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Report

"Effectiveness of Flight Time Limitation (FTL)"



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1 Executive summary

This report gives an overview of the work performed, results and recommendations, and critical assessment of the review of the effectiveness of the EU requirements concerning flight and duty time limitations and rest requirements.

A scientific study ranked duties by their impact on aircrew fatigue and focussed on the top-two ranked fatiguing duty types over 2 years.

This first phase of the research assessed the impact of 'night duties longer than 10 hours' and 'disruptive schedules' on the fatigue of aircrews. The research found an increased probability of high fatigue levels during nights and duty periods with late finishes, among both pilots and cabin crew. No significant increase of probability of high levels of fatigue at TOD was found for early start FDPs. A marginal increase was found for mixes of disruptive schedule FDPs.

The results of this phase highlight that prescriptive limits alone are not sufficient to prevent high fatigue during night flights. Further research is recommended alongside other actions to support air operators with their responsibility to tailor more effective fatigue risk management strategies for night duties.

2 Background

EASA has been mandated to perform a review of the effectiveness of the rules concerning flight and duty time limitations and rest requirements (FTL) contained in Annexes II and III of Commission Regulation (EU) No 965/2012.

The review shall include an assessment of the impact on aircrew alertness for the following envelope of duty periods¹:

1. duties of more than 13 hours at the most favourable time of the day,
2. duties of more than 10 hours at the less favourable time of the day,
3. duties of more than 11 hours for crew members in an unknown state of acclimatisation,
4. duties including a high level of sectors (more than 6),
5. on-call duties such as standby or reserve followed by flight duties, and
6. disruptive schedules.

The review commenced in 2017 with the commission of a scientific study. In view of both the large scope of the task encompassed by the review, it was eventually decided to breakdown the review work into several phases – with the first phase focusing onto two out of the six items referred to above.

One of the specific objectives of this first study was to rank the above listed duty periods based on the expected level of aircrew fatigue and select the two top-ranking as subject for the first study.

The research contract was awarded to a Consortium led by the Netherlands Aerospace Centre NLR with Stockholm University as partner and the German Aerospace Centre DLR, Jeppesen and the Finnish Institute of Occupational Health as subcontractors.

3 Research project

Renowned fatigue scientists were invited to join a Scientific Committee (SC) to support the Consortium during the project. The SC was asked to:

- assist with the gathering and synthesis of available background information and the definition of the scope and scale of the work to be performed during the project;
- support the project in the development of the data collection methodology;
- assess the suitability and significance of the sample population proposed for data collection;
- advise the project steering group with a view of ensuring that decisions are based on the best available scientific information; and
- provide a critique of the results of the project and peer-review the deliverables.

The SC engaged in critical review discussions for each milestone deliverable. Methods, documents and way forward were discussed during a total of eight encounters, either as meetings or WebEx conferences.

Furthermore, a Mirror Group (MG) with representatives of key stakeholders² interested in the review of the FTL regulation was set up to give advice to the definition of scale and scope, and to support the project in the data gathering by liaising with the relevant third parties – notably operators and national aircrew representatives.

Data for the analyses were obtained from three sources:

- an online survey with over 15000 aircrew respondents;
- rosters representing 260 000 flight duty periods (FDPs)³; and

¹ **Duty period** means a period which starts when a crew member is required by an operator to report for or to commence a duty and ends when that person is free from all duties, including post-flight duty. (ORO.FTL.105 (11), Annex III of COMMISSION REGULATION (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operation

² National aviation authorities, air operators, industry and crew member organisations

³ **Flight duty period (FDP)** means a period that commences when a crew member is required to report for duty, which includes a sector or a series of sectors, and finishes when the aircraft finally comes to rest and the engines are shut down, at the end of the last sector on which the crew member acts as an operating crew member (ORO.FTL.105 (12), Annex III of COMMISSION

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- a field study with participation from 381 crew members from 24 airlines.

The MG met at the beginning and at the end of the project. The purpose of the initial meeting was to explain the objective of the project and the role of the MG. During the project, the MG was briefed on the progress in two WebEX conferences and via e-mail updates. A wrap up meeting was held at the end of the projects to brief the MG on the findings and recommendations.

The results from the online survey and the bio-mathematical analysis of a range of possible specific schedules of each of the six duty periods were used to rank the listed aircrew duty periods based on the severity of fatigue. The two top-ranking aircrew duties were:

- duties of more than 10 hours at the less favourable time of the day and
- disruptive schedules⁴.

To review of the state of the art in aviation fatigue and alertness was compiled and fatigue experts with recent experience in large-scale fatigue studies in an operational aviation environment were interviewed. The information from the literature review and interviews was considered for the field data collection. A subset of Member States that are representative of the existing conditions in the EU aviation sector as a whole was selected and a set of criteria was defined to screen commercial air transport (CAT) aeroplane operators with the objective to identify a representative aircrew member population and the relevant types of operations for the field data collection. This method resulted in a set of candidate EU CAT operators which were approached and asked to participate in the data collection. Any other CAT operator could also volunteer to participate. 24 CAT operators volunteered to participate. 381 aircrew members offered to take part in the field data collection. The information collected concerned fatigue, sleepiness, mental effort and sleep for a period of 14 consecutive days. Objective sleep measurements were used to validate a subset of the sleep log data which were gathered with an online application.

REGULATION (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operation

⁴ **Disruptive schedule** means a crew member's roster which disrupts the sleep opportunity during the optimal sleep time window by comprising an FDP or a combination of FDPs which encroach, start or finish during any portion of the day or of the night where a crew member is acclimatised. A schedule may be disruptive due to early starts, late finishes or night duties (ORO.FTL.105 (8), Annex III of COMMISSION REGULATION (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operation

Early type of disruptive schedule means (ORO.FTL.105 (8a)):

- (i) for 'early start' a duty period starting in the period between 05:00 and 05:59 in the time zone to which a crew member is acclimatised; and
- (ii) for 'late finish' a duty period finishing in the period between 23:00 and 01:59 in the time zone to which a crew member is acclimatised.

Late type of disruptive schedule means (ORO.FTL.105 (8b)):

- (i) for 'early start' a duty period starting in the period between 05:00 and 06:59 in the time zone to which a crew member is acclimatised; and
- (ii) for 'late finish' a duty period finishing in the period between 00:00 and 01:59 in the time zone to which a crew member is acclimatised.

4 Research results

The field study showed an increased probability of high levels of fatigue⁵ at Top of Descent⁶ (TOD) during night⁷ and late finish⁸ FDPs compared to the baseline FDP⁹. No significant difference in fatigue at TOD was found between night duties longer than 10 hours, compared with shorter night FDPs. Night FDPs, both longer and shorter than 10 hours, were associated with an increased probability of high fatigue at TOD. This is not fully reflected in the current FTL regulation and guidance material. The regulation and guidelines explicitly note the need for appropriate fatigue risk management and the importance of obtaining sufficient sleep in relation to night duties *longer* than 10 hours, but not for those *shorter* than 10 hours.

Within the FDPs defined as 'night' FDPs in the current regulations, three subgroups can be distinguished and ranked based on the probability of occurrence of high fatigue at TOD:

1. FDPs starting between 2.00 and 4.59;
2. FDPs ending between 2.00 and 5.59 and starting at 1.59 or earlier; and
3. FDPs ending at 6.00 or later and starting at 1.59 or earlier.

The existence of these subgroups is not recognised in the current FTL regulation. Distinguishing these subtypes could help operators to design effective fatigue risk management strategies. No significant increase of probability of high levels of fatigue at TOD was found for disruptive schedules classed as early start FDPs. A marginal increase was found for mixtures of disruptive FDPs¹⁰.

The factors that best predicted increased odds of high fatigue at TOD varied by FDP type. This suggests that fatigue mitigation measures should be based on various fatigue management strategies and tailored to FDP type and operator context.

Since there are multiple other more influential determinants, the increased fatigue at TOD during longer night duties may be difficult to effectively control by merely adjusting the FDP duration. There are other non-schedule related strategies for reducing fatigue at TOD during (long) night FDPs. The use of rest before or during FDPs is supported by the findings about the frequency of napping on the flight deck. The frequency was higher than expected, as napping on the flight deck is only allowed to manage unexpected fatigue and to reduce the risk of fatigue during higher workload periods later in the flight.

5 Recommendations

The existence, frequency, and characteristics of the 'night' FDPs varies with each operator. It is therefore not possible to provide precise recommendations that would be of equal effectiveness for every operator. However, each operator may manage the fatigue risk of its specific characteristics of its schedule effectively

⁵ A high level of fatigue was defined by a KSS score ≥ 7 and an SP score ≥ 6 . The Karolinska Sleepiness Scale (KSS) measures the subjective level of sleepiness at a particular time during the day. On this scale subjects indicate which level best reflects the psycho-physical state experienced in the last 10 min. The KSS is a measure of situational sleepiness.

The Samn-Perelli Fatigue Checklist was originally designed as a simple measure of subjective state fatigue in pilots and is now widely used in fatigue research. Subjects rate their current fatigue on a 7-point Likert scale: 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.

⁶ Top of descent is referring to the computed transition from the cruise phase of a flight to the descent phase, the point at which the planned descent to final approach altitude is initiated.

⁷ **Night duty** means a duty period encroaching any portion of the period between 2.00 and 4:59 in the time zone to which the crew is acclimatised (ORO.FTL.105 (9)).

⁹ **Baseline FDP:** all collected FDPs

¹⁰ **Mixed FDPs** means an early start FDP preceded by a late finish FDP; an early start FDP preceded by a night FDP; a late finish FDP preceded by an early FDP; a late finish FDP preceded by a night FDP; a night FDP preceded by an early start FDP; and a night FDP preceded by a late finish FDP.

by following the principles of fatigue risk management. Therefore, the recommendations are aimed at fatigue risk management.

5.1 Recommendation 1

It is recommended to amend the definition of 'night' FDP to reflect the different subgroups of 'night' FDPs. This would help operators to design effective fatigue risk measures.

5.2 Recommendation 2

The current FTL regulation does not require operators to apply appropriate fatigue risk management to late finish FDPs. It is recommended to require operators to apply appropriate fatigue risk management to mitigate the fatiguing effect of late finish FDPs, regardless of FDP duration.

5.3 Recommendation 3

The study results indicated that high fatigue at TOD during night FDPs of both long duration (> 10h) and shorter duration (\leq 10h). It is recommended to require operators to apply appropriate fatigue risk management to mitigate the fatiguing effect of *all* night FDPs, regardless of FDP duration.

5.4 Recommendation 4

Within night FDPs, duty periods that end at 6.00 or later combined with a start at 1.59 or earlier show the greatest probability of high fatigue at TOD. It is recommended that the regulation define this category of FDP and require operators to pay specific attention to these FDPs when applying fatigue risk management.

5.5 Recommendation 5

The study found shorter prior sleep to be a predictor of high fatigue at TOD for all night FDPs. The current guidance material for night duties (GM1 CS FTL.1.205) stipulates that it is 'critical for the crew member to obtain sufficient sleep' for night duties longer than 10 hours. It is recommended that the GM be amended to state that it is critical for the crew member to obtain sufficient sleep before *all* night duties, regardless of FDP duration.

5.6 Recommendation 6

The analysis provides evidence of high fatigue at TOD during night FDPs. This seems to be fairly independent of FDP characteristics (e.g. start and end times, duration), as long as the FDP in question meets the criteria for a night FDP. The amount of prior sleep is the main predictor of eventual fatigue, therefore we recommend that for night FDPs, operators should be required to promote optimum use of sleep opportunities (i.e. before reporting and during the FDP).

6 Implementation of the recommendations

EASA shall evaluate in its next safety programming cycle the prioritisation of a rulemaking action to amend existing AMC and GM to the FTL regulation with a view to better reflect the different types of night duties.

Ensuring that crew members obtain sufficient sleep is a shared responsibility of the operator and the crew. The current regulation already describes the need for operators to provide resting opportunities and for crew to make optimum use of such opportunities. As this is essential for effective fatigue risk management, EASA should engage with national civil aviation authorities and industry stakeholders to actively promote the provision and use of rest facilities at or near airports in order to improve the probability of obtaining sleep as close as possible to the start of the night duty, as well as the use of resting opportunities (controlled rest and in-flight rest) in the context of night duties.

7 Follow-on actions

7.1 Assessment of the four remaining FDPs of interest

The review of the effectiveness of the FTL regulation was broken down into smaller research phases. The first phase studied the two top ranked FDPs; i.e. night FDPs of more than 10 hours and disruptive schedules. The FDPs ranked from third to sixth based on their expected level of fatigue still remain to be studied. EASA will call for tenders for a second phase of the review, notably of

- duties of more than 11 hours for crew members in an unknown state of acclimatisation;
- duties including a high level of sectors (more than six);
- duties of more than 13 hours at the most favourable times of the day; and
- on-call duties such as standby or reserve, followed by flight duties.

The rules concerning flight and duty time limitations and rest requirements are a system of interrelated prescriptive limits and management responsibilities. It is therefore preferable that the recommendations resulting from studies on all six FDPs and additional fatigue management subjects of interest are available and used to update the FTL rules.

7.2 Additional research on fatigue management

The findings on napping on the flight deck do not indicate to what extent naps were taken under a controlled rest procedure¹¹. 'Controlled rest' means an 'off task' period of time that may include actual sleep. Research has shown that short, controlled rest is an effective in-flight fatigue-mitigation strategy, as it can enhance alertness and performance. Therefore, EASA should include an assessment of the impact of controlled rest in its future research activities on the effectiveness of the FTL regulation.

Training and education are fundamental requirements for fatigue risk management. The current FTL regulation provides details on content to be covered in initial and recurrent fatigue management training for crew members, for personnel responsible for the preparation and maintenance of crew rosters, and for the management personnel concerned. It would be worthwhile to study further the effectiveness of the fatigue management training content and frequency.

8 Critical assessment of the project

8.1 Suggestions of the Consortium

The data collection was unique in that 24 different airlines agreed to participate and a large number of crew members within Europe were invited to join the field study and gather data. This crowdsourcing method yielded a sample over which the project only had indirect control. The subsequent research on the

¹¹ Although flight crew members should stay alert at all times during flight, unexpected fatigue can occur as a result of sleep disturbance and circadian disruption. To cover for this unexpected fatigue, and to regain a high level of alertness, a controlled rest procedure in the flight crew compartment, organised by the commander may be used, if workload permits and a controlled rest procedure is described in the operations manual. 'Controlled rest' means a period of time 'off task' that may include actual sleep. The use of controlled rest has been shown to significantly increase the levels of alertness during the later phases of flight, particularly after the top of descent, and is considered to be good use of crew resource management (CRM) principles. Controlled rest should be used in conjunction with other onboard fatigue management countermeasures such as physical exercise, bright cockpit illumination at appropriate times, balanced eating and drinking, and intellectual activity. Controlled rest taken in this way should not be considered to be part of a rest period for the purposes of calculating flight time limitations, nor used to justify any duty period. Controlled rest may be used to manage both sudden unexpected fatigue and fatigue that is expected to become more severe during higher workload periods later in the flight.

remaining four types of duty periods should undertake specific actions to increase the participation of women and cabin crew. The current field study population consisted of 75 % male and 68 % pilots, which is not representative of the demographic distribution the EU's aircrew population. Therefore, future research on the effectiveness of the FTL regulation should favour a more focussed data collection method.

8.2 Suggestions of the Scientific Committee

In the critical assessment of the work performed by the Consortium the SC highlighted in particular that:

- the literature review was incomplete and focussed mostly on methodological aspects;
- the time frame of the project complicated fulfilling the requirement to assess a sample of operators that were representative of the entire EU aviation industry;
- the Consortium successfully recruited 24 operators which proportionately represented the geographic distribution and size of aviation operators across Europe;
- additional scheduling factors, such as labour agreements and other air operator specific fatigue mitigations were not identified;
- the research did not thoroughly consider the schedules being worked, for example, how much time off was provided before or after long nights, or how early starts or late finishes were sequenced in runs of consecutive duties;
- participating operators were not specifically selected because they work schedules that are close to the regulatory limits, which means that the study does not constitute a 'pressure test' of the regulations;
- the results of this study provide an insight into how the regulations are incorporated in the day-to-day business, rather than of the effectiveness of the regulations per se.

The SC acknowledged that this has been the largest crew fatigue study across Europe so far and recognised that some important conclusions can be drawn from this study.

- The probability of high fatigue during FDPs night is not simply related to the duration of the FDP, as there are other influential factors such as the amount of sleep a crewmember obtains before the duty and the start and finish time of the duty.
- Therefore, rather than simply limiting FDP duration, a more comprehensive approach to managing the fatigue associated with night duties is necessary.
- The definition of a night FDP in the current regulation is too broad, and the three subcategories suggested by the researchers should be utilised instead.

The SC supported the recommendations of the Consortium. In addition, the SC highlights that there is need to better understand the actual practice of pre-flight and napping on the flight deck as effective mitigations for fatigue. At the same time the SC pointed out that sleep inertia¹² is associated with a reduction in performance, which makes it essential that the return of the napping crew member to an active role is managed.

9 Proposed actions

The following actions are proposed to address the issues that have been highlighted in this report:

- EASA shall publish a call for tenders for the second phase of research on the effectiveness of FTL. This second research project shall cover the four FDPs ranked from third to sixth plus an assessment of the impact of controlled rest in a more focussed manner. The second phase of research shall build on the lessons learned from the first phase. Notably, the recommendations of

¹² **Sleep inertia** is a physiological state of impaired cognitive and sensory-motor performance that is present immediately after awakening.

the Scientific Committee, as reflected in Appendix B, shall be considered for the design of the second phase. The research project shall start at the beginning of 2020 and shall run over 3 years. A scientific committee shall accompany the entire project, starting with supporting EASA with the selection of the best tender. EASA shall continue engaging Member States and industry stakeholders to support the second phase of the FTL research.

- EASA shall assess in its next safety programming cycle the prioritisation of rulemaking or safety promotion actions to better reflect the different types of night duties with a view to support air operators in their responsibility to manage fatigue.
- EASA shall engage with fatigue management experts from Member States, industry stakeholders and the scientific community to define a strategy to promote more decisively the use of resting opportunities in the context of night duties.
- EASA shall foresee in future safety programming cycles an assessment of the need to review the FTL regulation once the recommendations of the evaluation of the effectiveness of all FDPs listed in paragraph 2 are available.

Appendix A: Effectiveness of Flight Time Limitation (FTL) Final Report available via FTL Deliverables download on the [Effectiveness of Flight Time Limitation \(FTL\) Report](#) website

Appendix B: Scientific Committee Critique on the EASA Research Project Effectiveness of Flight Time Limitation available via the downloads area on the [Effectiveness of Flight Time Limitation \(FTL\) Report](#) website