Fatigue and Flight Crew Error

Introduction

Queenstown Airport is generally regarded as a demanding aerodrome, as evidenced by RPT jet operations only being authorised given RNP AR procedures and the associated crew selection and training. The very late runway alignment, limited approach lighting and turbulent and variable wind patterns demand a high level of pilot skill and is mentally demanding. Given these factors, together with the close in terrain during much of the approach paths and limited escape options, night operations into Queenstown were, until recently, considered by many to be unrealistic.

Following considerable research and work by an industry working-group spanning near to 2 years, the CAA approved in principle a Foundation Safety Case (FSC) for night operations (May 2014). The CAA subsequently approved an Air New Zealand Operator Safety Case (OSC) for night flights to Queenstown ahead of the 2016 winter season (Jetstar obtained similar approvals from CASA based upon the common FSC). The FSC (Navigatus 2016) identified *flight crew error* as a key threat to be managed in night operations to Queenstown Airport.

A key driver of flight crew error is 'fatigue' which has been shown to increase the risk of accidents (Goode 2003; Dorrian et al. 2011). ICAO has defined 'fatigue' as follows:

> *Fatigue is a physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, of workload (mental and/or physical activity) that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety-related duties (ICAO 2012).*

Research has shown that fatigue and error rate are tightly linked to duty hours and workload prior to undertaking an activity (Powell et al. 2008; Powell et al. 2007; Dorrian et al. 2011; Goode 2003). Given the demanding nature of Queenstown operations in general and night operations in particular, as well as the high consequences of errors, it is important that flight crews are not fatigued prior to operating into and out of the aerodrome at night.

Research Review

There is significant local and international research on the topic of fatigue as it relates to duty length and error rates. Research in a New Zealand context includes that led by Dr David Powell who, at the time of publishing, was Chief Medical Officer at Air New Zealand. The following papers were published in the *Aviation, Space, and Environmental Medicine* journal; they consider pilot fatigue and its relation to the number of sectors and duty length prior to the final decent of a schedule duty:

- Pilot Fatigue in Short-Haul Operation: Effects of Number of Sectors, Duty Length, and Time of Day (Powell et al. 2007)
- Fatigue in Two-Pilot Operations: Implications for Flight and Duty Time Limitations (Powell et al. 2008)

Both of these papers draw on data collected by Air New Zealand over a 12-week period in early 2003. During this period pilots were asked to complete the Samn-Perelli fatigue scale prior to descent at the end of each rostered duty.

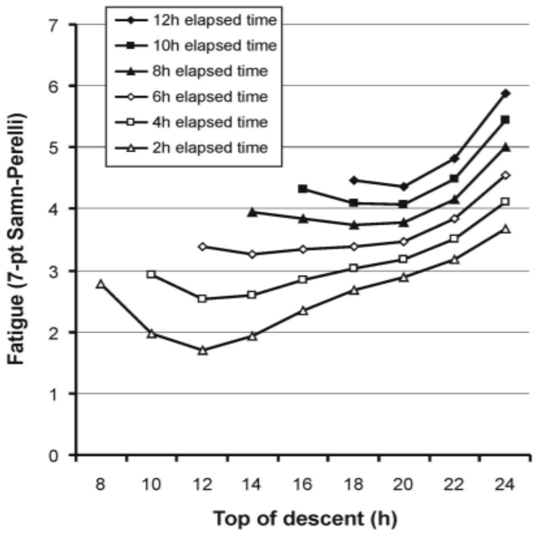
Powell et al. (2007) considered the data relating to domestic B737 operations. Overall, 1,370 usable responses from these operations were collected (67% of all rostered duties for these operations). The most important influences on fatigue were found to be the number of sectors flown and total duty length. The results are consistent with three studies carried out on domestic UK pilots using a different methodology (CAA UK 2005).

Powell et al. (2008) considered data collected from pilots operating B737, B767 and B747 aircraft between New Zealand and destinations within Australia and the Pacific Islands. Overall, 3,023 usable ratings were collected (72% of rostered duties for these operations). It was found that fatigue increased with the length of duty and was 56% higher at the end of a two-sector compared with a single sector duty.

Notably, the effect of the number of sectors previously flown was found to be similar in both studies despite markedly different sector lengths. Since the results were corrected for duty length, this effect would appear to be due to the workload associated with approach and landing.

Figure 1 is from Powell et al. (2007) and shows fatigue as it relates to time of day and prior length of duty.

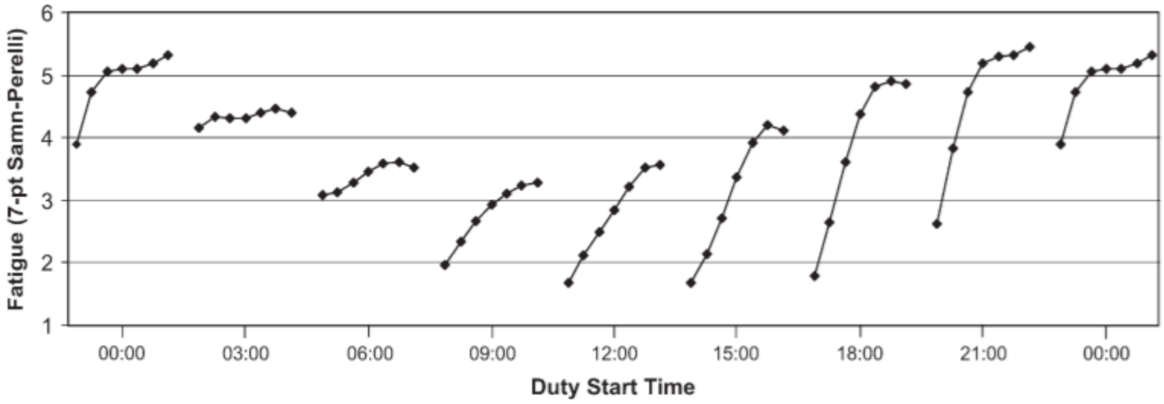
Figure 1 - Fatigue by Duty Length and Time of Day (Powell et al. 2007)



The vertical axis of Figure 1 shows the Samn-Perelli fatigue measure. The horizontal axis gives the time at the top of the last descent of the day. This is the time when the level of pilot fatigue was measured. Each individual curve shows how the level of fatigue changes over the day given a prior duty time. Note that while the level is shown as discrete points, in reality there is a range of levels of fatigue in each case, dependent on operational demands on the day and natural range of human performance.

Figure 2 is from Powell et al. (2008) and gives how the level of fatigue increases along with increased length of prior duty, and how this is influenced by duty start time.

Figure 2 - Trends in Fatigue with Increasing Length of Duty



As in Figure 1, the vertical axis of Figure 2 gives the Samn-Perelli fatigue measure. However, in this case, the horizontal axis now gives the duty start time. The seven points on each curve relate to lengths of duties of 3 hours, 4.5 hours, 6 hours, 7.5 hours, 9 hours, 10.5 hours, and 12 hours, respectively.

Figure 1 and Figure 2 indicate that flight crews operating in the late hours face greater susceptibility to the fatigue that results from the prior duty time.

Note on the Samn-Parelli Scale

The research by Powell et al. (2007, 2008) makes use of the ICAO-recognised Samn-Perelli fatigue scale. The following extract from *The Principles and Practice of Sleep Medicine* describes elements of the Samn-Perelli scale:

> *The scale was developed for military airlift operations and has been widely used in aviation studies. The original scale explicitly linked ratings to the likelihood of performance impairment. At scores of 1 to 3, no fatigue related performance is expected. For a score of 4, "performance impairment is possible but not a significant factor." A score of 5 is equated with "moderate fatigue, performance impairment possible, flying duty permissible but not recommended unless urgent." A score of 6 is equated with "severe fatigue, performance impairment probable, flying duty not recommended. A score of 7 is equated with "severe fatigue, performance definitely impaired, flying duty not recommended, safety of flight in jeopardy"*

In the case of Queenstown night operations, where a high level of crew performance is essential, a score of 4 or above must be considered a significant risk factor.

Summary

Flight crews operating during the late hours face greater susceptibility to fatigue resulting from prior sectors flown. Fatigue is a key driver in flight crew error, which the Night operations Foundation Safety Case identified as a significant threat within the context of Queenstown night-time operations. Given the demanding nature of winter night-time operations at Queenstown, it would be unwise to consider removal of controls that are intended to manage flight crew error.

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