European Commission

Effectiveness of Flight Time Limitation (FTL)

D3.2 Benchmark of this Analysis with Other Relevant Resources

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Chapter 1: Introduction to the research study

Main objective and scope of the research study

The European Aviation Safety Agency (EASA) was mandated to perform a continuous review of the effectiveness of the rules concerning flight and duty time limitations and rest requirements contained in Annexes II and III of Commission Regulation (EU) No. 965/2012[1].

The review commenced in 2017 with the commission of a research study.

The research study was broken down into smaller phases; each focused on specific flight duty periods (FDPs). The first and current research phase studied the following two FDPs:

- FDP1: Duties of more than 10 hours at the less favourable time of day.
  This focuses on operations that encroach (fully or partially) any portion of the period between 02:00h and 04:59h; and
- FDP2: Disruptive schedules.
  This focuses on consecutive early duty starts, late duty finishes, night duties, and combinations thereof.

Scope of the current deliverable

This Deliverable D3.2 (Benchmark of this Analysis with Other Relevant Sources) reports the results of the work performed to benchmark the findings of the aircrew data collection with other relevant sources – e.g., the results of other comparable studies carried out elsewhere – identified in D1 (Definition of the Baseline).

[1] Commission Regulation (EU) No. 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operations pursuant to Regulation (EC) No. 216/2008 of the European Parliament and of the Council.

Chapter 2: The results of the benchmarking

Fatigue during FDP1 (Night duties of more than 10 hours)

During 41% of all long-night FDPs high fatigue ratings (i.e. KSS ≥ 7) were observed in flight crews at top of descent (TOD) in the present study. This percentage was comparable to recent observations by Sallinen et al. (2017) who found that irrespective of FDP duration, the percentage of night FDPs with occurrence of high fatigue in pilots was approximately 50%. The higher percentage in the latter study may have been due to the fact that fatigue was assessed during various phases of each single flight within a FDP whereas our study focused on TOD of the final flight. Whereas the percentage of night-time FDPs with high fatigue must be considered high, the respective odds as estimated by logistic regression did not differ (OR = 1.06, not significant) between long-night FDPs (> 10h) and short-night FDPs (≤ 10h).

Our analyses furthermore revealed that long- and short-night FDPs differed with respect to several factors, including the time awake, sleep in the past 24 hours, and the timing of TOD with regard to the window of circadian low (WOCL). When controlling for some of these factors, FDP duration did not emerge as a significant contributing factor. This indicates that its influence on night-time fatigue was rather limited compared to the very strong time of day (i.e., circadian) effect. Our findings are consistent with those from studies of long-haul und ultra-long range operations in which FDP duration did not appear to be a significant predictor of fatigue during night-time flights in pilots (Gander et al. 2013, 2014, 2015) and in cabin crew (van den Berg et al. 2015) as long as sufficient sleep prior to and during the FDPs was obtained. It needs to be noted, however, that in the case of long-haul operations this also included in-flight sleep. In a study on short-haul pilots Powell et al. (2008) identified an effect of duty duration on fatigue. For long duties that began in the evening hours and extended into or beyond the WOCL this effect was rather small; for example an increase of approximately 0.25 points on the Samn-Perelli (SP) scale between 7.5 hour and 12 hour on duty. In contrast, in the same studies, fatigue at the end of a 12-hour duty varied by more than 2 points when duties with different start times across the 24-hour cycle were compared.

Benchmark studies together with our own study indicate that increasing prior sleep (quantified in the present study as sleep in the past 24 hours) appears to be a more effective strategy to mitigate crew fatigue at TOD during night FDPs than reducing FDP duration. Spencer and Robertson (1999) did recommend limiting night duties to 10 hours in their study on aircrew fatigue during the around-the-clock Haj operation between Indonesia and Saud-Arabia.

Fatigue during FDP2 (Disruptive schedules)

Early starts

During 19% of all early start FDPs high fatigue ratings were observed in crews. The odds of experiencing high fatigue when compared to daytime FDPs were 2.02. No significant contributing factor emerged in multiple logistic regression analysis. Analysis by single factors (univariate, unadjusted) pointed to a marginal influence of the start time such that an earlier start time of an FDP increased fatigue. Roach et al. (2012) reported that in short-haul pilots sleep duration immediately prior to FDPs starting in the morning (04:00h - 10:00h) decreased with earlier start times. Similar results were observed by Cabon et al. (2012) in regional airline operations. Earlier start times were also associated with higher fatigue at duty start (Roach et al. 2012). Although a less favorable time of day (i.e., circadian effect) may have contributed to the latter finding, the authors of that study stress the importance of increasing sleep duration prior to early start FDPs through scheduling and fatigue risk management. The average sleep duration prior to early starts was 5.4 hour in both the study by Roach and the present study. It is important to note, however, that early starts in the study by Roach also included FDPs that began before 05:00h. Indeed, by including duty starts between 03:00h and 06:59h ('very early starts') in our analysis the fatigue reducing effect of sleep duration became stronger and reached statistical significance.

In general, of all the disruptive duties the early starts turned out to be associated with the lowest fatigue scores. The results are consistent with recent studies in short-haul pilots by Vejvoda et al. (2014) who specifically compared fatigue levels between early starts and late finishes. Taking the current study and earlier studies together, the results indicate that through increasing sleep duration prior to an FDP, particularly in the last 24 hours (e.g. Thomas & Ferguson, 2010), the negative effects of early and very early starts on fatigue could be reduced. On the other hand it should be kept in mind that the ability to initiate sleep in the evening hours prior to an early start is limited so far as sleep is attempted during the circadian wake maintenance zone.

Late finishes

During 31% of all late finish FDPs high fatigue ratings were observed in crews. The odds ratio for flight crews to experience high fatigue when compared to daytime FDPs was 3.77. Longer FDP duration was the only predictor of high fatigue. The results are consistent with observations in short-haul pilots by Vejvoda et al. (2014). These authors also reported that average fatigue levels at end of late finishing duties reached moderate to severe levels (20-point SP fatigue checklist). Moreover, they separated out FDP duration and the time awake prior to the start of the FDP and found that both factors affected fatigue at the end of duty, indicating that late finish FDPs are associated with long times awake at a time when the circadian system stops promoting alertness (Dijk et al. 1992). Thus, taken together, the data suggest that limiting the FDP duration and breaking up the extended time awake, for example by strategically placed naps, may reduce fatigue in late finish FDPs. Of note, even a decent amount of sleep during the night prior to a late finish FDP (e.g. 7.6 hours in the study by Vejvoda) does not prevent high fatigue levels as long as the ensuing time awake remains continuous (e.g. 14 hours in the study by Vejvoda) and extends into the late night.

Other studies, in particular those that have focused on short-haul operations, identified the number of sectors and subjective workload as factors contributing to fatigue (Powell et al. 2007; Vejvoda et al. 2014; Aeschbach et al., 2017). Although these variables often increase together with time awake and/or duty duration, their influences on fatigue appear to be separate and additive. This was reported by a recent simulator study (Honn et al. 2016) in which the number of sectors (1 vs 5) was varied while duty duration was kept constant. In the present study no effect of the number of sectors was found. It is likely that such an effect becomes apparent only with a sizable variation in this variable (> 4), which is the case mainly for short-haul operations.

Nights

During 34% of night FDPs high fatigue ratings were observed in flight crews. The odds ratio for flight crews to experience high fatigue when compared to daytime FDPs was 3.21. Logistic regression analysis identified variables related to the timing of the FDP and thus representing a proxy of the underlying circadian effect, and sleep in the preceding 24 hours as factors contributing to crew fatigue. The very strong circadian effect is consistent with and confirms the results of many previous field studies in aviation (e.g. De Mello et al. 2008; Powell et al. 2008; Gander et al. 2014, 2015;

Sallinen et al. 2017) as well as of controlled laboratory studies (Cohen et al. 2010; Ferguson et al. 2012).

Whereas the performance impairment is strongest inside the WOCL (e.g. Powell et al. 2008), there is a complex interaction between the timing of a flight and FDP duration (Gander et al. 2015). For example a long FDP duration with TOD outside the WOCL may result in lower fatigue than a shorter FDP duration with TOD inside the WOCL. This complexity may have contributed to the absence of a significant effect of FDP duration in the current data set. Although this is not to say that FDP duration is not a relevant variable influencing fatigue in night duties, by its own it does not appear to be the primary factor to be controlled in order to limit fatigue at night. However, it is obvious that the length of time crew members are fatigued during night FDPs can be mitigated by shortening FDP duration.

Our FTL study indicates that sleep duration in the prior 24 hours significantly influences fatigue at TOD. This observation is in line with other observations in long-range transmeridian flights demonstrating the importance of pre- and inflight sleep, outweighing the role of the FDP duration (e.g. Gander et al. 2014). Moreover, laboratory studies revealed a non-linear interaction between acute and chronic homeostatic sleep pressure on one hand and circadian phase on the other hand such that the circadian fluctuations in human performance were much larger when sleep pressure was high compared to when it was low (Cohen et al. 2010). These results underscore the importance of optimizing prior sleep duration as a means to reduce the extent of the negative effect of the WOCL on crew performance.

Interestingly, cabin crew experienced proportionately more often high levels of fatigue at TOD compared to pilots. This is unlikely to be due to differences in the gender distribution. Although females were previously reported to rate higher sleepiness than males (Åkerstedt et al. 2017), gender did not emerge as a significant factor affecting fatigue in the current study. Instead, there may be differences in situational factors at the time of TOD. Whereas cabin crew presumably just completed a busy work period in the cabin, pilots were engaged in alertness-promoting activities as they prepared for landing.

Two consecutive disrupting schedules

Fatigue did not increase from the first duty to the second duty for any of the consecutive disruptive duties. The limited data available did not allow us to draw conclusions over more than two consecutive disruptive duties. Judging from the odds ratios obtained in logistic regression analysis, it appears that the effects size for a difference in fatigue between any disruptive FDP and a daytime FDP is greater than the effect size for a difference between two consecutive disruptive FDPs. Whereas this aspect of duty scheduling and fatigue has not been researched systematically, laboratory studies indicate that continued sleep restriction over several days results in a monotonic decline of cognitive performance (e.g. Belenky et al. 2003; Cohen et al. 2010).

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List of abbreviations

Abbreviations	***Description***
D	Deliverable
EASA	European Aviation Safety Agency
EC	European Commission
EU	European Union
FDP	Flight Duty Period
FTL	Flight Time Limitation
KSS	Karolinska Sleepiness Scale
SP	Samn-Perelli
TOD	Top Of Descent
WOCL	Window Of Circadian Low

European
Commission