aeromedical pilots reported being sufficiently alert, approximately one third of pilots of in each operation type reported feeling mild fatigue (regional (33.7%), charter (37%), and aeromedical pilots (36.4%)).

In comparison between groups, long-haul, short-haul pilots reported feeling statistically significantly less alert than regional pilots, single pilot charter, and aeromedical pilots ($p<0.05$).

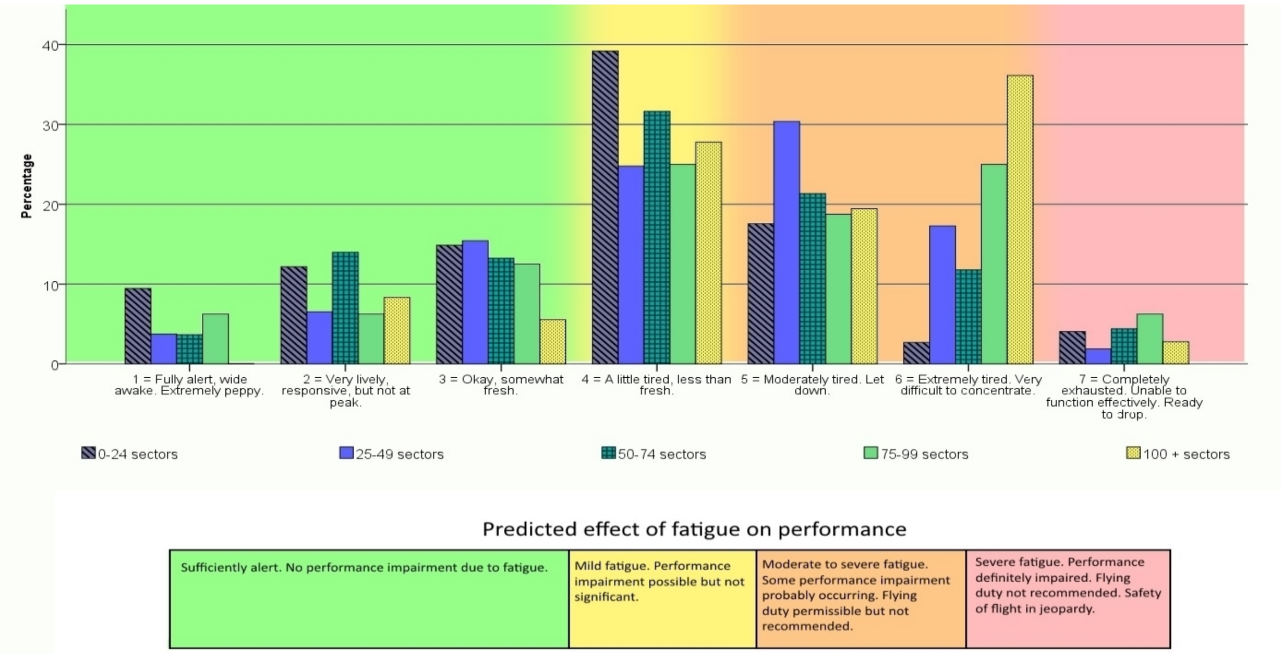
Figure 9: Distribution of alertness ratings at the end of last duty



Ratings of alertness by sectors flown (excluding long-haul pilots)

Pilots who flew 75 sectors or more per month rated their perception of their level of fatigue as ‘Extremely tired. Very difficult to concentrate’ more frequently than other groups (Figure 10).

Figure 10: Alertness after last duty by sectors flown

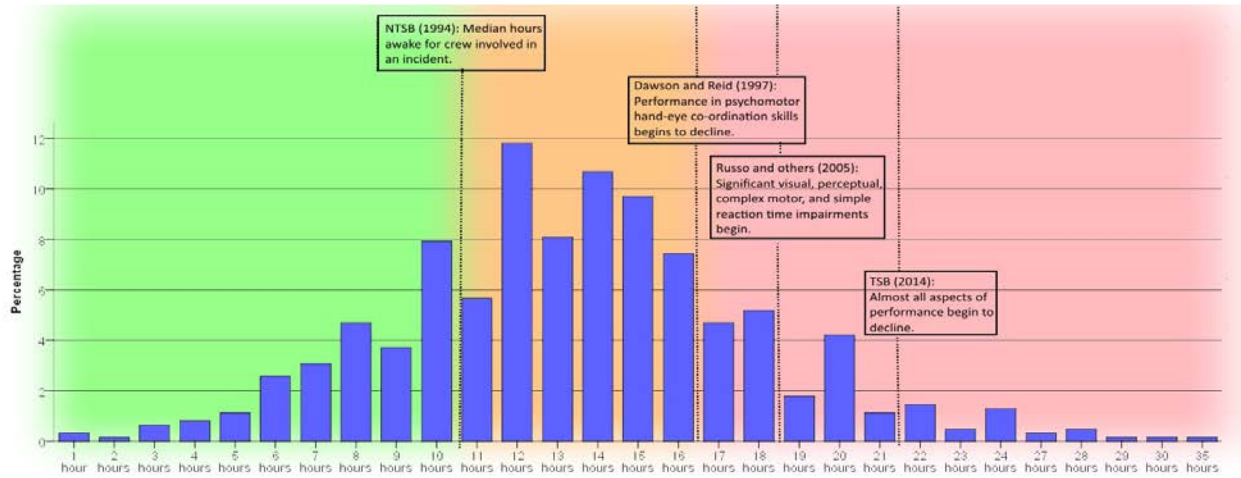


A statistical comparison analysis between groups found pilots who flew 100 sectors or more perceived they felt significantly less alert at the end of duty than pilots who flew 0–24 sectors and 50–74 sectors ($p<0.05$). Pilots who flew 25–49 sectors felt significantly less alert than pilots who flew 0–24 sectors ($p<0.05$).

Hours awake at the end of duty

The average hours awake at the end of their last duty was 13.5 hours (SD = 4.6 hours) (Figure 11). Eighty per cent of pilots reported they were awake less than 17 hours at the end of their last duty. Around 11 per cent of pilots reported they were awake 19 hours or more and around 4 per cent of pilots reported they were awake 22 hours or more. These thresholds are associated with impairments in performance (Russo and others 2005; Transportation Safety Board 2014).

Figure 11: Distribution of hours awake overall



Distribution of hours awake by operation type

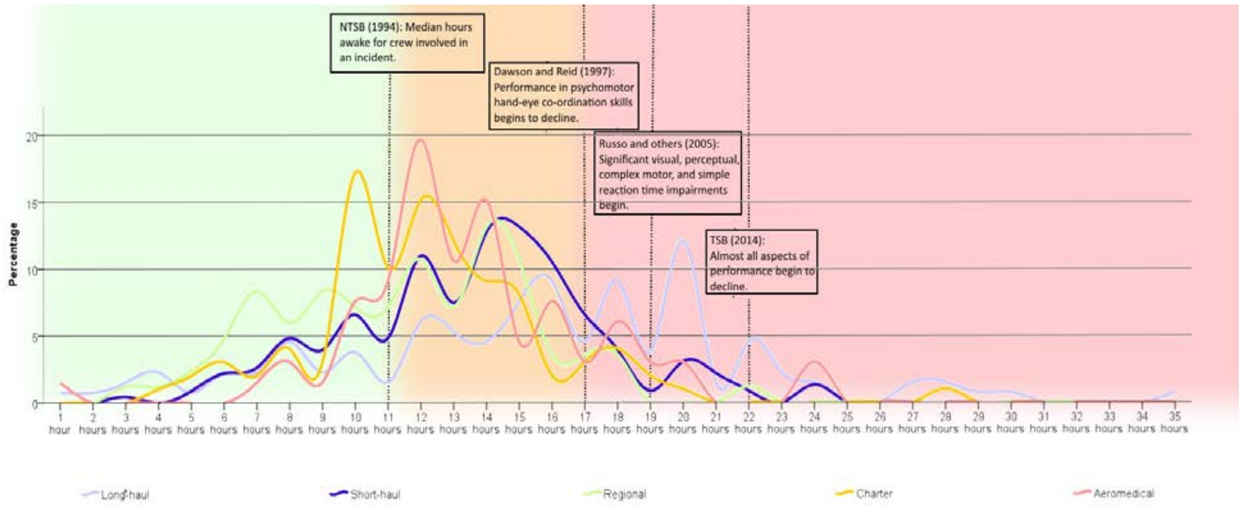
Table 5 below shows the average, median, and standard deviation of hours awake by operation type.

Table 5: Average, median, and standard deviation of hours awake by operation type

	Average	Median	Standard deviation
Long-haul	15.5	16	6.2
Short-haul	13.6	14	3.8
Regional	11.5	12	3.7
Charter	12.1	12	3.6
Aeromedical	13.5	13	3.8
Helicopter	12.2	11.50	5.1

Nearly one third (29.4%) of short-haul and half of long-haul pilots (53.8%) had been awake for 16 hours or more at the end of their last duty. Around half of short-haul (54%) and regional pilots (45.2%) were awake between 12 and 16 hours. Around half of charter pilots (54.6%) were awake between 10 and 13 hours. Around half of aeromedical pilots (45.5%) were awake between 12 and 14 hours (Figure 12).

Figure 12: Distribution of hours awake at the end of their last duty by operation type



Long-haul and short-haul pilots were awake significantly longer than regional pilots, charter, and aeromedical pilots ($p<0.05$). Below is a case study of how extended wakefulness has been identified in an incident.

Case Study: Descent below approach path involving Boeing 777, VH-VPF, Melbourne Airport, Victoria on 15 August 2013

ATSB investigation AO-2013-130

On 15 August 2013, a Boeing 777 aircraft, registered VH-VPF operated by Virgin Australia International Airlines, was conducting a visual approach at Melbourne Airport, Victoria. During the approach and after the waypoint SHEED, the aircraft descended below the approach path to about 500 ft. above ground level. Upon recognising the descent profile error, the captain disengaged the autopilot and flew the aircraft level, re-intercepting the profile and continuing the approach to land.

The ATSB found, due to extended wakefulness, the crew were probably experiencing fatigue at a level that has been demonstrated to affect performance, particularly given the first officer's workload due to training duties. However, fatigue could not be confirmed as contributing to the error in developing the approach profile.

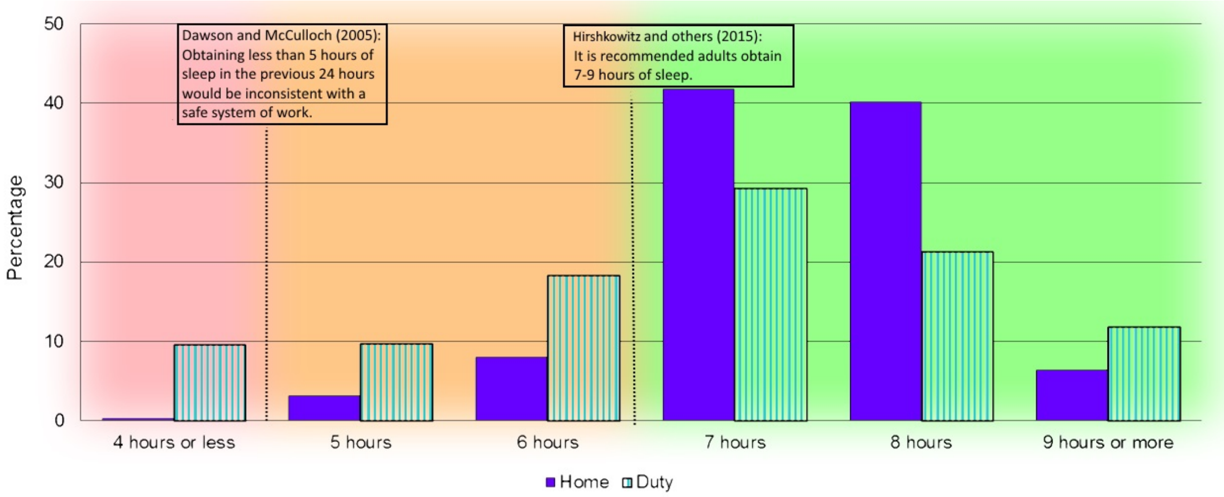
Hours of sleep at home and in the previous 24 hours at the end of duty

The average hours of sleep at home was 7.3 hours (SD = 0.9 hours) overall and the median was 7 hours. The average hours of sleep in the previous 24 hours prior to duty was 6.8 hours (SD = 2.3 hours) and median of 7 hours.

Overall comparison with sleep at home

Around half of pilots reported having 7 to 9 hours of sleep in the previous 24 hours at the end of their last duty, whereas around 90 per cent reported obtaining these hours of sleep at home. Obtaining 7 to 9 hours of sleep a night for adults is recommended in the literature (Hirshkowitz and others, 2015). Around 10 per cent of pilots reported having less than 5 hours of sleep in the previous 24 hours at the end of their last duty (Figure 13). In contrast, less than 1 per cent reported obtaining less than 5 hours of sleep at home. Obtaining less than 5 hours of sleep in the previous 24 hours is believed to be inconsistent with a safe system of work (Dawson and McCulloch, 2005).

Figure 13: Sleep hours in the past 24 hours comparing home and duty



An exact sign test (Appendix B) was used to compare hours of sleep at home by hours of sleep in the previous 24 hours to last duty. There was a statistically significant median decrease in hours of sleep in the previous 24 hours to the end of last duty than sleep at home ($p<0.05$), indicating pilots obtained significantly less sleep when they have flying duties than when they do not.

Distribution of hours of sleep at the end of duty in previous 24 hours by operation type

The average, median, and standard deviation of sleep at the end of duty in the previous 24 hours for each of the operation types are in Table 6 below.

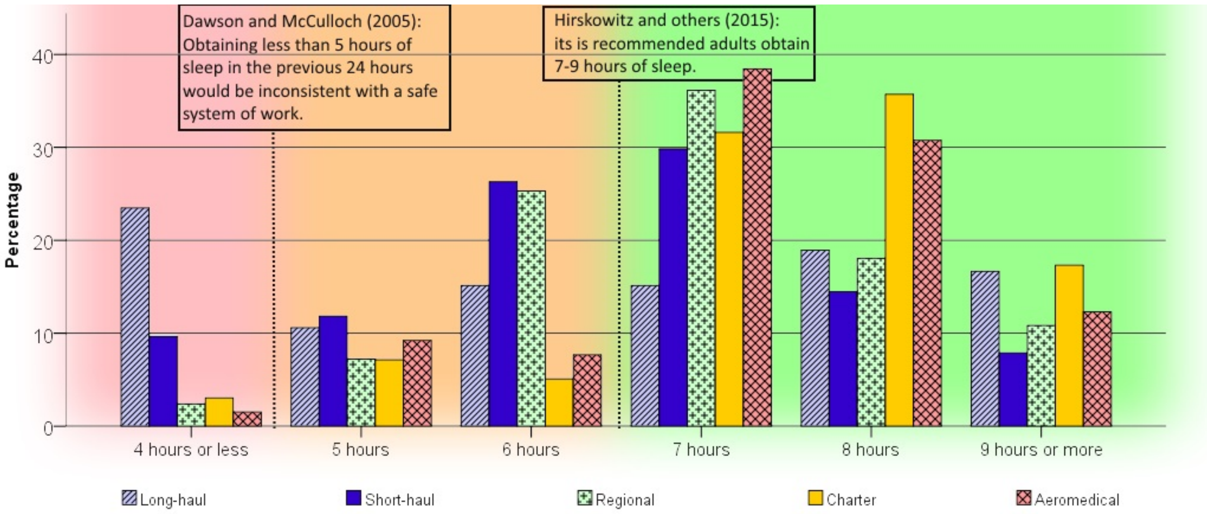
Table 6: Average, median, and standard deviation of hours of sleep in the previous 24 hours by operation type

	Average	Median	Standard deviation
Long-haul	6.3	6.5	2.9
Short-haul	6.5	6.5	2.2
Regional	7.0	7.0	1.5
Charter	7.6	7.5	2.2
Aeromedical	7.2	7.0	1.7
Helicopter	7.7	7.0	2.6

Long-haul pilots' average hours of sleep in the previous 24 hours at the end of duty was 6.3 hours. The average Samn-Perelli score was 5, equal to 'Moderately tired. Let down'. Both these results were equivalent to the data obtained by Petrilli and others (2006).

Around 10 per cent of short-haul pilots and around one quarter of long-haul pilots (23.5%) reported obtaining less than 5 hours of sleep in the previous 24 hours at the end of their last duty. Very few pilots from regional, charter, and aeromedical categories reported having less than 5 hours sleep (Figure 14).

Figure 14: Hours of sleep obtained in the previous 24 hours at the end of their last duty by operation type



Aeromedical and charter pilots were found to obtain significantly more hours of sleep in the previous 24 hours than long-haul and short-haul pilots ($p<0.05$).

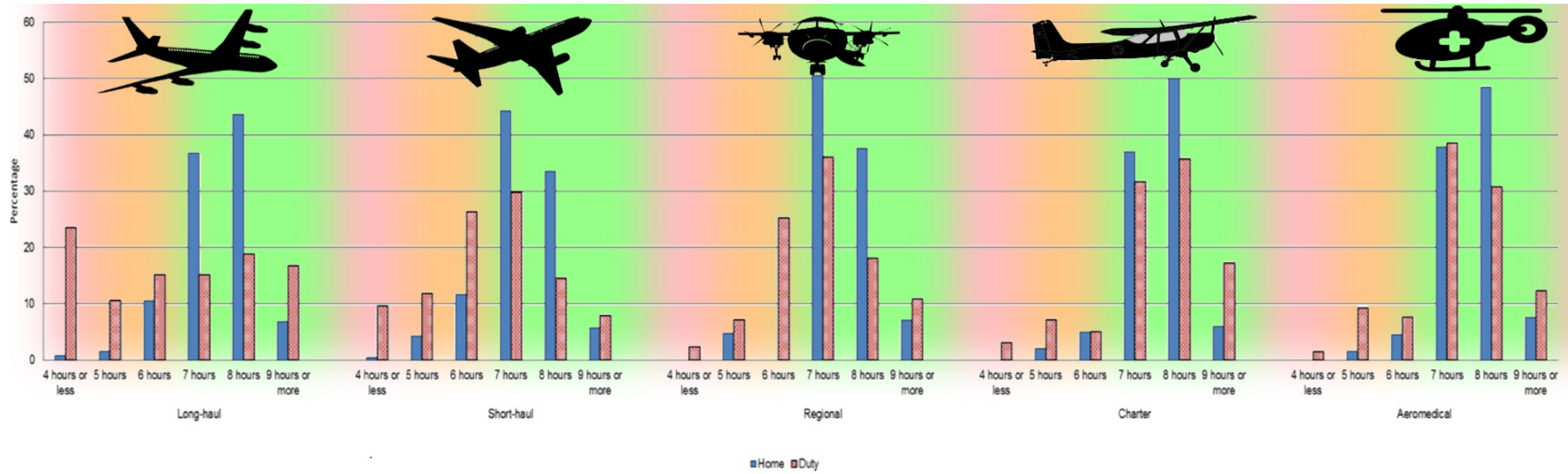
Comparison to sleep at home by operation type

The differences in hours of sleep at home and sleep obtained in the previous 24 hours at the end of pilots' last duty were reflected in each operation type. Overall, less than 1 per cent of pilots in all operation types reported obtaining less than 5 hours of sleep at home. However, around 10 per cent of short-haul pilots and around one quarter of long-haul pilots (23.5%) reported obtaining these hours in the previous 24 hours at the end of their last duty (Figure 15).

Between 80 and 90 per cent of pilots of all operation types reported obtaining 7 to 9 hours of sleep at home. However, only around one third (35.6%) of long-haul pilots, nearly half of short-haul (41.6%), over half of regional (57.8%), and two thirds of charter (69.3%) and aeromedical pilots (64.6%) reported obtaining 7 to 9 hours of sleep in the previous 24 hours at the end of their last duty.

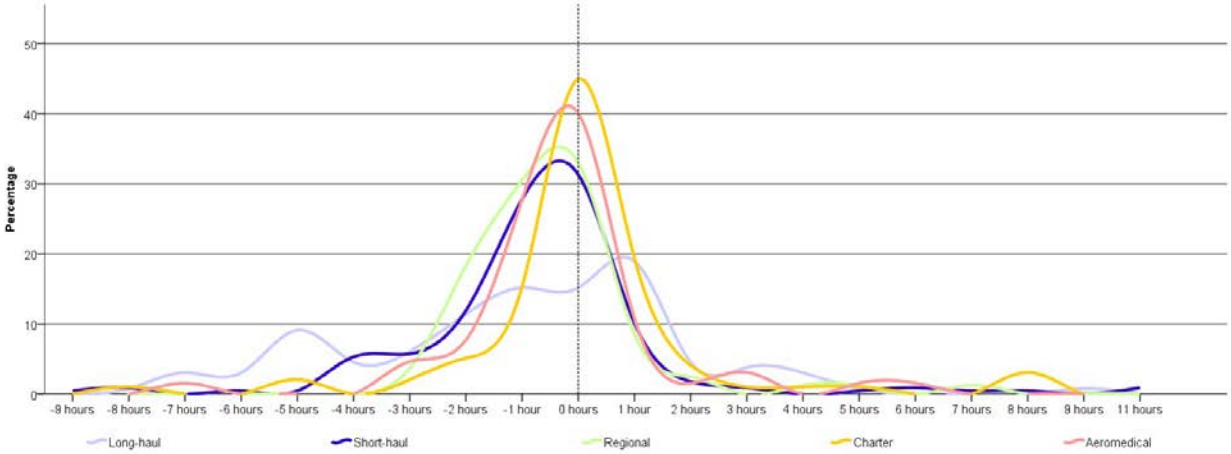
An exact sign test was used to compare hours of sleep at home by hours of sleep in the previous 24 hours to last duty by operation type. There was a significant difference in the hours of sleep obtained at home and in the 24 hours prior to duty in all operation types ($p<0.05$).

Figure 15: Comparison of normal sleep at home and sleep prior to the end of the last duty in the previous 24 hours by operation type



Half of long-haul and short-haul pilots reported obtaining fewer hours of sleep prior to duty compared with sleep at home (Figure 16). In contrast, nearly half of charter and aeromedical pilots reported obtaining the same amount of sleep at home and prior to the end of duty in the previous 24 hours. Below is a case study where sleep obtained has been identified as a factor contributing to the incident.

Figure 16: Distribution of differences in sleep obtained at home compared with the previous 24 hours at the end of their duty by operation group



Case Study: Stickshaker activation, Boeing 717-200, VH-NXE, Alice Springs, NT, 18 September 2008

ATSB investigation AO-2008-064

On 18 September 2008, a Boeing Company 717-200, registered VH-NXE, was being operated on a scheduled passenger flight from Cairns, Queensland to Alice Springs, Northern Territory. During the manually-flown visual approach by the captain at Alice Springs Aerodrome, the stickshaker activated. The pilot flying lowered the nose while continuing the turn onto the final approach path. The stickshaker activated again before the flight crew stabilised the approach to within the operator's criteria and landed without further incident.

The investigation also found that the captain’s judgement and monitoring abilities were probably adversely affected by personal and work stress and associated fatigue, although the duty roster met the necessary standards. The captain reported obtaining around 4 hours of sleep a night while staying in temporary accommodation, and reported feeling drowsy during the day between 1300 and 1500. Pilots operating within flight and duty time limitations can still experience fatigue. Responsibility for adequate flight crew wellbeing before flight rests with both operators and their pilots.

Hours of sleep in the previous 48 hours at the end of duty

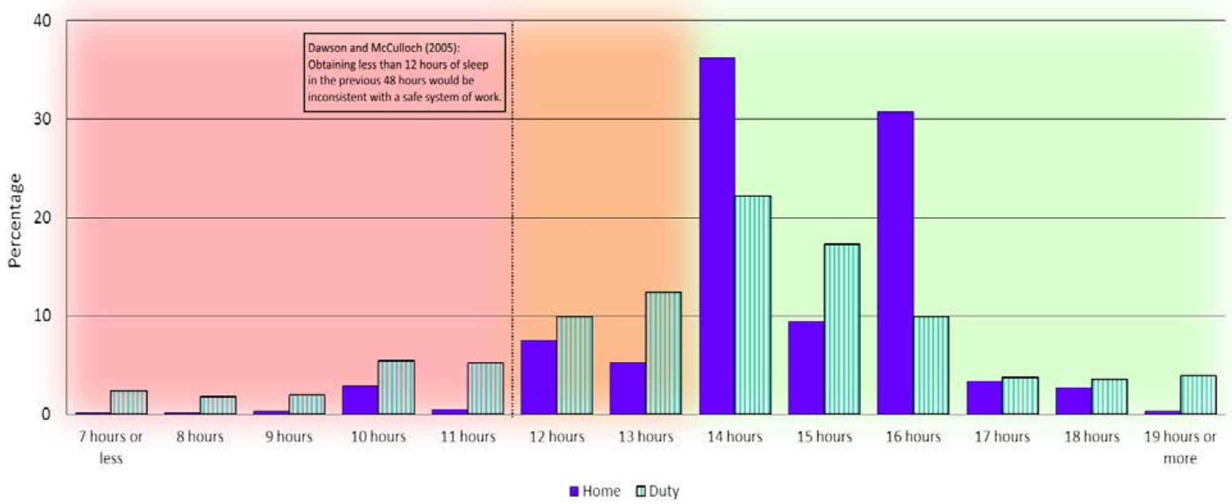
The average number of hours of sleep in the previous 48 hours at the end of their last duty was 13.8 hours (SD = 3.2) and the median was 14 hours (Figure 17).

Overall comparison with sleep at home

Around half (47.3%) of pilots reported obtaining between 14 and 16 hours of sleep in the previous 48 hours at the end of duty, whereas three quarters (76.6%) of pilots reported obtaining these hours of sleep at home. Around 17 per cent of pilots reported having less than 12 hours of sleep in the previous 48 hours, with less than 5 per cent of pilots reported obtaining less than 12 hours of sleep in the same period. Obtaining less than 12 hours of sleep in the previous 48 hours is believed to be inconsistent with a safe system of work (Dawson and McCulloch, 2005).

An exact sign test found pilots reported obtaining significantly less sleep in the previous 48 hours of duty compared with sleep at home ($p<0.05$).

Figure 17: Comparison of hours of sleep obtained at home and end of duty



Distribution of hours of sleep in the previous 48 hours by operation type

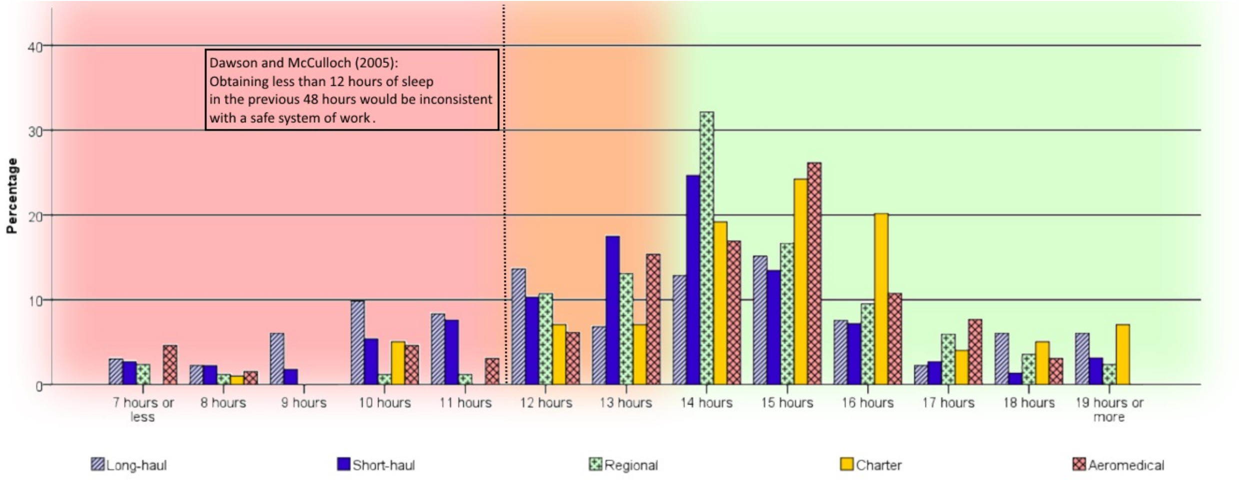
The average, median, and standard deviation of hours of sleep in the previous 48 hours at the end of their last duty by operation type are shown in Table 7.

Table 7: The average, median, and standard deviation of hours of sleep in the previous 48 hours by operation type

	Average	Median	Standard deviation
Long-haul	13.3	13.3	3.5
Short-haul	13.4	13.5	3.2
Regional	14.1	14.0	2.3
Charter	15.1	15.0	3.3
Aeromedical	13.8	14.0	2.6
Helicopter	14.2	14.0	1.7

Charter pilots reported more hours of sleep in the previous 48 hours of duty than long-haul and short-haul pilots ($p<0.05$) (Figure 18).

Figure 18: Distribution of sleep hours obtained in the previous 48 hours by operation type



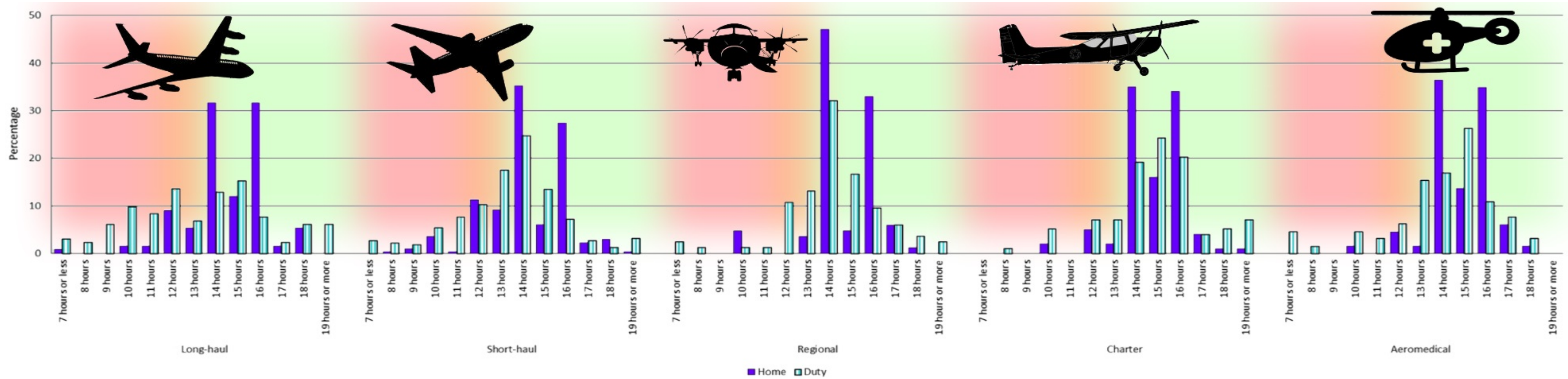
Comparison with sleep at home

A similar pattern was found when comparing between operation types (Figure 19). Less than 5 per cent of all pilots reported obtaining less than 12 hours of sleep at home. Nearly 20 per cent of short-haul and 30 per cent of long-haul pilots reported obtaining less than 12 hours of sleep in the previous 48 hours at the end of duty. Only around 6 per cent of regional, charter, and aeromedical pilots reported obtained less than 12 hours in this period.

Around three quarters of all pilots reported obtaining between 14 and 16 hours of sleep at home. However, only around one third of long-haul (33.8%) and short-haul pilots (41.3%) reported obtaining these hours in the previous 48 hours at the end of duty.

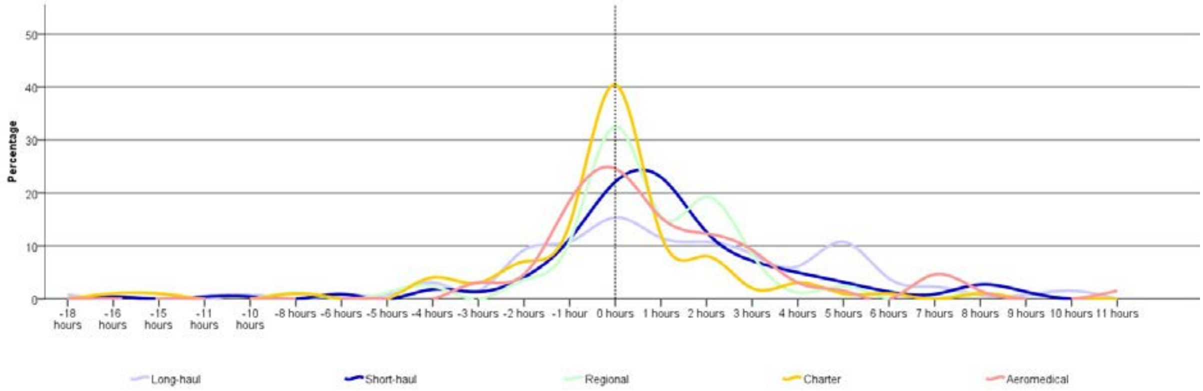
Long-haul pilots, short-haul, regional, and aeromedical pilots, reported obtaining significantly less sleep in the 48 hours prior to the end of duty than at home ($p<0.05$).

Figure 19: Comparison of hours of sleep obtained at home and prior to the end of their last duty in the previous 48 hours by operation type



Over one quarter (27.8%) of long-haul pilots and one fifth of short-haul pilots (21.1%) had some sleep loss in the 48 hours prior to duty compared with sleep normally obtained at home (Figure 20). Around one third of regional (32.5%) and charter pilots (40.4%) have the same amount of sleep at home and in the 48 hours prior to duty.

Figure 20: Distribution of differences in sleep obtained at home compared with duty in the previous 48 hours by operation type



Sleep obtained and ratings of alertness

Pilots who reported obtaining 7 hours or less of sleep in the previous 48 hours had a median response of 6, representing feeling ‘Extremely tired, very difficult to concentrate’. The pilots who reported obtaining less than 7 hours of sleep in the previous 24 hours or less than 14 hours in the previous 48 hours had median response of 5, representing feeling ‘Moderately tired. Let down’. Pilots who reported having 7 hours or more of sleep in the previous 24 hours or 14 hours or more in the previous 48 hours had a median response of 4, representing feeling ‘A little tired, less than fresh’.

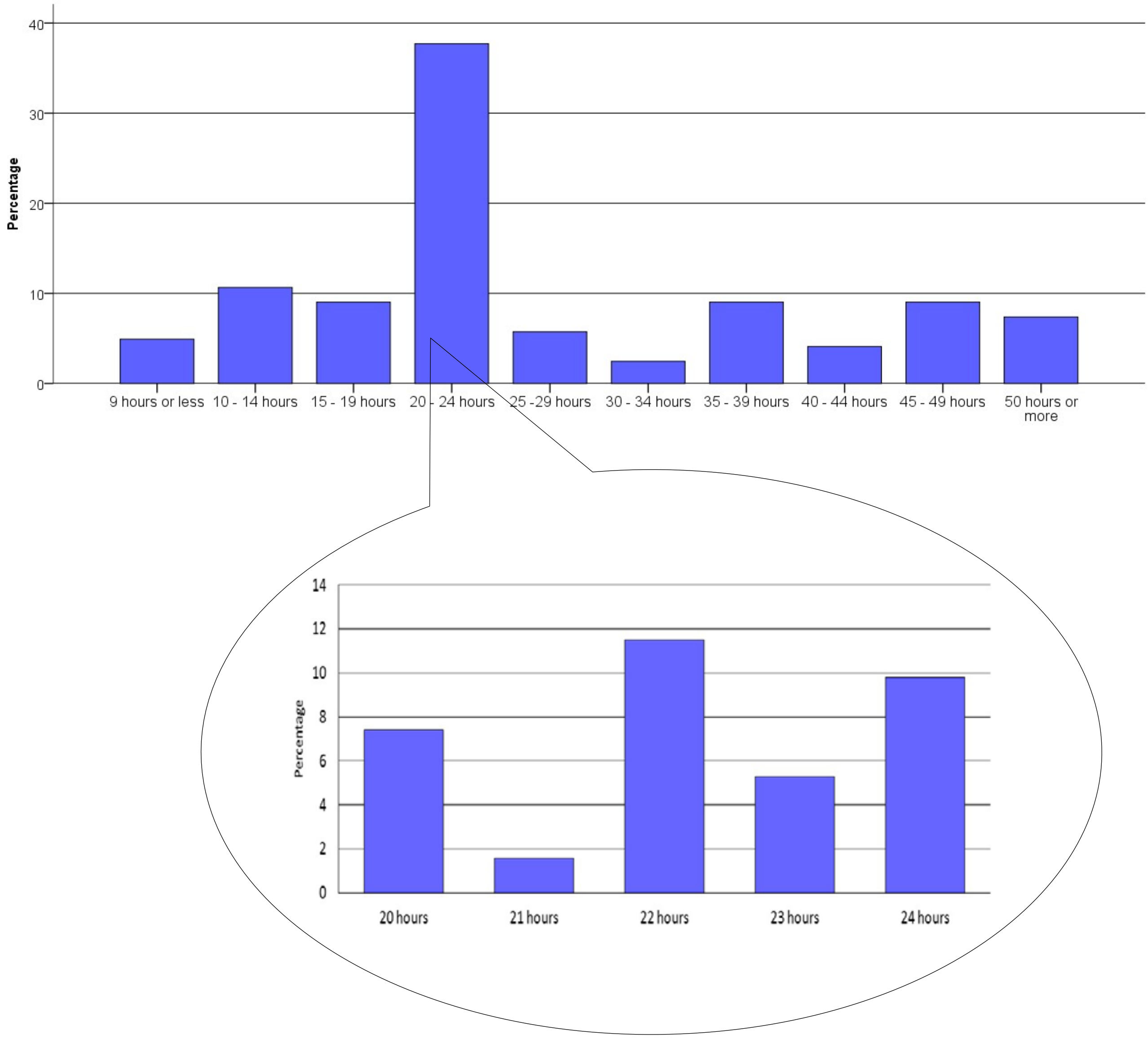
A similar pattern existed for hours awake, where pilots who reported being awake for 14 hours or less at the end of their previous duty had a median of 4, representing feeling ‘A little tired, less than fresh’, and pilots who reported being awake 15 hours or more had a median of 5, representing feeling ‘Moderately tired. Let down’.

Non-duty hours during layover

Long-haul

The most common layover time, among long-haul pilots, was 20 to 24 hours, with a median number of non-duty hours during a layover of 23 hours (Figure 21). Nearly 80 per cent (79.5%) had a layover less than 40 hours, with 5 per cent reporting a layover of 8 hours or less.

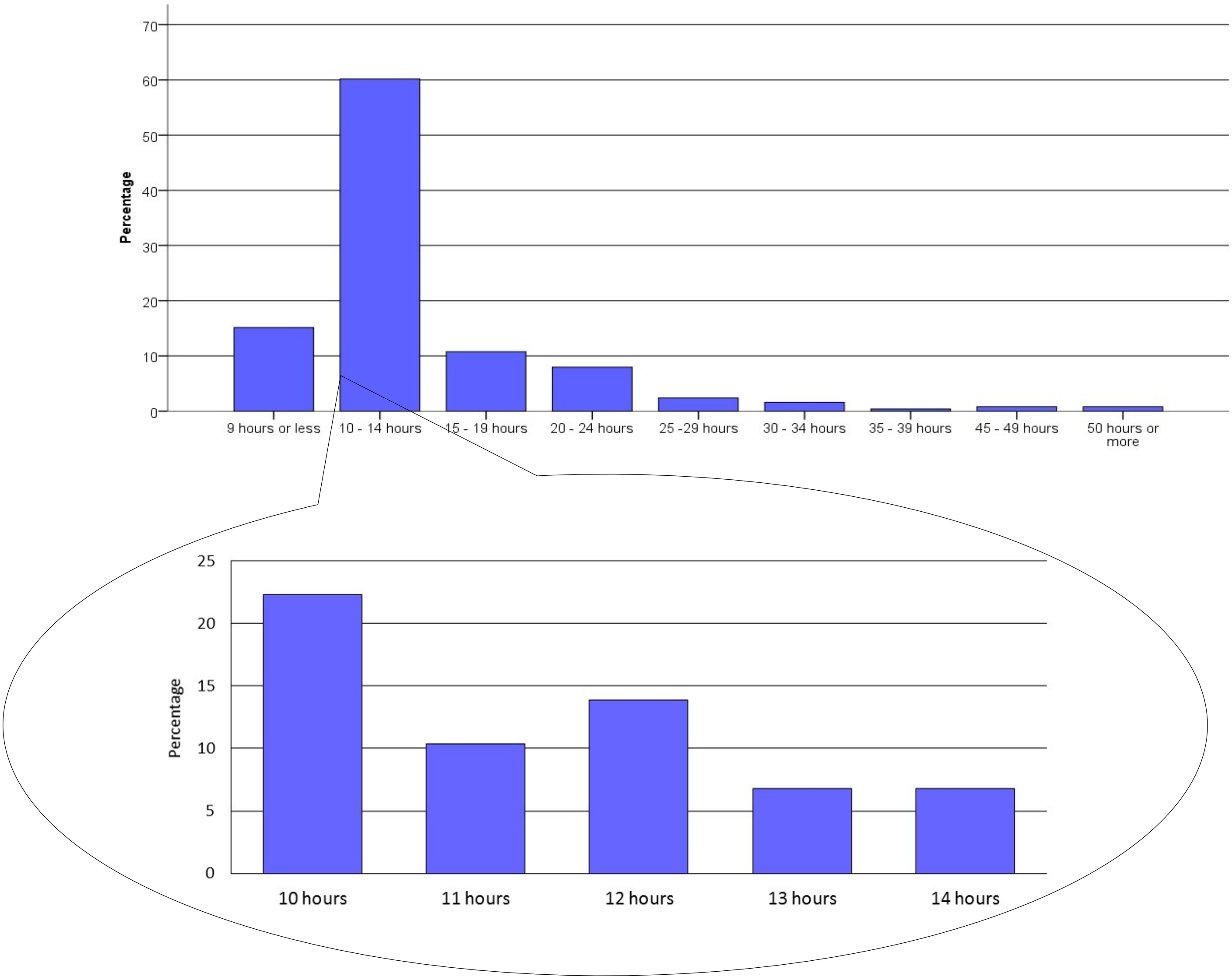
Figure 21: Long-haul pilots' non-duty hours during a layover



Short-haul

The most common layover time, among short-haul pilots, was 10 to 14 hours, with a median of 12 hours (Figure 22). Around 80 per cent of pilots reported having 10 hours or more of non-duty time during their last layover. Seven per cent reported having eight hours or less.

Figure 22: Short-haul pilots' non-duty hours during layover



Distribution of non-duty hours by operation type

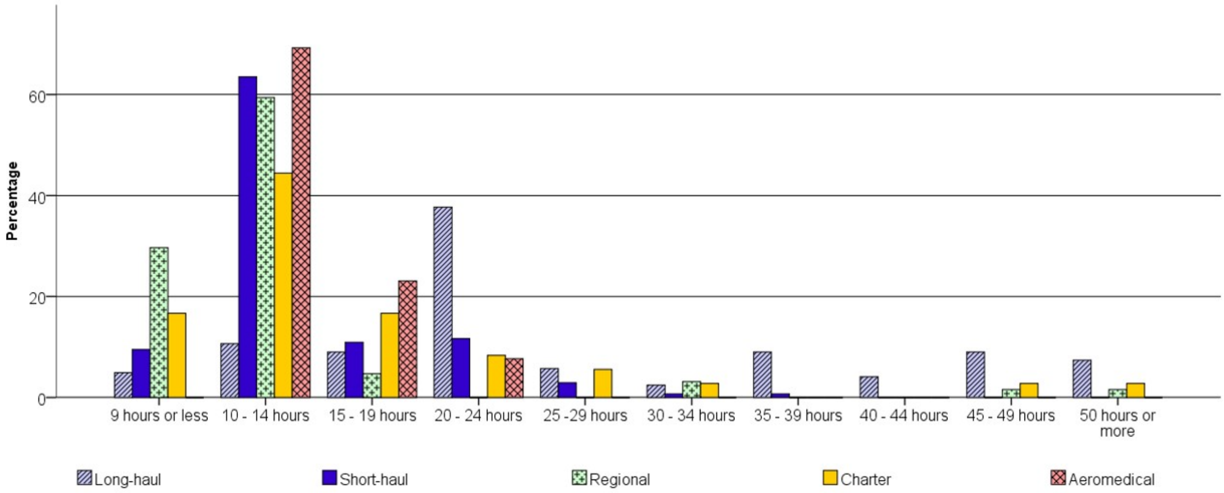
The mode and median of non-duty hours during a layover by operation type are in Table 8 below.

Table 8: The mode and median of non-duty hours during a layover by operation type

	Mode	Median
Short-haul	11	12
Regional	10	10
Charter	12	13.8
Aeromedical	10	12

Short-haul pilots had significantly longer layovers than regional pilots, with charter pilots having the longest layovers of the two operation groups. Long-haul pilots had significantly longer layovers than all other operation types ($p<0.05$) (Figure 23).

Figure 23: Distribution of non-duty hours during a layover by operation type

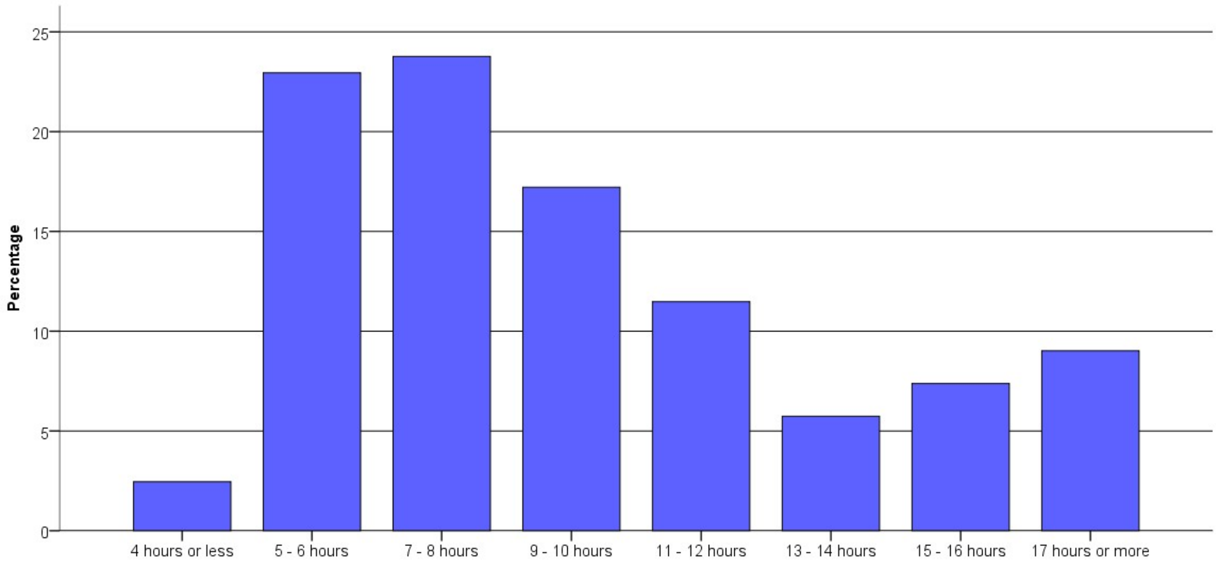


Hours of sleep during layover

Long-haul

For long-haul pilots, nearly half (46.7%) reported obtaining between 5 and 8 hours of sleep during their last layover. The median number of hours was 8.5 hours (Figure 24). Nearly three quarters (72.1%) of long-haul pilots reported obtaining 7 or more hours of sleep.

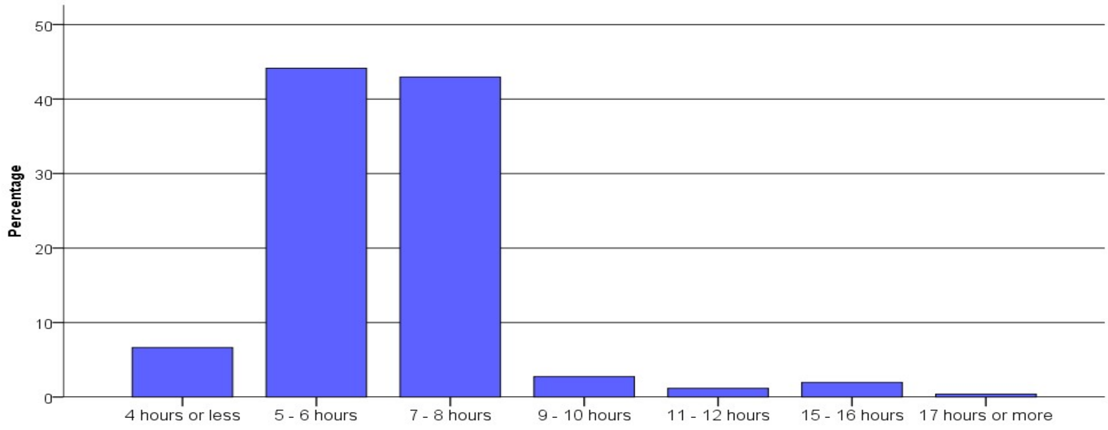
Figure 24: Long-haul pilots' hours of sleep during a layover



Short-haul

The most common number of layover hours for short-haul pilots was 6 hours, with the median layover also being 6 hours. Under half (44.1%) reported obtaining 6 hours or more of sleep on their last layover (Figure 25).

Figure 25: Short-haul pilots' hours of sleep during a layover



Distribution of layover sleep hours by operation type

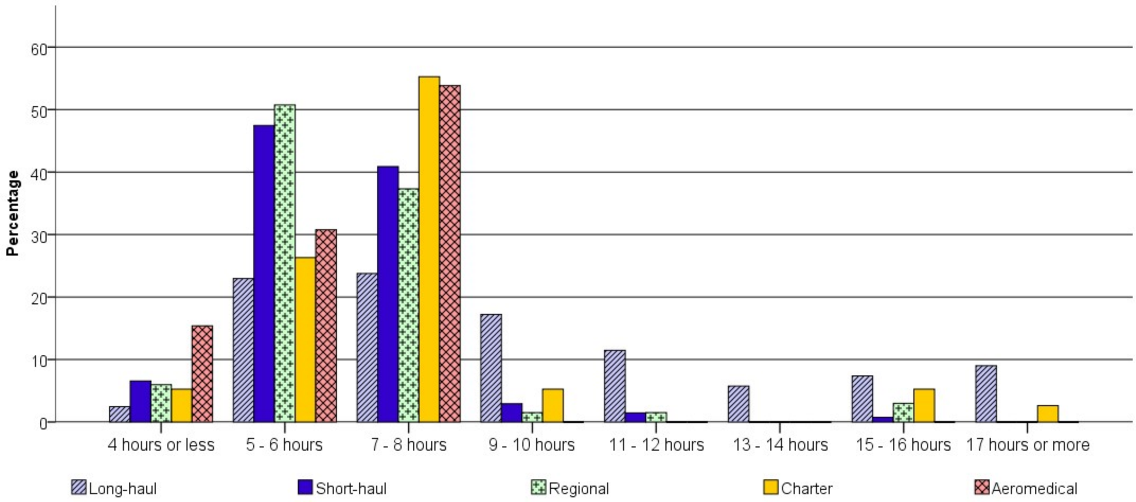
The mode and median of sleep hours during a layover by operation type are in Table 9 below.

Table 9: The mode and median of layover sleep hours by operation type

	Mode	Median
Long-haul	6.0	8.5
Short-haul	6.0	6.0
Regional	8.0	6.0
Charter	8.0	7.5
Aeromedical	7.0	6.5

Over half of short-haul (54%) and regional pilots (56.7%) reported having 6 hours or less of sleep during their last layover. Long-haul pilots reported obtaining significantly more hours of sleep compared with short-haul and regional pilots ($p<0.05$) (Figure 26).

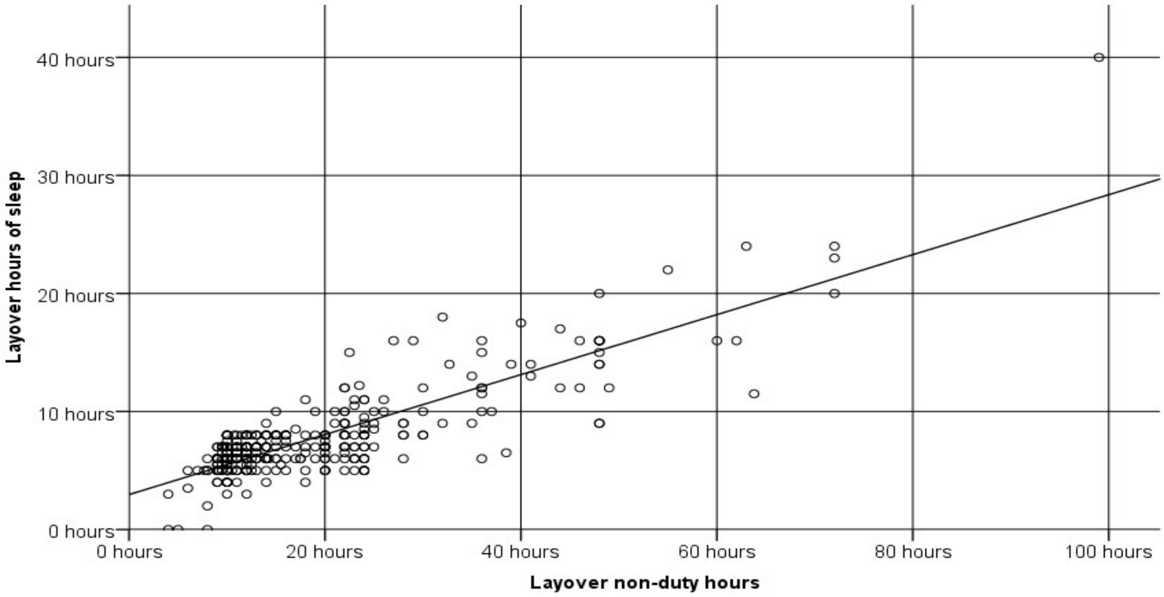
Figure 26: Distribution of layover sleep hours by operation type



Distribution of layover non-duty hours and layover hours of sleep

Figure 27 shows a scatterplot distribution of layover non-duty hours and layover hours of sleep. This shows that when given the opportunity of longer layovers, pilots were using the time to obtain more sleep.

Figure 27: Scatterplot of layover non-duty hours by layover hours of sleep



The case study below provides an example of how duty hours can affect hours of sleep, and subsequently fatigue.

Case Study: Navigation event involving Embraer E170 VH-ANO, 232 km north-west of McArthur River Mine, NT on 10 January 2013

[ATSB investigation AO-2013-010]

On 10 January 2013, the crew of an Embraer Regional Jet 170 (E170), registered VH-ANO and operated by Airnorth, were flying from Darwin to McArthur River Mine, Northern Territory. Shortly after passing navigational waypoint SNOOD, 125 NM (232 km) north-west of McArthur River Mine, the aircraft's flight path started diverging from its planned track. The problem was identified by air traffic control and the crew were advised. The aircraft was re-cleared direct to the initial approach fix and continued to McArthur River Mine.

Although it could not be concluded as contributing to the crew's errors, the ATSB also found that, due to restricted sleep in the previous 24 hours, the crew probably experienced a level of fatigue known to have a demonstrated effect on performance. The captain reported obtaining 5 hours of sleep and the first officer reported having 4 hours of sleep in the previous night.

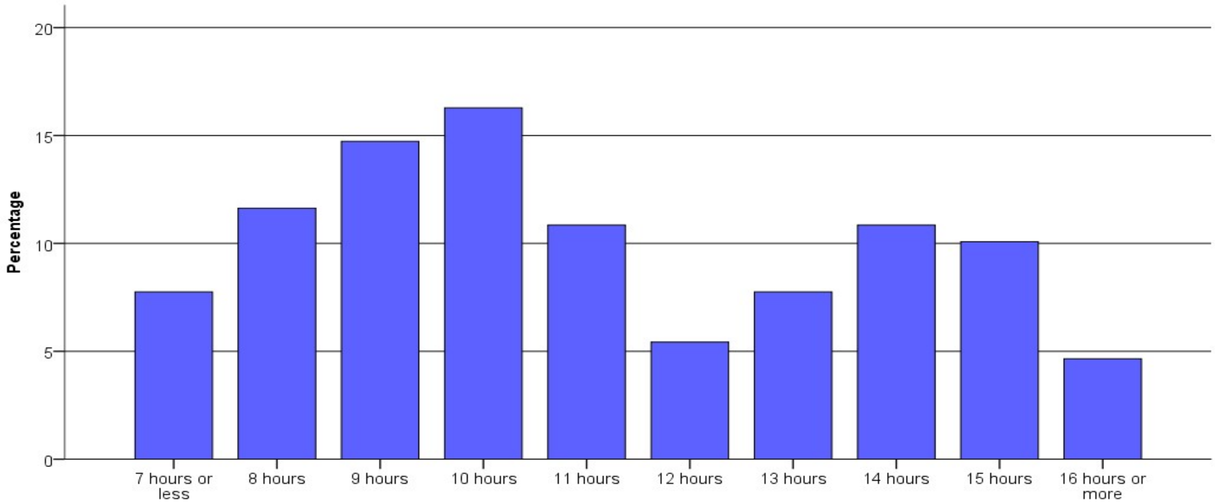
Although the operator's rostering practices were consistent with the existing regulatory requirements, it had limited processes in place to proactively manage its flight crew rosters and ensure that fatigue risk due to restricted sleep was effectively minimised. In the day prior to the occurrence, the crew had 9 hours of time free of duty. It is recognised by regulatory authorities, such as CASA that duty free periods should allow for at least an 8-hour sleep opportunity, as well as time to attend to personal requirements and commuting. This would require a minimum time free of duty of 10 hours.

Long-haul flight time and rest

Flight time

The most commonly reported long-haul flight time was 10 hours and the median was 10.5 hours (Figure 28).

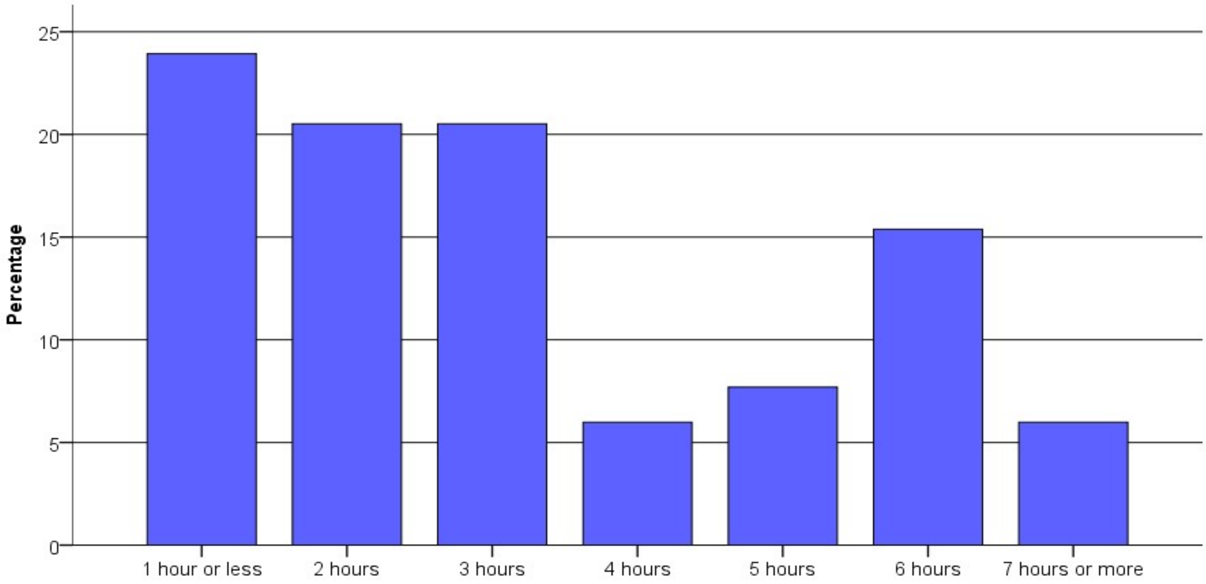
Figure 28: Long-haul flight time



Hours of rest during flight

Long-haul pilots reported the average number of hours' rest during their flight was 3.1 hours with a median of 2.6 hours. Around 15 per cent of pilots responded that they had no hours of rest (Figure 29).

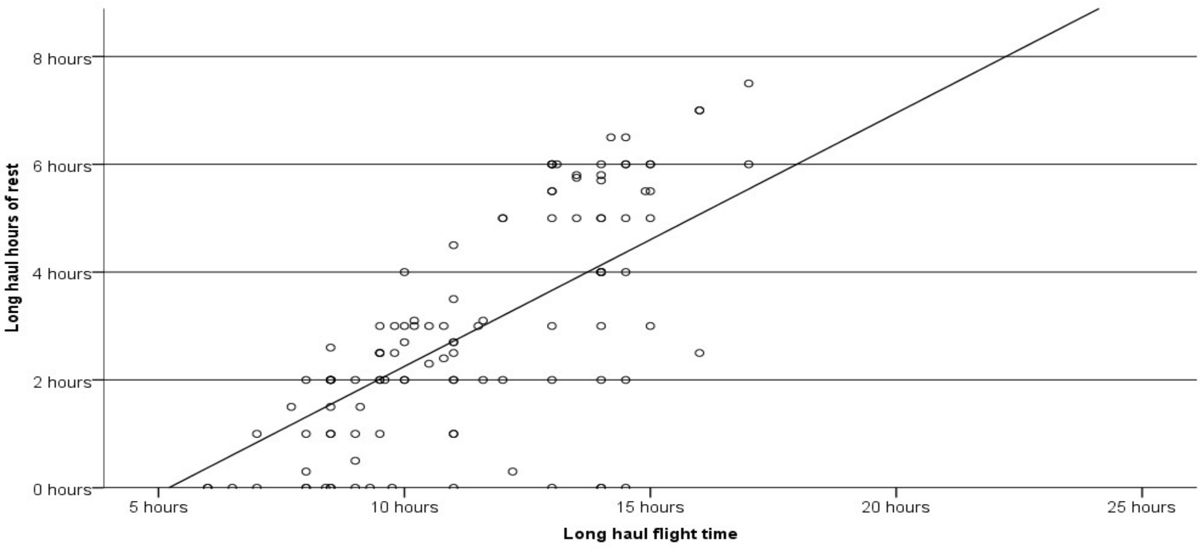
Figure 29: Long-haul hours of rest during their last flight



Distribution of long-haul flight time and long-haul hours of rest

Figure 30 shows the distribution of long-haul flight time and hours of rest. Outliers have been removed. This showed that longer flights generally resulted in more rest during the flight. However, a small percentage of pilots who reported their last long-haul flight was between 10 and 14 hours, reported they had no rest on the flight.

Figure 30: Scatterplot of the distribution of long-haul flight time and hours of rest

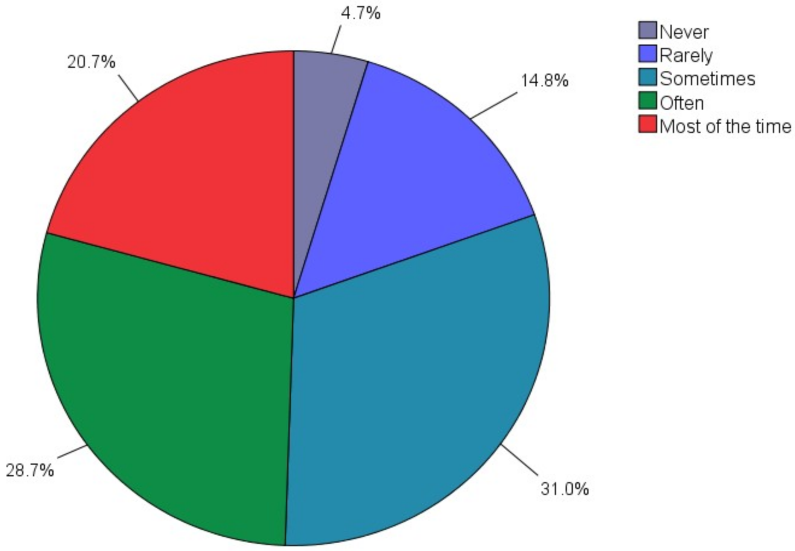


Rest opportunity

Number of times a duty was completed on a stand-by day

Respondents who answered with 'not applicable' were removed from the analysis, leaving a sample of 574 for this question. Almost half of those pilots (49.4%) who answered the questions, indicated they had 'often' or 'most of the time' completed a duty on a stand-by day in the past 12 months (Figure 31).

Figure 31: Overall responses to the number of times a duty was completed on a stand-by day.

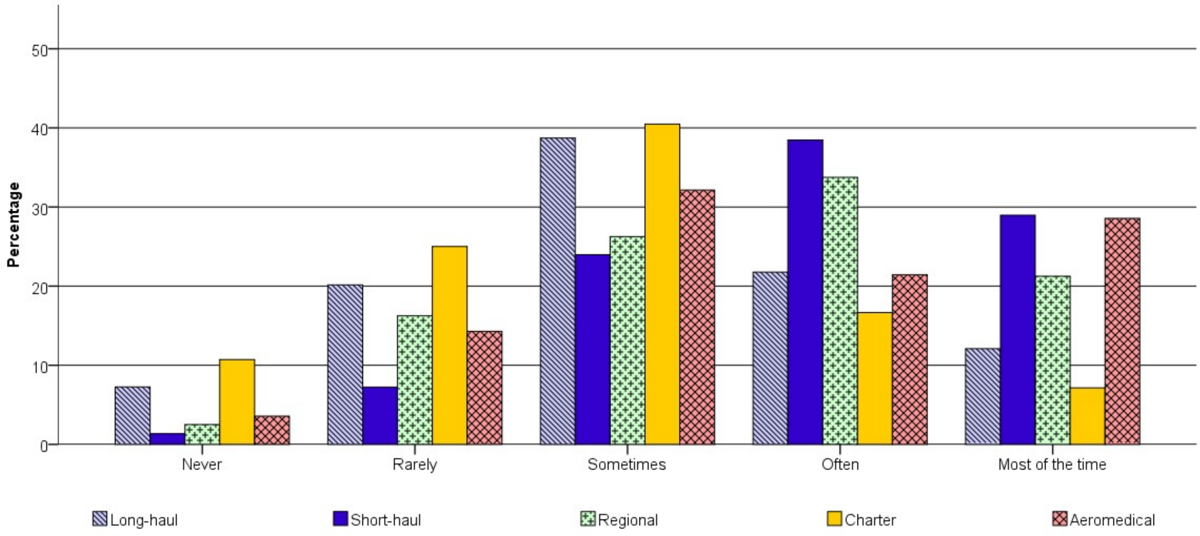


Distribution of completing duty on stand-by days by operation type

Half of aeromedical pilots (49.6%) and regional pilots (55.1%), and around two thirds of short-haul pilots (67.9%), indicated they 'often' or 'most of the time' completed a duty on a stand-by day (Figure 32). In addition, nearly a third of short-haul and aeromedical pilots indicated that they completed a duty on a stand-by day 'most of the time' (29% and 28.6% respectively).

Aeromedical pilots, short-haul, and regional pilots reported completing duties significantly more often on stand-by days than charter and long-haul pilots ($p<0.05$).

Figure 32: Number of times a duty was completed on a stand-by day in the past 12 months by operation

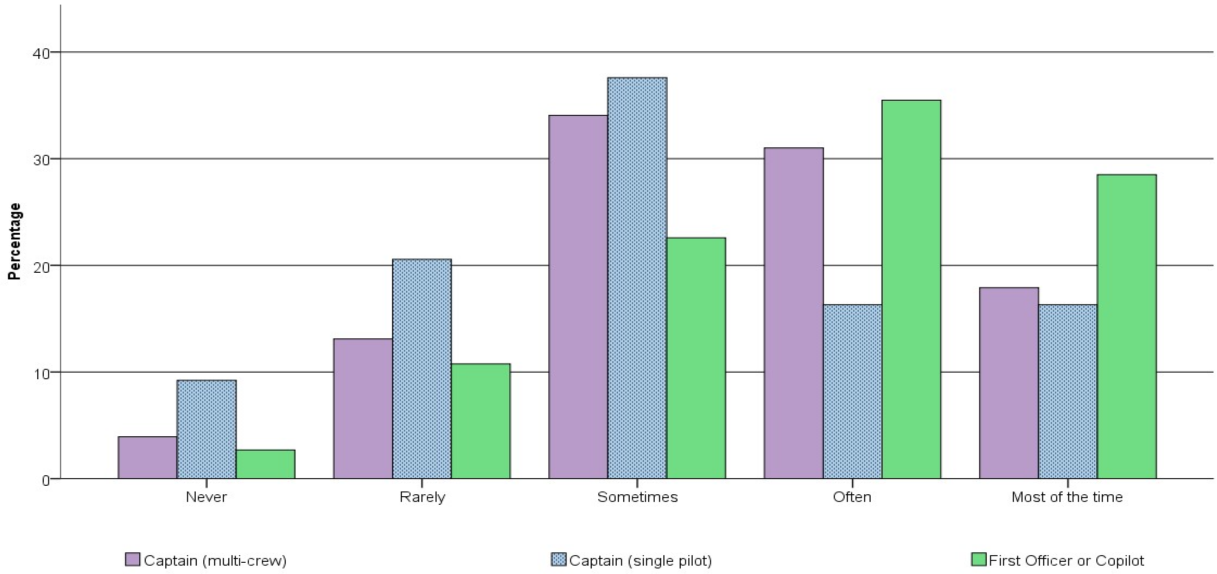


Distribution of completion of duty on stand-by day by role

Around two thirds of first officers (64%) and half of captains who fly multi-crew operations (48.9%) reported they 'often' or 'most of the time' had completed a duty on a stand-by day in the previous 12 months (Figure 33).

First officers reported completing duties on a stand-by day significantly more often than captains who flew multi-crew and single pilot operations. Captains who flew multi-crew operations also reported completing duties on a stand-by day significantly more than captains who flew single pilot operations ($p<0.05$).

Figure 33: Number of times a duty was completed on a stand-by day in the past 12 months by role

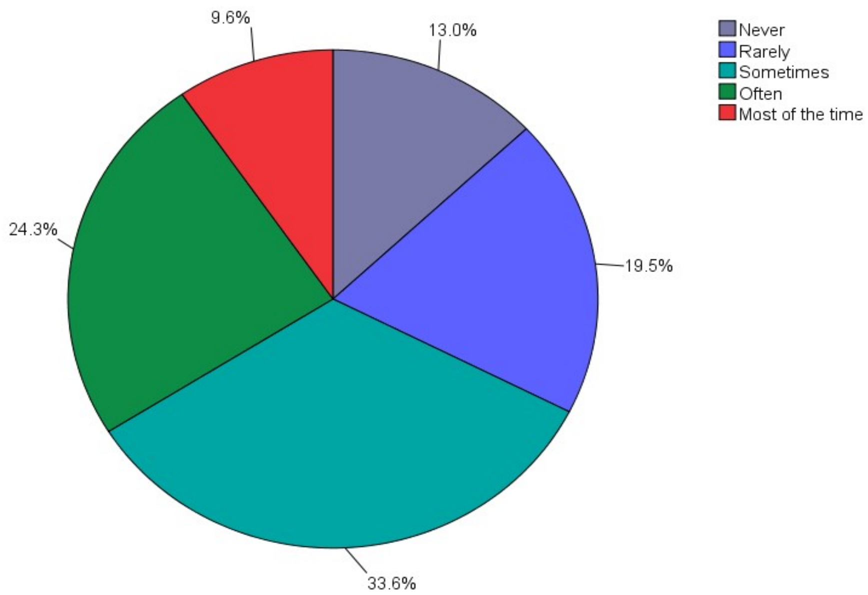


Rest period too short between scheduled duties

In the 12 month period, around one third (33.9%) of pilots indicated the rest period between duties was too short to obtain adequate rest 'often' or 'most of the time'. However another third of pilots indicated that the rest period between duties was 'never' or 'rarely' too short (Figure 34). A selection of pilots made the following comments about rest periods when asked about safety concerns in aviation:

> Rest periods planned to minimums at home base, when not absolutely necessary, e.g. 12 hours and sometime reduced to 10 hours sign off to sign on does not allow for average travelling time to and from work the extra time off duty when most get to work earlier than sign on, 15 mins sign off after brakes parked is often not enough to cover the time it takes to leave work after completion of the flight. These and others add up to an erosion of quality rest time left available.
>
> Fatigue in short-haul operations. Very long days with minimum rest and travel times to and from the airport.
>
> Minimum rest periods are not long enough, need time to wind down after being so alert. It takes time to get proper QUALITY food and then get QUALITY sleep. This never happens due to time in transit and then finding food and actually getting to sleep all takes time. Humans are not robots.

Figure 34: Overall distribution of rest period being too short between duties



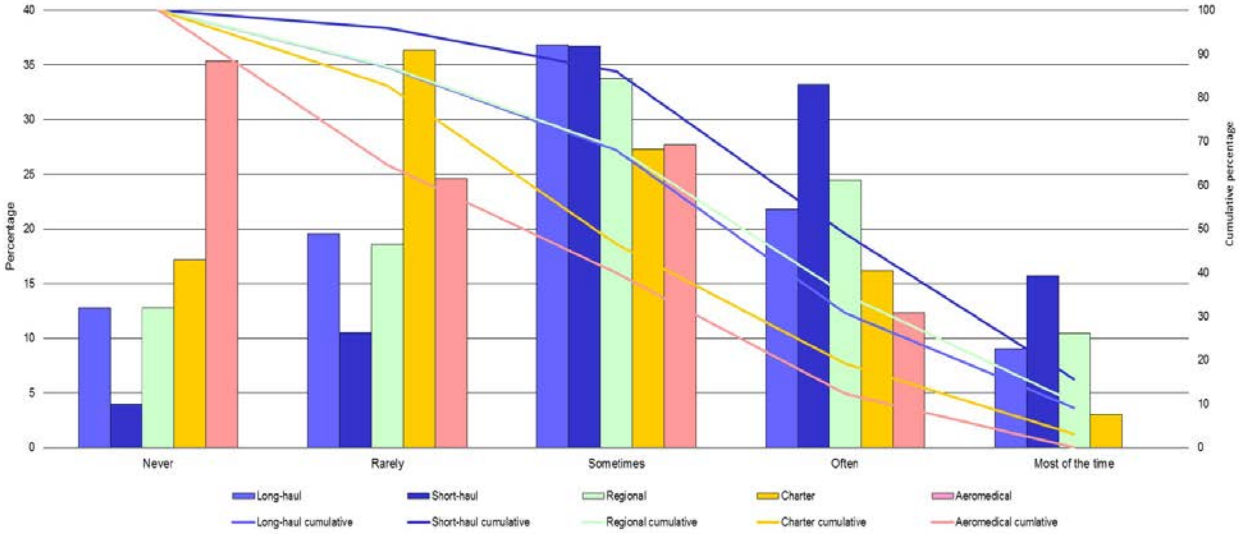
Distribution of perception rest period is too short by operation type

More than half of the aeromedical pilots (60%) and charter pilots (53.5%), and around one third of long-haul pilots (32.3%), perceived the rest period between duties as ‘never’ or ‘rarely’ too short. In contrast, around half of short-haul pilots (48.9%) perceived the rest period was too short to obtain adequate rest ‘often’ or ‘most of the time’ (Figure 35).

Aeromedical and charter pilots perceived the rest period was too short between duties to obtain adequate rest significantly less often than long-haul, short-haul, and regional pilots ($p<0.05$).

Short-haul pilots perceived the rest period was too short between duties significantly more often than long-haul pilots and regional pilots ($p<0.05$).

Figure 35: Rest period was too short in the past 12 months by operation type

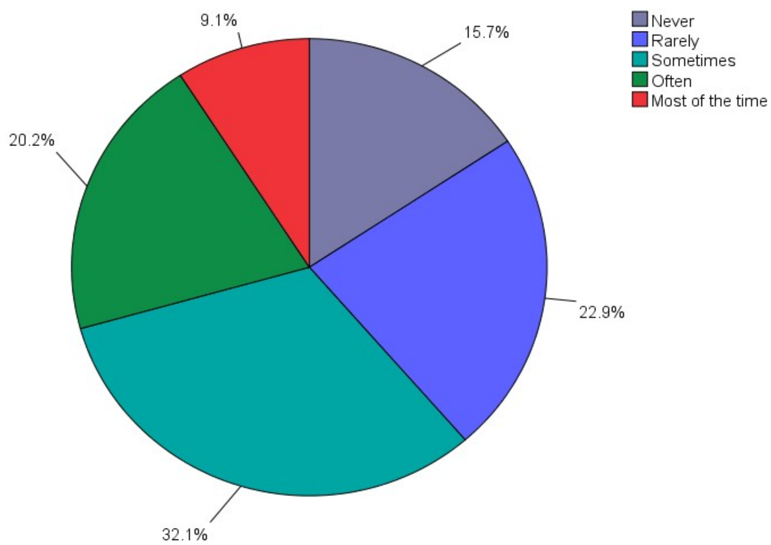


Duty period too long to manage fatigue

Around 40 per cent of pilots perceived their duty period was 'never or 'rarely' too long to manage fatigue (Figure 36). In contrast, about 30 per cent indicated that duty periods were too long 'often' or 'most of the time'. A selection of pilots made the following comments about duty periods when asked about safety concerns in aviation:

> Fatigue: Long duties, minimum rest, extensions of duties, combination of early starts then late finishes, not accounting for home rest, no reserve coverage.
>
> Long duty periods followed by early starts, rostering of six long four sector days in a row.
>
> Duty periods inducing fatigue due to length, or access to food, or length/quality of rest period prior.
>
> Pilot Fatigue. Many remote pilots work vast hours before/after duty period ceases to be logged, answering phones, paperwork, aircraft washing etc.
>
> Fatigue. Airlines use limits as targets. The limits are beyond what we are generally able to sustain peak performance. After two sectors you feel fine. On the 4th sector I believe most of us are functioning well below our ability.

Figure 36: Overall distribution of perception duty period was too long

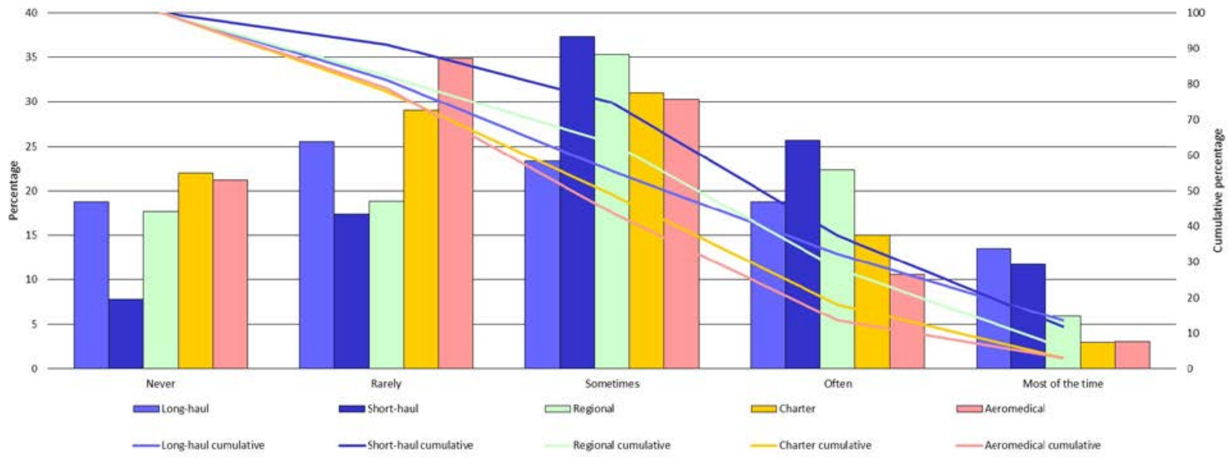


Distribution of the perception duty period was too long by operation type

Over one third of regional (36.5%), around half of long-haul (44.4%), charter (51%), and aeromedical pilots (56%) perceived their duty period was 'never' or 'rarely' too long (Figure 37). In contrast, around one third of short-haul pilots (37.4%) pilots perceived the duty period was 'often' or 'most of the time' too long (Figure 37). This is consistent with research by Bourgeois-Bougrine and others (1997) where short-haul pilots perceived that long duty days were the most fatiguing.

Short-haul pilots perceived that the duty period was too long significantly more often than charter and aeromedical pilots (p<0.05).

Figure 37: Duty period was too long to manage fatigue by operation type



Access to food during duty

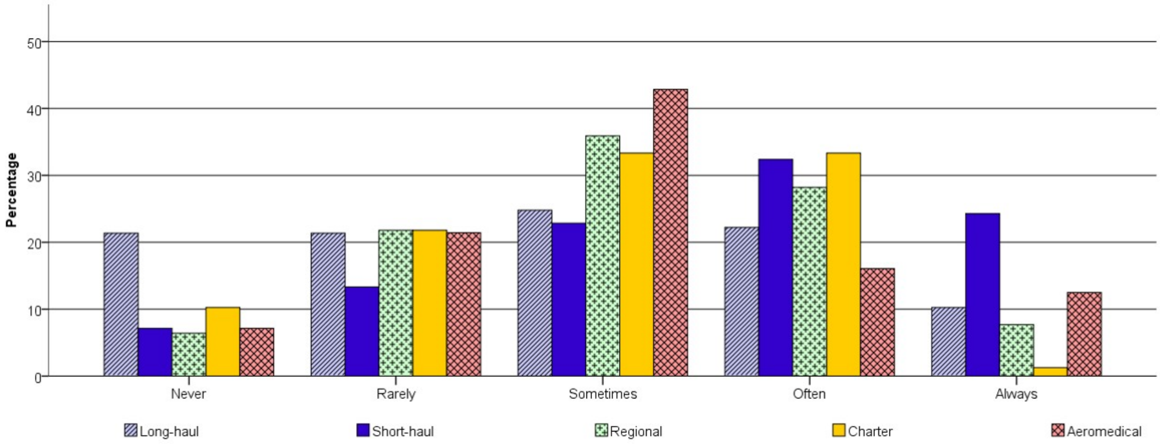
Pilots who answered 'not applicable' from this question were removed from the analysis, resulting in a sample of 546 for this question. Around half of these pilots (42.3%) reported food was 'often' or 'always' difficult to access. A selection of pilots also noted that access to food was a safety concern. Comments included:

> Very poor food provided in flight, high sugar and fat, not cooked properly
>
> Sustenance during flight, no set calorific or nutritional standard operators have to meet. E.g. one sandwich for dinner on a 7-hour duty

Access to food and operation type

Less than half of long-haul pilots perceived it was 'never' or 'rarely' difficult to access food during duty (42.8%), although nearly a third of long-haul pilots (32.5%) perceived it was 'often' or 'always' difficult to access food during flight. Around half of short-haul (56.7%), around one third of regional (35.9%), and charter pilots perceived it was 'often' or 'always' difficult to access food (Figure 38). Short-haul pilots perceived it significantly more difficult to access food than all other pilots (p<0.05).

Figure 38: Access to food during duty by operation type



Below is an example of how little nutrition can influence fatigue.

Case Study: Flight path management and ground proximity warning involving Airbus A330-202, VH-EBV, 15 km NNE of Melbourne Airport, Victoria on 8 March 2013

ATSB investigation AO-2013-047

On 8 March 2013, the flight crew of a Qantas A330 aircraft, registered VH-EBV, was conducting a visual approach to Melbourne Airport, Victoria. The captain was the pilot flying with autopilot engaged. The descent was conducted in auto-flight open descent mode and reached a maximum of 2,200 feet per minute. As the aircraft was descending through about 1,800 ft. the first officer advised the captain that they were low. The captain reduced the rate of descent by selecting auto-flight vertical speed mode, but a short time later the enhanced ground proximity warning system provided ‘TERRAIN’ alerts followed by ‘PULL UP’ warnings. The crew carried out the recovery manoeuvre and subsequently landed via an instrument approach.

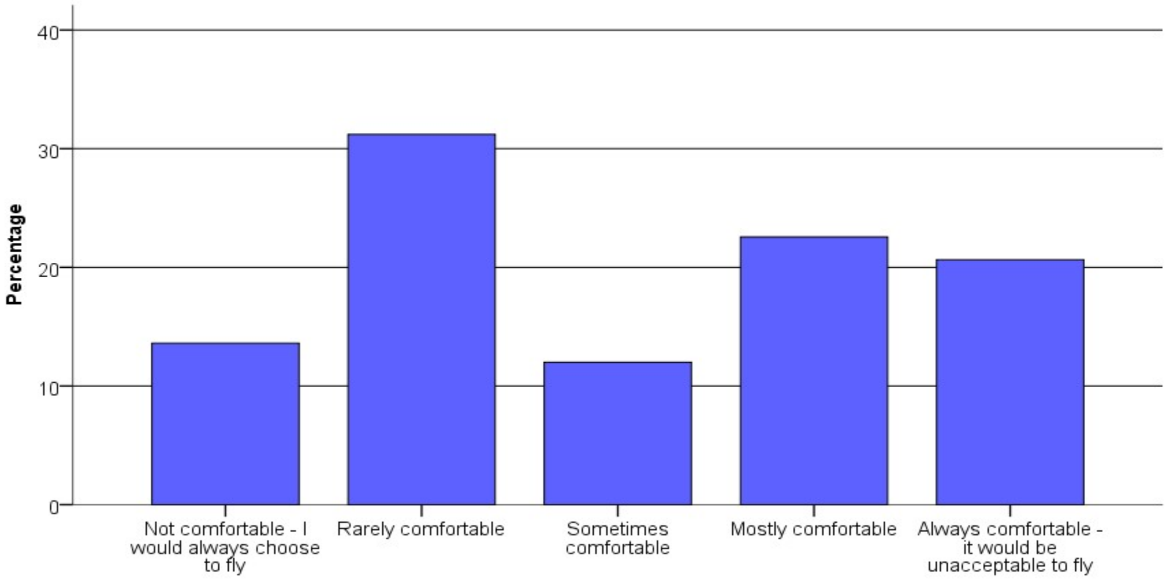
The ATSB found that, during the visual approach, the captain’s performance capability was probably reduced due to the combined effects of disrupted and restricted sleep, a limited recent food intake and a cold/virus. The captain reported obtaining 6 hours of sleep the night before the incident and having very little nutrition on the day, including no breakfast or lunch.

Organisational support

Comfortable removing self from duty

Nearly one quarter of pilots (22.4%) felt ‘mostly comfortable’ in removing themselves from duty (Figure 39). Nearly one third (31.3%) of pilots felt ‘rarely comfortable’ in removing themselves from duty when they felt fatigued in the previous 12 months, and another 13.6 per cent indicated they would always choose to fly. There were no statistically significant differences between operation types.

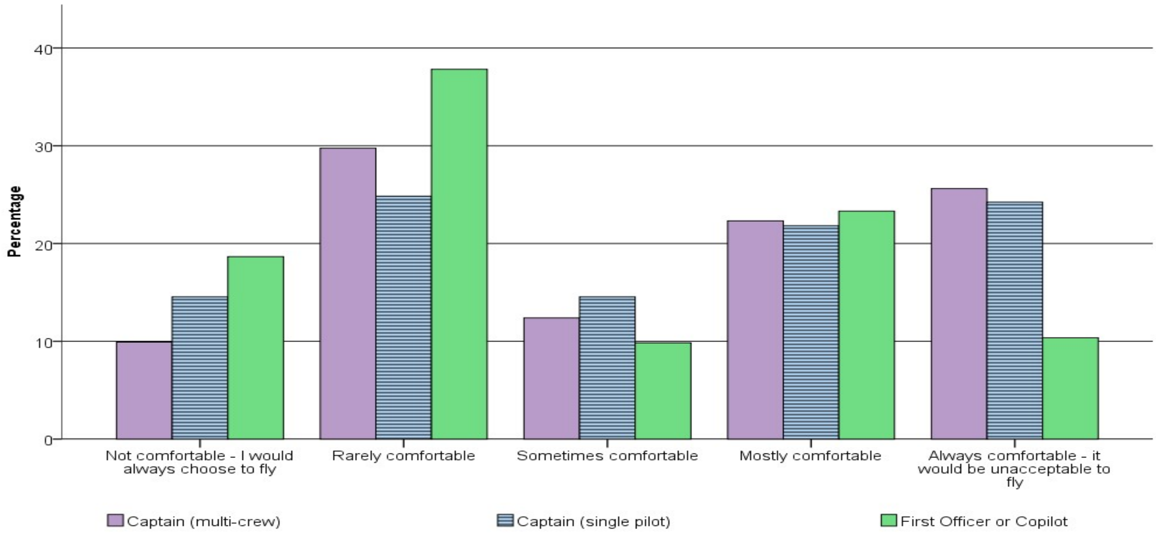
Figure 39: Overall responses to feeling comfortable removing self from duty due to fatigue



Feeling comfortable removing self from duty and role

Over half of first officers (56.5%) and around 40 per cent of captains who fly multi-crew and single pilot operations felt ‘rarely’ or ‘not comfortable’ removing themselves from duty due to fatigue. Around half of captains who fly both multi-crew (47.9%) and single pilot operations (46%) reported feeling ‘mostly comfortable’ and ‘always comfortable – it would be unacceptable to fly’. In comparison, a third (33.7%) of first officers similarly responded (Figure 40). Captains from multi-crew and single pilot operations felt significantly more comfortable than first officers in removing themselves from duty ($p<0.05$).

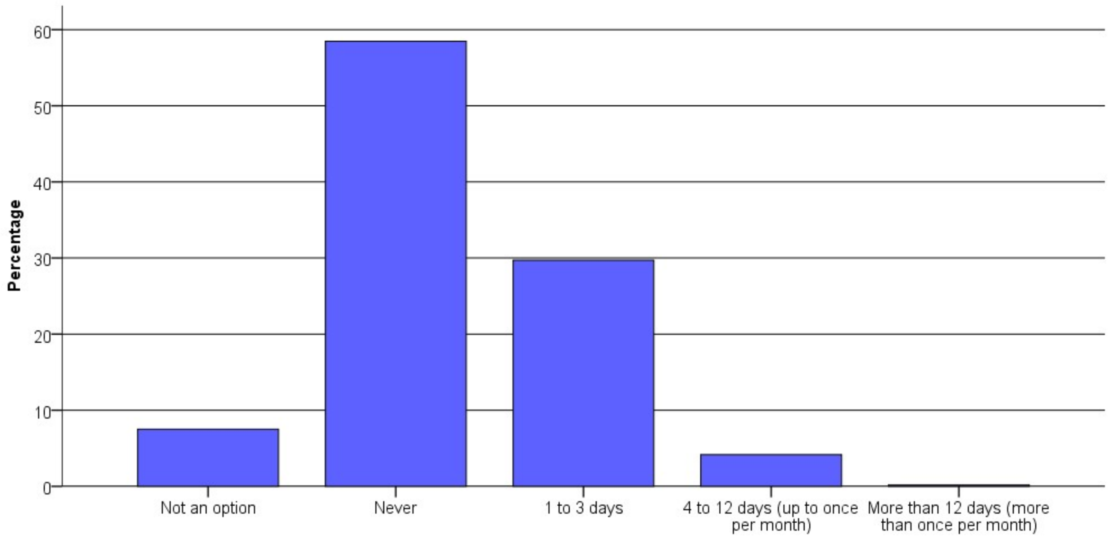
Figure 40: Comfortable removing self from duty due to fatigue in the past 12 months by role



Removing self from duty

More than half of pilots (58.4%) responded that they 'never' used their company's processes for removing themselves from duty because they felt they were experiencing fatigue (Figure 41). However, a third of pilots had reported removing themselves from duty due to fatigue. Only 7.5 per cent of pilots indicated this was not an option in their company.

Figure 41: Overall distribution of frequency of removing self from duty

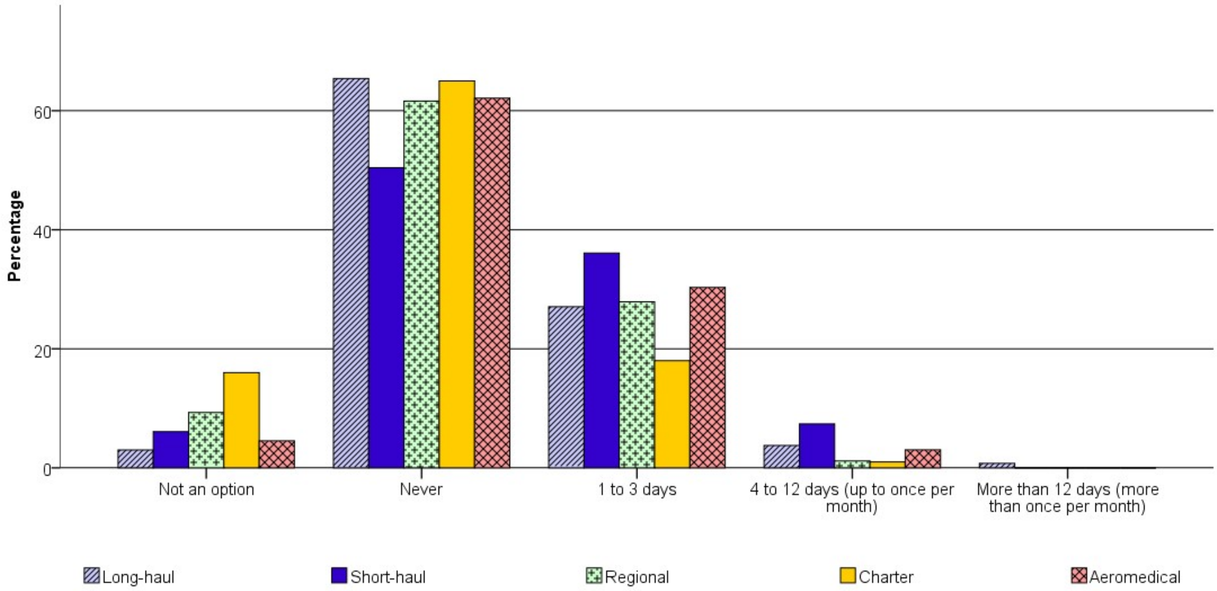


Distribution of removing self from duty and operation type

Figure 42 outlines the distribution of responses across operation types. Around one quarter of long-haul (27.1%) and regional pilots (27.9%), as well as around one third of short-haul (36.1%) and aeromedical pilots (30.3%) in the last 12 months reported removing themselves from duty '1 to 3 days' because of fatigue.

It was also found that long-haul and short-haul pilots removed themselves from duty significantly more than charter ($p<0.05$).

Figure 42: Number of times in the past 12 months where respondents have removed themselves from duty due to fatigue by operation type

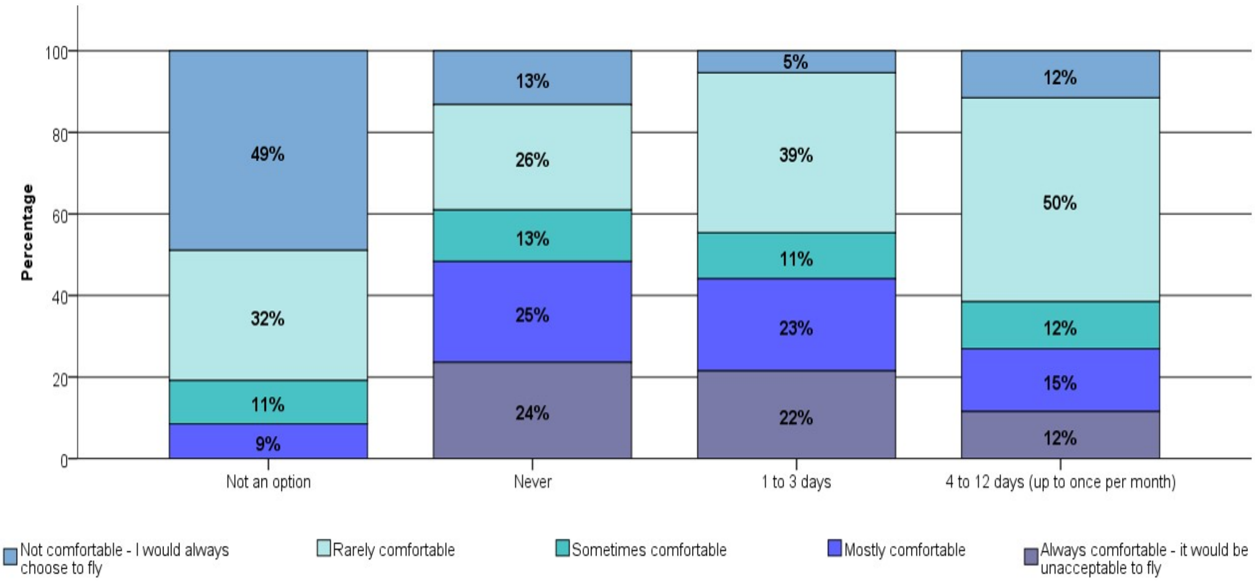


Comfortable removing themselves from duty by frequency

Overall, around half of pilots (49%) who reported 'never' removing themselves from duty felt 'mostly' or 'always comfortable' in removing themselves from duty due to fatigue experienced in the previous 12 months (Figure 43).

Despite using the provision to remove themselves from duty because of fatigue, around half of pilots (44%) who removed themselves from duty '1 to 3 days', and nearly two thirds (62%) removed themselves '4 to 12 days', felt 'not comfortable' or 'rarely comfortable' in removing themselves from duty.

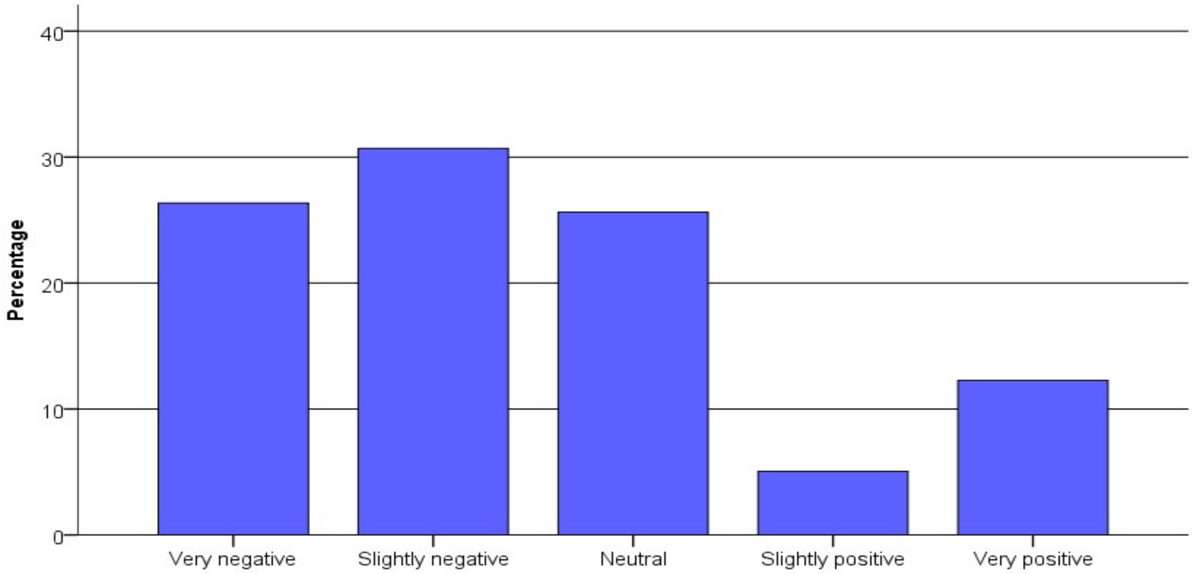
Figure 43: Ratings of comfort in removing self from duty by frequency



Impression with management

This question was only analysed for those respondents who indicated to have taken time off for fatigue, as outlined above. Of the 277 pilots who reported removing themselves from duty, more than half (57.1%) believed they left a negative impression with management (Figure 44).

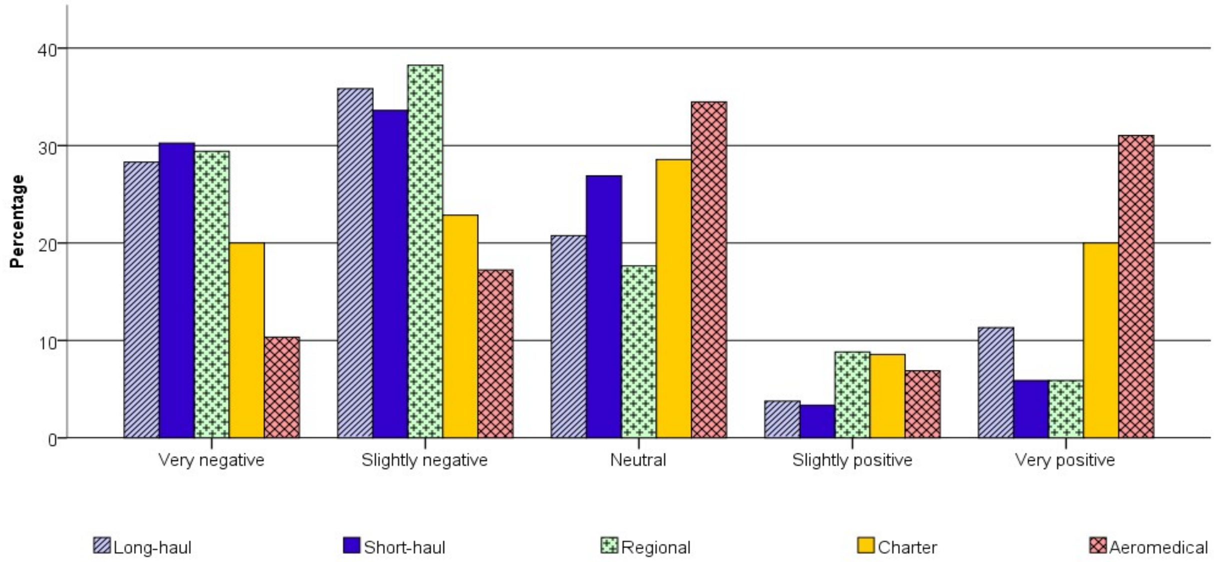
Figure 44: Overall responses for impressions left with management



Distribution of impression and operation type

Over one third of aeromedical pilots (39.9%) reported they perceived they left a 'very positive' or 'positive' impression with management when they removed themselves from duty. In contrast, around two thirds of long-haul (64.1%), short-haul (63.9%), and regional (67.6%) perceived they left a negative impression (Figure 45). Aeromedical pilots reported they perceived they left a significantly more positive impression than long-haul pilots, short-haul, and regional pilots ($p<0.05$).

Figure 45: Impression left with management when time was taken for fatigue in the past 12 months by operation type



Discussion

The aim of this research was to measure the amount of sleep and rest obtained by Australian commercial pilots who fly scheduled and non-scheduled passenger, freight, and aeromedical operations, as well as measure their perceptions of how fatigue was managed within their organisations. The fatigue factors that were explored were rest obtained, rest opportunity provided, and organisational support.

Rest obtained

A majority of pilots reported they were sufficiently rested at the end of their duty. However, around 11 per cent of pilots reported they were awake 19 hours or more and around 4 per cent of pilots reported they were awake 22 hours or more at the end of their last duty. These are thresholds associated with impairments in performance (Russo and others 2005 and Transportation Safety Board 2014). Long-haul pilots reported being awake the longest compared with the other pilots with around half reported being awake 16 hours or more. This reflects the nature of long-haul operations where duty times can almost be a day.

Around one quarter of pilots perceived they were sufficiently alert at the end of their duty, however nearly half of pilots perceived they were experiencing moderate to severe fatigue at the end of their duty as they indicated they were feeling 'Moderately tired. Let down' or 'Extremely tired. Very difficult to concentrate'. Long-haul pilots and short-haul pilots reported feeling more tired at the end of duty than other groups. Long-haul pilots and short-haul pilots reported feeling more tired at the end of duty than the other groups (regional, charter, and aeromedical). Around 50 per cent of short-haul and 60 per cent of long-haul pilots indicated they were feeling 'Moderately tired. Let down' or 'Extremely tired. Very difficult to concentrate' at the end of their last duty.

Overall, pilots awake for 15 hours or more reported feeling 'Moderately tired, let down'. When looking at only short-haul operations, it was also found that, the more sectors flown in a month, the more tired pilots reported feeling. Pilots who undertake many sectors will have many take-offs and landings, both high workload phases of flight, which can increase feelings of fatigue. Powell and others (2007) found that the more sectors completed in a duty, the higher self-rating of fatigue pilots provided.

Around 90 per cent of pilots reported obtaining between 7 and 9 hours of sleep at home. However, only half of the pilots reported obtaining these hours of sleep in the 24 hours prior to the end of duty. Additionally, less than 1 per cent of pilots reported obtaining less than 5 hours of sleep at home. Ten per cent of pilots reported obtaining less than 5 hours of sleep in the previous 24 hours at the end of duty. Seventeen per cent of pilots reported they obtained less than 12 hours of sleep in the previous 48 hours, whereas less than 5 per cent reported obtaining these hours of sleep at home.

Similar to hours awake, more long-haul pilots than other pilots reported obtaining less than 5 hours of sleep in the previous 24 hours. Around 10 per cent of short-haul pilots reported obtaining less than 5 hours of sleep in the previous 24 hours at the end of duty and around 20 per cent reported less than 12 hours of sleep in the previous 48 hours. Pilots from other operation types (regional, charter, aeromedical) rarely reported less than 5 hours sleep. Dawson and McCulloch (2005) reported that, obtaining less than 5 hours of sleep in the previous 24 hours and less than 12 hours in the previous 48 hours is inconsistent with safe work.

Around 30 per cent of pilots reported the same amount of sleep at home and in the 24 hours prior to the end of their previous duty. Charter and aeromedical pilots comprised the majority of this group. Around half of long-haul and short-haul pilots reported obtaining less hours of sleep in the 24 hours prior to duty than at home. Acute sleep disruptions are reductions in the quality or quantity of sleep that have occurred within the prior 3 days (Transportation Safety Board of Canada 2014). Losing as little as two hours of sleep will result in acute sleep loss, which will induce fatigue and degrade subsequent waking performance and alertness (Dinges and others 1996). Future research in this area could examine the effect of duty length and duty start/finish times on sleep obtained.

Of the long-haul pilots who responded to the survey, nearly 80 per cent reported their last layover had less than 40 hours of non-duty time. Research has found that long-haul flight crew who had a shorter layover (less than 40 hours) self-reported a higher level of fatigue and recorded slower reaction times in a vigilance task than flight crew who had a longer layover (average of 62 hours). This indicated that the short layover did not provide sufficient opportunity for recovery from the outbound flight (Lamond and others 2006). However, the direction of travel (east-bound or west-bound) was not gathered in the survey. Research has been found that adding an additional day to an east-bound flight had no effect on fatigue (Powell and others 2010).

Only around 7 per cent of short-haul pilots had less than 8 hours non-duty time during their layover. The Civil Aviation Safety Authority (2017) has stated that crew should get the required sleep opportunity (8 hours), plus sufficient time to address personal requirements, and to travel to and from accommodation, meaning layovers should ideally be around 10 hours minimum. Eighty per cent of pilots reported obtaining these hours in their last duty.

While most long-haul pilots had some sleep during their last flight around 15 per cent of long haul pilots responded that they had no hours of rest during their last long-haul flight. Pilots on long haul flights who napped have been found to have a higher level of alertness and performed better on vigilance and reaction time tasks compared with those who did not nap (Rosekind and others 1994). However, from the survey, it was unknown whether the pilots who did not nap attempted to nap or whether there was a scheduled rest break during the flight, but can be examined in future research.

Rest opportunity provided

Of the pilots who completed a duty on a stand-by day, around half reported they completed these duties ‘often’ or ‘most of the time’, particularly aeromedical and short-haul pilots. It was also found first officers completed duties more often than captains who fly multi-crew and single pilot operations.

Around one third of pilots perceived overall their rest period was too short between duties ‘often’ or ‘most of the time’, particularly short-haul pilots, who represented around half of these responses. While around 40 per cent of pilots perceived the duty period was ‘never’ or ‘rarely’ too long, around one third of short-haul pilots perceived their duty period was too long ‘often’ or ‘most of the time’. Overall, half of the pilots perceived food was difficult to access during duty, particularly short-haul pilots with around half reporting their perceived access to adequate food being ‘often’ or ‘always’ difficult.

Short-haul pilots fly operations that include long duty days with short sectors, which means more take-offs and landings. These are high workload phases of flight as evidenced by heart rate (Lee and Liu 2003), which can also contribute to feeling fatigued.

Organisational support

Over 90 per cent of pilots indicated their employer offered a formal process for removing themselves from duty due to fatigue.

One third of pilots reported removing themselves from duty because of fatigue in the previous 12 months ‘1 to 3 days’, with around 60 per cent indicating they did not take time off in the previous 12 months.

Of the pilots who removed themselves from duty, long-haul and short-haul pilots reported removing themselves from duty more often than other pilots. The pilots who removed themselves from duty overall perceived they left a ‘slightly negative’ or ‘very negative’ impression with management. The exception was aeromedical pilots, who perceived they left a ‘very positive’ or ‘slightly positive’ impression. Reasons for these perspectives could be examined in future research. Overall, pilots did not feel comfortable in removing themselves from duty, particularly first officers compared with captains. Of the pilots who reported removing themselves from duty, around half felt ‘not comfortable’ or ‘rarely comfortable’.

Findings

With the data collected, the following findings have been made in respect to fatigue experiences and culture in Australian commercial air transport in 2015-2016. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety factors

- A small proportion of pilots reported conditions consistent with thresholds that have been shown to be associated with impaired performance due to fatigue at the end of their last duty. These included:
  - 11 per cent of pilots reported they were awake 19 hours or more, and around 4 per cent of pilots reported they were awake 22 hours or more
  - 10 per cent of pilots overall (and 25 per cent of long-haul pilots) reported obtaining less than 5 five hours of sleep in the previous 24 hours
  - 17 per cent overall (and 30 per cent of long-haul pilots) reported obtaining less than 12 hours of sleep in the previous 48 hours.
- Pilots who removed themselves from duty due to fatigue generally did not feel comfortable doing so and perceived they left a negative impression with management.

Other findings

- Half of short-haul (domestic) pilots reported completing duties on a stand-by day. They also believe the rest period between duties is too short, duty periods are too long, and indicated access to food during duties is difficult compared with pilots from other operation groups (long-haul, regional, charter, and aeromedical).
- Over 90 per cent of pilots indicated their employer offered a formal process for removing themselves from duty due to fatigue. Overall pilots do not remove themselves from duty often due to fatigue, but one third had removed themselves at least once in the past 12 months.
- Aeromedical pilots that removed themselves from duty due to fatigue perceived they left a positive impression with management.

Sources and submissions

References

Anund, A, Fors, C, Kecklund, G, van Leeuwen, Torbjorn, A, 2015, *Countermeasures for fatigue in transportation: a review of existing methods for drivers on road, rail, sea, and in aviation*. Swedish National Road and Transport Research Institute: Linköping.

ATSB 2004, *ATSB aviation safety survey – safety climate factors.* (Report No. B2003/0122) ATSB: Canberra.

ATSB 2005, *ATSB aviation safety survey – pilots' flying experiences.* (Report No. B2003/0176) ATSB: Canberra.

Battelle Memorial Institute 1998, *An overview of the scientific literature concerning fatigue, sleep, and the circadian cycle,* Report prepared for the Office of the Chief Scientific and Technical Advisor for Human Factors, US Federal Aviation Administration.

Bonnet, MH, 1991, The effect of varying prophylactic naps on performance, alertness, and mood throughout a 52-hour continuous operation, *Sleep, 14*(4), 307-315.

Bourgeois-Bougrine, S, Carbon, P, Gounelle, C, Mollard, R, and Coblentz, A, 2003, Perceived fatigue for short-and long-haul flights: a survey of 739 airline pilots. *Aviation, space, and environmental medicine, 74*(10), pp.1072-1077.

Caldwell, JA, Mallis, MM, Caldwell, JL, Paul, MA, Miller, JC, and Neri, D, 2009, Fatigue countermeasures in aviation. *Aviation, space, and environmental medicine, 80*(1), 29-59.

Civil Aviation Safety Authority 2013, *Civil Aviation Order 48.1 Instrument 2013* (Cth). Available from www.casa.gov.au

Civil Aviation Safety Authority 2017, *CAAP 48-01 – Fatigue management for flight crew members,* CASA: Canberra.

Dawson, D and McCulloch, K, 2005, Managing fatigue: it's about sleep. *Sleep medicine reviews, 9*(5), 365-380.

Dawson, D and Reid, K, 1997, Fatigue, alcohol and performance impairment. *Nature, 388*(6639), 235-235.

Dinges, DF., Graeber, RC., Rosekind, MR. & Samel, A, 1996. *Principles and guidelines for duty and rest scheduling in commercial aviation*. National Aeronautics Space Administration, California.

Gander, PH, Gregory, KB, Curtis Graeber, R, Connell, LJ, Miller, DL, & Rosekind, MR 1998, Flight crew fatigue II: Short-haul fixed-wing air transport operations. *Aviation, Space, and environmental medicine, 69*(9, supplement): B8-15.

Gander, P, Hartley, L, Powell, D, Cabon, P, Hitchcock, E, Mills, A, and Popkin, S, 2011, Fatigue risk management: Organizational factors at the regulatory and industry/company level. *Accident Analysis & Prevention, 43*(2), 573-590.

Goode, JH, 2003, Are pilots at risk of accidents due to fatigue? *Journal of safety research, 34*(3), 309-13.

Hirshkowitz, M, Whiton, K, Albert, SM, Alessi, C, Bruni, O, DonCarlos, L, Hazen, N, Herman, J, Katz, ES, Kheirandish-Gozal, L, and Neubauer, DN, 2015, National Sleep Foundation's sleep time duration recommendations: methodology and results summary. *Sleep Health: Journal of the National Sleep Foundation, 1*(1), 40-43.

International Civil Aviation Organization 2016, *Manual for the oversight of fatigue management approaches (Doc 9966)*, 2nd edition. ICAO: Montréal.

Lamond, N, Petrilli, RM, Dawson, D, & Roach, GD 2006, Do short international layover allow sufficient opportunity for pilots to recover? *Chronobiology International, 23*(6), 1285-1294.

Lee, YH and Liu, BS, 2003, Inflight workload assessment: Comparison of subjective and physiological measurements. *Aviation, space, and environmental medicine*, 74(10), 1078-1084.

National Transportation Safety Board 1994, *A review of flight crew-involved major accidents of U.S. carriers, 1978 through 1990*. NTSB: Washington.

Petrilli, RM, Roach, GD, Dawson, D, and Lamond, N, 2006, The sleep, subjective fatigue, and sustained attention of commercial airline pilots during an international pattern. *Chronobiology international, 23*(6), 1357-1362.

Powell, D, Spencer, M.B, Holland, D, Broadbent, E, and Petrie, K.J., 2007. Pilot fatigue in short-haul operations: Effects of number of sectors, duty length, and time of day. *Aviation, Space, and Environmental Medicine*, *78*(7), pp.698-701.

Powell, D, Spencer, MB, and Petrie, KJ, 2010, Fatigue in airline pilots after an additional day's layover period. *Aviation, space, and environmental medicine, 81*(11), 1013-1017.

Reason, J, 1997, *Managing the Risks of Organizational Accidents*, Ashgate Publishing Limited, Aldershot, England

Roach, GD, Sargent, C, Darwent, D, & Dawson, D, 2012, Duty periods with early start times restruct the amount of sleep obtained by short-haul airline pilots. *Accident Analysis and Prevention, 45S*, 22-26.

Rosekind MR, Graeber RC, Dinges DF, Connell LJ, Rountree MS, Spinweber CL, Gillen KA, 1994, *Crew factors in flight operations 9: Effects of planned cockpit rest on crew performance and alertness in long-haul operations*. National Aeronautics and Space Administration: Moffett Field, CA.

Rosekind, MR, Gander, PH, Gregory, KB, Smith, RM, Miller, DL, Oyung, R, Webbon, LL and Johnson, JM, 1996, Managing fatigue in operational settings 2: an integrated approach. *Behavioral Medicine, 21*(4), 166-170.

Russo, MB, Kendall, AP, Johnson, DE, Sing, HC, Thorne, DR, Escolas, SM, Santiago, S, Holland, DA, Hall, SW and Redmond, DP, 2005. Visual perception, psychomotor performance, and complex motor performance during an overnight air refueling simulated flight. *Aviation, space, and environmental medicine*, *76*(7), pp.C92-C103.

Samn, SW and Perelli, LP, 1982. *Estimating aircrew fatigue: A technique with application to airlift operations*. (No. SAM-TR-82-21). Brooks Air Force Base, TX: School of Aerospace Medicine.

Signal, TL, Gale, J, & Gander, PH, 2005, Sleep measurement in flight crew: comparing actigraphic and subjective estimates to polysomnography. *Aviation, Space, and Environmental Medicine, 76*(11), 1058-1063.

Thomas, MJ and Ferguson, SA, 2010, Prior sleep, prior wake, and crew performance during normal flight operations. *Aviation, Space, and Environmental Medicine, 81*(7), 665-670.

Transport Safety Board 2014, *Guide to investigating sleep-relating fatigue*, TSB: Quebec

Wiegmann, DA, Zhang, H, von Thaden, TL, Sharma, G, & Gibbons, AM, 2004, Safety culture: An integrative review. *The International Journal of Aviation Psychology, 14*(2), 117–134.

Williamson, A, Lombardi, DA, Folkard, S, Stutts, J, Courtney TK, & Connor JL 2011, The link between fatigue and safety. *Accident Analysis and Prevention, 43,* 498-515.

Appendices

Appendix A – Survey questions

Demographic information

1. What are your total flying hours?
2. At the moment, what is the most common type of aircraft do you usually fly commercially? *(1 = Wide body jet, 2 = Narrow body jet, 3 = Turboprop aeroplane, 4 = Piston aeroplane, 5 = Helicopter)*
3. At the moment, what is the most common type of operation do you usually fly? *(0 = Other (please specify), 1 = Scheduled passenger, 2 = Non-scheduled passenger (charter), 3 = Scheduled freight, 4 = Non-scheduled freight)*
4. In your current employment, about how many sectors (take-off and landing) do you operate each month? (including as pilot not flying/pilot monitoring)?
5. What is your current role? *(0 = Other (please specify), 1 = Captain (multi-crew), 2 = Captain (single pilot), 3 = First Officer, 4 = Second Officer)*

Fatigue

15. In the past 12 months, how often have you used your company's processes for removing yourself from duty so you do not perform operational duties in a fatigued state? *(1 = Not an option, 2 = Never, 3 = 1 to 3 days, 4 = 4 to 12 days – up to once per month, 5 = More than 12 days – 6 = More than once per month)*

16. In the past 12 months, what type of impression do you think you left with management when you took time off because of fatigue? *(1 = Very positive, 2 = Slightly positive, 3 = Neutral, 4= Slightly negative, 5= Very negative, 6 = N/A – Did not take any time off for fatigue)*

17. How comfortable are you removing yourself from duty if you feel fatigued? *(1 = Not comfortable – I would always choose to fly, 2 = Rarely comfortable, 3 = Sometimes comfortable, 4 = Mostly comfortable, 5 = Always comfortable – it would be unacceptable to fly)*

18. In the past 12 months, how often have you completed a duty on a stand-by day? *(1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Most of the time)*

19. In the past 12 months, how often was your rest period too short for you to obtain adequate rest? *(1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Most of the time)*

20. In the past 12 months, how often was your duty period too long to adequately manage fatigue? *(1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Most of the time)*

21. At the end of the last flight of your last duty period, how alert did you feel? *(1 = Fully alert, wide awake. Extremely peppy, 2 = Very lively, responsive, but not at peak, 3 = Okay, somewhat fresh, 4 = A little tired, less than fresh, 5 = Moderately tired. Let down, 6 = Extremely tired. Very difficult to concentrate, 7 = Completely exhausted. Unable to function effectively. Ready to drop)*

22. When at home, how many hours sleep do you normally get each night?

23. At the end of your last flight of your last duty, how many hours had you been awake?

24. At the end of your last flight of your last duty, how many hours of sleep had you had in the previous 24 hours?

25. At the end of your last flight of your last duty, how many hours of sleep had you had in the previous 48 hours?

26. During your last layover, how many non-duty hours did you have?

27. During your last layover, how many hours of sleep did you have?

28. How long was your last long-haul flight time?

29. During your last long-haul flight, how many hours of rest did you have during the flight?

36. In the past 12 months, how often has it been difficult to access adequate food during duty periods? *(1 = Never, 2 = Once, 3 = Twice, 4 = 3 or 4 times – once every 3 months, 5 = Monthly, 6 = Weekly, 7 = Daily)*

Appendix B – Statistical analyses

Kruskal-Wallis H test

The Kruskal-Wallis test (also known as the Kruskal-Wallis one-way analysis of variance) is a non-parametric (distribution free) test when there are three or more independent groups to compare. It is a non-parametric version equivalent to a one-way analysis of variance (ANOVA). It is calculated by ranking all the scores, then computing the sum for the ranks for each group. This test was used because the responses were not normally distributed, therefore analyses such as ANOVA or multiple regression were not suitable to be run. The responses to the 16 questions on fatigue and one question on access to food were ranked. The groups of operation type (passenger, freight, aeromedical), aircraft flown (wide body jet, narrow body jet, turboprop aeroplane, and piston aeroplane), role (captain – multi-crew), captain- single pilot, and first officer), combinations between role and aircraft, combinations between role and operation type, and combinations between operation type and aircraft, and sectors flown (0-24 sectors, 25-49 sectors, 50-74 sectors, 75-99 sectors, and 100 + sectors) were tested for differences on these responses. Groups with small numbers (less than 20) were excluded from the analysis.

Sign test

The sign test is a non-parametric equivalent to a paired sample t-test. It is used to test differences between pairs of observations if they are non-normally distributed. It is conducted by calculating the differences between pairs of observations and assessing whether the positive and negative differences would be likely to occur if conditions were the same.

This test was used to compare sleep in the previous 24 hours to prior duty with normal sleep hours at home by operation types, aircraft, and sectors flown.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

Enquiries 1800 020 616
Notifications 1800 011 034
REPCON 1800 020 505
Web www.atsb.gov.au
Twitter @ATSBinfo
Email atsbinfo@atsb.gov.au
Facebook atsbgovau
Linkedin Australian Transport Safety Bureau

Research

ATSB Transport Safety Report
Aviation Research Investigation

Fatigue experiences and culture in Australian commercial air transport pilots

AR-2015-095

Final – 22 January 2019