Moebus

Final Report

"Scientific and Medical Evaluation of Flight Time Limitations"

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The aim of this study was to perform a scientific and medical evaluation of some of the FTL provisions contained in Subpart Q of the EU OPS. As a result, MOEBUS Aviation (MA) provided various independent experts as a special panel of experts in order to attain a consensus on 18 open points or to raise any other issues of relevance to mitigate fatigue and its effect on the safety of flight operations.

The project was planned to be executed within 8 months and 3 weeks, from January 4 to September 30, 2008 and is divided in three phases; 1) Familiarisation phase, 2) Investigation phase and 3) Final Report phase.

At the end of Phase 2, the expert panel (See below *Table 1*) had submitted an interim report of the work completed to that point. Although much effort had been exerted, no decisive conclusion could be drawn. However it became clear that most if not all open issues would be concluded in a consensus among the group of experts.

	Name	Organisation, Country
1	**Dr. Barbara Stone**	**QinetiQ, UK**
2	**Dr. Karen Robertson**	**QinetiQ, UK**
3	**Dr. Alexander Gundel**	**DLR, Germany**
4	**Mr. Martin Vejvoda**	**DLR, Germany**
5	**Dr. Mick Spencer**	**Human Factor Investigation, UK**
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8	**Dr. Philipp Cabon**	**University of Paris Descartes, France**
9	**Prof. Dr. Régis Mollard**	**University of Paris Descartes, France**
10	**Prof. Dr. Simon Folkard**	**Swansea University, UK**

Table 1 The list of the FTL expert Team

The following key events have taken place during the Phase 3:

- Continued analysis of the open 18 issues
- Experts meeting on 4th and 5th September 2008 at the premises of the DLR in Cologne, Germany
- Preparation of the draft final report
- Delivery of the final report to MOEBUS Aviation by 30.09.2008.
- Evaluation of data received and composition of FTL Final Report.

In conclusions, over the course of the global project, MA has fulfilled every step stone in order to arrive at milestone three and thus completing the project in its entirety.

We, MOEBUS Aviation are pleased to inform EASA of the successful end of the "Scientific and Medical Evaluation of Flight Time Limitations" which will assist EASA in its evaluation of the provisions of Subpart Q which the Agency is due to submit to the Commission by 16 January 2009 as mandated by Regulation (EC) No 1899/2006. It is our sincere wish to thank the members of ECASS which have provided, with their very unique expertise, the basis for this report.

The experts have come to a consensus on all of the 18 open issues laid before them. We expect and hope that this final report achieves the aim of the project and be useful to further discussion and work on FTL.

However, should you come across any questions or require more information, please feel free to contact us any time. Philipp Moebus' mobile phone: +41 (0)76 322 15 20 or Email: philipp@moebus-aviation.ch

Zurich Airport, 30.09.2008

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2 Introduction

2.1 Background Information

The aim of this study was to perform a scientific and medical evaluation of some of the FTL provisions contained in Subpart Q of the EU OPS. After a first review, EASA has concluded that some elements of the regulations on flight and duty time limitations and rest requirements need more attention to resolve disagreement between the main parties affected by FTL regulations. As a result, EASA decided to select MOEBUS Aviation to put various independent experts as a special panel of experts to reach a consensus on the below 18 points that had been identified by the FTL Advisory Group comprising the concerned stakeholders or to raise any other issues of relevance to mitigate fatigue and effect on safety of flight operations.

1. the permissible maximum of 180 duty hours in 3 consecutive 60 hour weeks and the 1800 block hours in 18 consecutive months (ref. EU OPS 1.1100)
2. the provisions for the maximum daily flight duty period (FDP), including extensions and mitigating conditions on their own, and in the framework of the entire subpart Q (ref. EU OPS 1.1105 para 1.3)
3. the use of rostered extensions including the mitigating measures (ref. EU OPS 1.1105 para2)
4. the FDP limit of 11:45 hours in the period 22:00 to 04:59, the need for additional provisions for duties within the WOCL, and the FDP limit of 11:45 hours starting in the WOCL on consecutive early days (ref. EU OPS 1.1105 para 2.7)
5. the provisions of FDP extension for cabin crew including the need for additional conditions (ref. EU OPS 1.1105 para 3.1)
6. which detailed provisions and guidelines are needed within Subpart Q regarding split duty (ref. EU OPS 1.1105 para 6)
7. what provisions and/or guidelines are needed on rest for time zone crossings (ref. EU OPS 1.1110 para 1.3)
8. what provisions are needed for reduced rest arrangements (ref. EU OPS 1.1110 para 1.4.1)
9. the potential impact of reporting at 0400 on the effectiveness of the weekly rest period (ref. EU OPS 1.1110 para 2.1)
10. the effects of the format of rest periods on cumulative fatigue (ref. EU OPS 1.1110 para 2.1)
11. what provisions are needed for extended FDP operations with augmented crews and/or timezone crossings (re. EU OPS 1.1115 para 1.1)
12. the quality of rest regarding rest location / rest facilities for flight crew and cabin crew (re. EU OPS 1.1115 para 1.1 and 1.2)

13. what provisions are needed for cabin crew regarding extended FDP operations with in-flight rest and/or time zone crossings? (re. EU OPS 1.1115 para 1.2)

14. what provisions are needed for the calculation of maximum FDP when called out from airport standby (re. EU OPS 1.1125 para 1.3)

15. what provisions are needed for the calculation of maximum FDP and minimum post duty rest when called out from other forms of standby (re. EU OPS 1.1125 para 2.1.4)

16. what guidelines are needed for the counting of standby times for cumulative duty hours (reEU OPS 1.1125 para 2.1.5)

17. what guidelines are needed for the provision of a meal and drink opportunity, in particular for cabin crew (re. EU OPS 1.1130)

18. the possibility of alterations to Subpart Q for operations which are exclusively based on night time operations, particularly regarding the number of consecutive night duties and FDP provisions (ref. EU OPS Article 1 Recital 9a)

These 18 open issues of Flight Time Limitations (FTL) were presented to the experts of ECASS (European Committee for Aircrew Scheduling and Safety). As the group comprises a number of experts from different fields, covering specific aspects of human performance and medical issues attributed to flight time limitations, individual issues were assigned to the appropriate experts. The findings of the experts are then circulated within the group for second opinions and verification.

Once the process of analysis/research, crosschecks and verification was completed it formed the consolidated opinion of the group and is represented as such.

This process, though time consuming and expensive ensured a most accurate answer to the open issues under the given conditions. Although a consensus had been found on all open issues, some of the issues may require further scrutiny or even dedicated detailed research in order to derive to a more decreeing answer where necessary.

2.2 Objective of Phase 3

The final phase was set out to conclude a final consensus on as much of the 18 open issues as possible. It is our distinct pleasure to announce that such consensus, though unexpected, had been reached by the ECASS group. Further, the appropriate work to populate the final report had been concluded, bringing the project of "Scientific and Medical Evaluation of Flight Time Limitations" to a conclusion

These final findings have been integrated and only reformatted to fit into this report under point 3. The report of the ECASS experts is in full and nothing of its original content has been changed, added, omitted or otherwise been tempered with by MOEBUS Aviation.

3 Final Report of ECASS on the Scientific and Medical Evaluation of Flight Time Limitations

3.1 ECASS findings

The findings of ECASS were submitted to MOEBUS Aviation and are integrated below;

Consensus report prepared by ECASS:

Scientific and medical evaluation of flight time limitations

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Dedication

We dedicate this report to our late colleague Dr Alex Samel who contributed so much to the understanding of aircrew fatigue and performance and who is greatly missed.

Introduction

This review has been undertaken by ECASS (European Committee for Aircrew Scheduling and Safety) on behalf of Moebus Aviation. The report has been prepared in response to the 18 questions specified in the ITT (No. EASA.2007.OP.08) entitled 'Scientific and medical evaluation of flight time limitations', and it represents the views of all the members of ECASS.

In addressing the questions we have drawn on data from a range of relevant areas, including the scientific literature on fatigue and performance related to flight crews, as well as data from other modes of transport and from other occupational groups. Many of the studies relating to aircrew have been undertaken by members of the ECASS group themselves. The 18 questions cover a wide range of different topics. Some of these topics have been studied in considerable detail and we are able to make specific recommendations. Elsewhere, where information is lacking, we have indicated whether further studies would be necessary and beneficial.

We have concentrated on the specific issues highlighted in the 18 questions, and have not sought to extend the discussion more generally to other aspects of Subpart Q. The only exception is the inclusion of a definition of 'acclimatization', as this term is referred to in some of our answers. We have deliberately kept our answers brief, but would be happy to expand further on any of the issues if required.

In many of our responses we have suggested the specific limits that we would consider to be appropriate. However at all times we have attempted to keep in mind practical issues, and have not proposed limits which are, in our view, unreasonably restrictive. There is a problem faced by all FTL schemes that set prescriptive limits across a comprehensive range of issues. Even if individual limits are set at reasonable levels it may be possible to construct schedules within the regulations where a combination of factors gives rise to an unacceptable schedule. Yet at the same time, perfectly acceptable schedules may be prohibited. It is for this reason, among others, that approaches based on a Fatigue Risk Management System (FRMS) [ICAO, 2008] are now becoming more widespread. We would certainly support this development and have identified in some of our answers where such an approach would be desirable.

Finally, we should mention that our recommendations are not intended to apply to ultra-long-range (ULR) operations, as these are subject to a different regulatory approach, based on guidance material produced by the Flight Safety Foundation.

Question 1

The permissible maximum of 180 duty hours in 3 consecutive 60 hour weeks and the 1800 block hours in 18 consecutive months (ref. EU OPS 1.1100).

Scientific research has established that fatigue [Spencer MB *et al*, 2006] and the risk of accidents and injuries [Folkard S & Tucker P, 2003] increases over successive work days, and that these increases are dissipated over periods of rest days. While the scientific evidence is not sufficient to support the precise values given in OPS 1.1100, most of the values contained in it seem "reasonable", although we would prefer to see a lower limit (of perhaps 180 hours) per 28 consecutive days. Nevertheless, if it is deemed that the protection provided by the 190 hour duty limit in 28 days is "reasonable" (based on experience rather than scientific evidence), it seems unreasonable to permit almost all these hours to be worked in the first 21 days. Further, the "180 duty hours in 3 consecutive 60 hour weeks" cited in Question 1 are at odds with the requirement that the "190 duty hours in any 28 consecutive days" are "spread as evenly as practicable". In the light of these problems we feel that an additional limit per 14 consecutive days is required. This would form OPS 1.1100, para 1.1(c), and read:

> 1.1.(c) and 100 duty hours in 14 consecutive days.

It should also be borne in mind that everything depends on the type of duty that is being carried out (days, nights, regular, irregular, short-haul, long-haul, etc). We consider that these duty limits would be too high for long-haul duties across multiple time zones, and that it would be appropriate to have lower limits for these disruptive schedules. However, we recognise that long-haul operations are effectively restricted not by the duty limits, but by the block limits (para 1.2(b)) i.e.100 block hours in 28 consecutive days. This follows from the fact that the majority of time spent on such long-haul duties is spent actually flying, in contrast to short-haul, multi-sector duties.

Likewise, the "1800 block hours in 18 consecutive months" cited in Question 1 seems to us to be unreasonable. The problem here is that EU OPS 1.1100 para 1.2(a) limits block hours per 'calendar year' rather than 'per 12 consecutive calendar months', thereby allowing 900 hours to be worked in the final nine months (nine x 28 days) of one year and 900 hours in the first nine months (nine x 28 days) of the following year. To overcome this problem we would recommend changing para 1.2(a) to read:

> 1.2(a) 900 block hours per 12 consecutive calendar months.

Question 2

The provisions for the maximum daily flight duty period (FDP), including extensions and mitigating conditions on their own, and in the framework of the entire subpart Q (ref. EU OPS 1.1105 para 1.3).

The provisions of EU OPS for the maximum basic FDP of 13 hours (extending up to 14 hours) are not in keeping with the body of scientific evidence. Duty length has been associated with the risk of accidents. For duties of 10-12 hours the relative risk of an accident was 1.7 times higher than for all duties, and for duties of 13 hours or more, the relative risk was over 5.5 times higher [Goode JH, 2003]. In addition, field studies of single-sector two-crew operations have shown that some crews were having difficulty remaining awake during overnight duties of 11 hours or more [Samel t al, 1997a; Spencer MB & Robertson KA, 1999]. Based on this and other information elating to fatigue and sleepiness, it is recommended that FDPs for minimum crew should not exceed 10 hours overnight. It has also been shown that during the day crews will be able to undertake longer FDPs than at night but this will depend on the duty start time [Samel A et al, 1997a; Samel A et al, 1997b; Spencer MB & Robertson A, 2007], and hence the amount of prior sleep, and whether they are acclimatized to local time, but a single FDP should never exceed 13 hours. It is recommended that a single maximum daily FDP should be set, based on duty start time, which excludes the provision for extensions. For example, 13-hour FDPs are only acceptable under specific conditions; these include the opportunity to obtain a sufficiently long prior rest period, a single sector, and a favourable duty start time.

The development of cumulative fatigue tends to be increased during consecutive periods of duty, especially for long duties or when early starts, late finishes or overnight duties are involved that disrupt the normal pattern of sleep [Spencer MB & Robertson KA 2000; Spencer MB & Robertson KA 2002]. It is sensible therefore to limit the number of duties and/or reduce the maximum FDP of these duties when they run consecutively, especially where they are close to maximum FDP limits. Following a sequence of consecutive duties mitigating strategies could involve scheduling a rest day including one local night.

A number of studies have shown that fatigue increases with the number of sectors [e.g. Powell DM et al, 2007; Spencer MB & Robertson KA, 2000; Niederl T et al, 2008; Bourgeois-Bougrine S et al, 2003]. Based on this information, it is recommended that the maximum FDP be reduced by 30 minutes per sector for every sector after the first. As there is limited information on the effect of more than four sectors on fatigue, further studies are required.

Currently, EU OPS does not include any provisions that relate to crew acclimatization. Desynchronization from local time following time zone crossings is known to lead to impairments in alertness and performance [Klein KE et al, 1970; Samel A et al, 1995]. For this reason, it is suggested that the maximum FDP should be reduced for unacclimatized crews. Guidance could be provided on how to manage and implement provisions associated with time zone transitions but this is beyond the scope of this question. As a general rule, the rate of synchronization could be approximated by the use of a factor that assumes a one-hour adjustment per day. However, in some circumstances this may overestimate the time required for adaptation to the new time zone.

The information outlined above emphasises the complexity of flight time limitations and the fact that it is very difficult to propose simple maximum FDP limits that properly account for all the relevant variables (e.g., duty start time, number of consecutive duty days, number of sectors, duration of duty periods preceding the current duty, degree of acclimatization, etc.). In summary, the provisions for the maximum FDP proposed by EU OPS are not supported by the available data. To formulate more precise limits further studies are required.

Question 3

The use of rostered extensions including the mitigating measures (ref. EU OPS 1.1105 para 2).

As outlined in question 2, it is strongly recommended that the provision of extensions to the maximum FDP are removed from EU OPS.

Question 4

The FDP limit of 11:45 hours in the period 22:00 to 04:59, the need for additional provisions for duties within the WOCL, and the FDP limit of 11:45 hours starting in the WOCL on consecutive early days (ref. EU OPS 1.1105 para 2.7).

Night duty is associated with work during the circadian trough and extended time awake. During night hours fatigue increases and vigilance decreases more markedly with ongoing duty hours than during the day. Scientific investigations show that night duty hours are especially vulnerable to severe fatigue [Samel A et al, 1997b; Spencer MB & Robertson KA, 1999] and there is also evidence that pilots take involuntary naps and micro-sleeps on the flight deck [Samel A et al, 1997a; Wright NA & McGown A, 2001]. The detrimental effects of sleep deprivation, time since sleep, and the window of circadian low on alertness lead to severe fatigue with increasing time on task. Furthermore, fatigue during return night flights is often exacerbated in unacclimatized crews, and as outlined in question 2, there is no provision for adaptation to local time in the current scheme.

As outlined in the answer to question 2, it is recommended that night duties and duties that encompass the WOCL are limited to 10 hours. It is also proposed that the number of consecutive duties starting or ending in the WOCL should be limited. Subsequently, there should be a rest period that includes at least one local night.

We also propose to extend the definition of 'early starts' to FDPs commencing before 07:00. When scheduling early morning duties it is important to ensure that the start times are not advanced on consecutive days (i.e. if duty start times change from day to day they should start later rather than earlier) as this will impact on the time available for sleep and the recovery period.

Question 5

The provisions of FDP extension for cabin crew including the need for additional conditions (ref. EU OPS 1.1105 para 3.1).

The tasks of Flight attendants (FAs) require a sufficiently high level of alertness and cognitive performance to ensure safety and adequate response especially in nonroutine situations. From the viewpoint of general health and physiological needs, the same requirements for cockpit and cabin crew should be applied. It has been shown [Vejvoda M *et al.* 2000] that the fatigue levels of cabin crew towards the end of flight duty period tend to be much higher than those of cockpit crew. In addition, flight attendants have reported increased perceived stress and workload due to changes in duties and responsibilities since "9/11" [Nesthus T *et al.* 2007]. This result from a study among US cabin crew appears equally applicable to European cabin crew and may further contribute to higher fatigue levels.

It can be assumed that during onboard service periods, hypoxia is more severe in cabin crew than in cockpit crew. Although the resting SaO2 is well preserved up to ~2400 m (max. cabin altitude), the drop in PaO2 decreases the diffusion of oxygen from the lungs to the blood and then from the blood to the cells. This decrease in oxygen diffusion rate becomes apparent during physical activities as an arterial oxygen desaturation at altitudes as low as 1000 m [Muza SR *et* al, 2004; Mollard P *et al*, 2006]. FAs' duties include considerably more physical activities than those of pilots. The high heart rate values that are recorded from cabin crew are usually associated with hard physical workloads [Vejvoda M *et al*, 2000]. This may be an additional cause of fatigue in cabin crew.

The task of cabin crew contains safety aspects such as identification and management of non regular in-flight situations. These comprise e.g. insidious hypoxia (loss of cabin pressure), fire on board, weather conditions, handling of medical events, and unruly passengers etc. Furthermore, it is generally accepted that the performance of cabin crew is of crucial importance to safety in emergency situations. Fatigue and lowered alertness in cabin crew may have negative affects on safety, although the degree of these affects is a matter of ongoing discussions. However, normal pre- and in-flight duties and passenger services also require adequate performance of cabin crew (an extensive description of flight attendant duties is given by Nesthus *et al.*2007).

Although the hazards of impaired functioning of cabin crew may differ from those of dysfunctioning cockpit crew, the maintenance of optimal alertness and performance of cabin crew is of crucial importance. Therefore, the same duty and rest requirements should be applied for both cockpit crew and cabin crew (e.g. see answers to questions 11 and 12).

Within regular flight procedures, briefing after reporting time is a necessary feature of flight safety for both cockpit crew and cabin crew. In practice, longer FDPs for cabin crew are caused by the fact that cabin crew would need more time than cockpit crew for pre-flight briefing. It is recommended to develop more efficient briefing strategies in order to reduce the time period necessary for pre-flight briefing of cabin crew. In cases where it would be impossible to reduce the time for pre-flight preparation, the FDP of cabin crew may be extended by 30 minutes, as long as the cabin crew follow the same schedule as the cockpit crew. In that case, it should be considered that an extension of 30 minutes may necessitate an adjustment of the rest periods for cabin crew and that the reporting time for cabin crew should fall in the same circadian time category as the reporting time of the cockpit crew (e.g. with 30 minutes extra, cabin crew may have to report before 07:00 – which is considered as a time limit for early starts – while the cockpit crew may report after, or at, 07:00).

Question 6

Which detailed provisions and guidelines are needed within Subpart Q regarding split duty (ref. EU OPS 1.1105 para 6)?

We know of no scientific study on the impact of split duty on aircrew and studies are required before this question can be properly addressed. One such study is currently being undertaken by the French CAA (DGAC) (results available in 2009)2 on split duties currently used by some French airlines. Other forms of split duties are used in other European countries and this implies that additional research is required to over these specific aspects. However, even if specific data on split duties are not yet available, it has been established that both fatigue [Powell DMC *et al*, 2007] and risk [Folkard S & Tucker P, 2003] build up over the course of a duty, such that they are substantially higher at the end of longer duties. It is also scientifically established that the body clock has a major impact on both sleep propensity and duration (see response to question 1), such that the ability to fall asleep and the subsequent sleep duration are significantly impaired at sub-optimal (i.e. during the day) times of day. Finally, it has been established that if insufficient sleep has been obtained between consecutive duties then fatigue and risk will increase [Belenky G *et al*, 2003].

In this light, we consider that split duties should only need special provisions and guidelines when they result in an extension of the total flight duty period, i.e. from reporting for the first flight to "engines off" at the end of the last flight. Thus similar considerations apply to those for augmented crew operations. We would argue that the use of split duties should be carefully monitored since they potentially combine the adverse effects of prolonged duty periods with those of reduced rest periods. This might prove a particular problem in the case of consecutive split duties and there is a strong need for research on this since there is a paucity of data on their potential consequences.

Under these circumstances we would recommend:

1. That the break between the two sub-duties should be at least one third of the length of the total flight duty period;
2. Adequate sleeping facilities must be provided by the operator if the break does not take place where the crew lives;
3. That the total flight duty period of a split duty should never start before 06:00 or end after 22:00;
4. That in the case of consecutive split duties, the total FDP of a split duty should never be extended beyond 14 hours in order to allow an absolute minimum of 10 hours daily rest;

5. Consecutive split duties with reduced daily rest time must be accompanied by an FRMS that includes training of crews and a reporting system. Our response is limited to split duties that extend the FDP beyond 12 hours. For split duties that do not extend the FDP, we have assumed that Ops 1.1095 para 1.3 applies to the break between the two sub-duties.

2 [illegible]

Question 7

What provisions and/or guidelines are needed on rest for time zone crossings (ref. EU OPS 1.1110 para 1.3)?

Based on the literature, a significant time-zone crossing is considered to cover more than two time zones within one FDP [Roach GD *et al*, 2002; Kantermann T *et al*, 2007]. Recommendations regarding rest on layover and rest on recovery back at home base will be discussed separately.

Rest on layover

Many studies have shown that sleep times are displaced and sleep disrupted when aircrew have to sleep during layovers after crossing several time zones [e.g. Graeber RC, 1986; Spencer MB *et al*, 1990; Samel A *et al*, 1991; Lowden A & Åkerstedt T, 1998]. Therefore, the minimum rest should be increased to allow for the reduced period when normal sleep time on the body clock overlaps with normal sleep time in the local environment. Taking this into consideration, we recommend that the minimum rest should be 14 hours during layovers after significant time crossing.

Recovery at home base

The purpose of the home base recovery period is to ensure that a crew member's body clock has recovered to home base local time before the start of the next FDP. For that purpose, simulations were made using the model underlying the SAFE program [Belyavin AJ & Spencer MB, 2004]. The result is presented in the table below which specifies the recommended recovery periods for aircrew in terms of the number of local nights required to readapt to within an hour of home time, depending on the maximum time zone difference and preceding layover length. In addition, if any part of the FDP for the return flight overlaps the WOCL (on home base time), then at least two local nights free of duty should be provided. This is to ensure sufficient time for the recovery of sleep before any further flying duties are undertaken.

Layover (h)	Maximum time difference (h)		
	<5	**5-7**	**8-12**
<36	1	2	2
36-60	2	3	3
60-84	3	3	3
84-132	3	4	5
>132	3	5	6

Table 1 Home base recovery period: recommended number of local nights required to readapt to within an hour of home time given for various time zone differences and preceding layover durations.

Question 8

What provisions are needed for reduced rest arrangements (ref. EU OPS 1.1110 para 1.4.1)?

We assume that the minimum rest requirements (EU OPS 1.1110 paras 1.1. & 1.2) are intended to ensure that any fatigue that has built up over the previous duty period can be adequately dissipated. However, the efficacy of the rest period in achieving this will depend crucially on whether it includes the entire WOCL period, since rest periods that fail to include it are unlikely to result in adequate sleep [Spencer MB *et al*, 2006].

Any reduced rest arrangement is likely to result in increased fatigue levels following the reduced rest. In the light of this we would recommend that reduced rest is only allowed as part of a comprehensive FRMS, and that the FRMS would need to take account of a wide range of factors including both the time spent commuting and the influence of the body clock on sleep duration.

We would also recommend that any reduced rest that is less than 12 hours long should include the entire WOCL period, and that consideration should be given to ensuring that the subsequent flight duty is not too onerous and to specifying an absolute minimum reduced rest period, even in presence of an FRMS. Although there is currently no scientific data to suggest what this absolute minimum should be, it should be noted that data on this question should become available in 2009 through a study currently being undertaken by the French DGAC3.

3 http://www.biomedicale.univ-paris5.fr/LAA/STAFF/E index.htm

Question 9

The potential impact of reporting at 0400 on the effectiveness of the weekly rest period (ref. EU OPS 1.1110 para 2.1).

A weekly rest period is essential to allow the dissipation of the cumulative fatigue that has been scientifically established to build up over consecutive periods of duty [Spencer MB *et al*, 2006]. However, scientific research has also established (i) that sleep duration depends crucially on the time of day at which individuals attempt to go to sleep [Folkard S *et al*, 2007], and (ii) that the duration of sleep may be severely truncated by the requirement to start work early [Folkard S & Barton J, 1993; Spencer MB & Robertson KA, 2000].

The basic requirement given in OPS 1.1110 para 2.1 is for a weekly rest period of 36-hours including two local nights which are defined as a period of 8 hours falling between 22:00 and 08:00 local time4. This means that the duty following the second local night could not start before 06:00 and under normal circumstances this should allow two reasonably long night sleeps to be taken, and hence for any cumulative fatigue to be dissipated. However, the "exception" would allow the second local night to start at 20:00 (and hence presumably to end at 04:00), hence the wording of Question 9. We consider this "exception" to be unacceptable, and to negate the purpose of the weekly rest period. The reasons are (i) that it would severely truncate the second local night sleep, by as much as three hours [Folkard S & Barton J, 1993; Spencer MB & Robertson KA, 2000], and hence (ii) that it would result in aircrew starting their week of consecutive duty periods in a fatigued state. This follows from the fact that the extra four hours allowed for the weekly rest period would occur at a suboptimal time of day for sleep. In short, we would argue that the "exception" (i.e. the last sentence) should be omitted from OPS 1.1110 para 2.1 (see also our response to question 10).

4 It should be noted that this definition means that the weekly rest period is unlikely to fully dissipate fatigue if it occurs after a rapid time-zone transition.

Question 10

The effects of the format of rest periods on cumulative fatigue (ref. EU OPS 1.1110 para 2.1).

As discussed in our responses to questions 1 & 9, it is well established that fatigue and risk show a cumulative build up over consecutive duties. The weekly rest period (OPS 1.1110 para 2.1.) is clearly designed to dissipate this fatigue by allowing two night sleeps. However, its effectiveness in this respect will clearly be limited by the fact that the second night sleep would certainly be truncated by about two hours if it were followed by a duty period starting as early as 06:00 [Folkard S & Barton J, 1993; Spencer MB & Robertson KA, 2000]. For this reason, it would be better to define a local night as a "period of 10 hours falling between 22:00 and 10:00".

Even if the definition of a local night is changed in this manner, it is clear that the effectiveness of the weekly rest period in fully dissipating any cumulative fatigue will depend on a number of factors. These will include the extent of any cumulative fatigue, which will depend on how onerous the previous week's duty periods have been, including whether they involved night duties. Another factor that would influence the effectiveness of the weekly rest period is whether any of the preceding duties involved rapid time zone transitions.

The provision of a weekly rest period after 168 hours effectively means that only three days off may be provided within a 28-day (four-week) period and ten in an 84- day (12-week) period. In the absence of direct scientific evidence, it is not possible to provide clear guidance on the relationship between cumulative fatigue and the frequency of days off. However, we consider that it would be a wise precaution to increase the frequency of days off over longer periods, for example by requiring four weekly rest periods in every consecutive 28 days.

Question 11

What provisions are needed for extended FDP operations with augmented crews and/or time zone crossings (re. EU OPS 1.1115 para 1.1)?

As the benefits of in-flight sleep in terms of improved alertness have been sufficiently demonstrated, in-flight rest periods should be allowed to crew members to maintain sufficient alertness in extended FDP operations. If the bunk facilities are of a sufficient standard5, crews are able to obtain good quality recuperative sleep [e.g. Spencer MB *et al*, 1990; Pascoe PA *et al*, 1995; Simons M *et al*, 1994; Rosekind MR *et al*, 2000; Signal L *et al*, 2003; Spencer MB & Robertson KA, 2004; Simons M & Spencer MB, 2007].

From calculations we have previously carried out based on the results of a large number of studies [Simons M & Spencer MB, 2007], we believe that, where in-flight relief and adequate bunk facilities are provided, the permitted FDP may be extended by a period equal to three-quarters of the total rest taken. This would apply to aircrew who are acclimatized at the point of departure (see page 25 for definition). For aircrew who are not acclimatized, the recuperative effect of bunk sleep may be reduced, and the permitted extension should be only one half of the total rest taken.

For example, on a 15-hour FDP with one additional crew member, it might be reasonable to suppose that each of the three flight crew would be allotted four hours' rest. This is on the basis that approximately 12 hours would be available for rest during the cruise phase. In this case, an extension of three hours (4 times ¾) would be permitted for acclimatized crews, thereby allowing an increase from 12 to 15 hours [Simons M & Spencer MB, 2007].

These provisions are based on the following assumptions:

1 The bunk facilities are of sufficient standard5;

2 Care has been taken to ensure a reasonable assignment of the rest periods to the individual crew members;

3 Crews do not return to the controls within [illegible] minutes of waking after bunk rest.

5 The bunk facility should be completely separated from cockpit and passenger compartment and should be adequately insulated and situated to minimize random and aircraft noise and light. It should contain one or two horizontal sleeping surfaces of adequate size. Preferably, it also has a comfortable seat, climate and humidity control. It is assumed that the requirements for rest facilities will be covered under a separate document after conducting comparative studies of different bunk arrangements (e.g. advisory circular).

Question 12

The quality of rest regarding rest location / rest facilities for flight crew and cabin crew (re. EU OPS 1.1115 para 1.1 and 1.2).

Various adjustments will be required if the rest facilities do not meet the standards of a 'good quality' bunk (see question 11 footnote). From studies that have investigated the extent to which aircrew are able to rest and recuperate in seating accommodation, it has been concluded that rest in a 'normal' business class seat separated from the passengers is 75% effective compared with bunk rest, and rest in a flight deck seat that meets certain minimal standards is 33% effective [Simons M & Spencer M, 2007]. These factors should therefore be applied to those for bunk sleep so that, for example, the 75% increase, applied to bunk sleep, is reduced to 0.75 x 0.75 = 56% and 0.75 x 0.33 = 25% respectively. No data have been collected from aircrew resting in normal economy seating, and it is not recommended that any increase in maximum FDP be allowed in that case (until studies are carried out on this).

To summarize, the recommended extensions to the unaugmented FDP, based on the quality of accommodation described below, expressed as a percentage of the rest period available to a single crew member, are as follows [Simons M & Spencer M, 2007]. The percentages have been suitably rounded for ease of application.

	Acclimatized6	**Unacclimatized**
Bunk	75%	50%
Business Seat	60%	40%
Flight deck/other seat	25%	20%
Economy seat	No extension	No extension

Table 2: Recommended extensions to the unaugmented FDP, as a percentage of the rest period

The seating arrangement must meet certain minimum specifications for these extensions to be justified. A business seat should be a seat reclining to at least 40° back angle to the vertical, outside the cockpit and separated from the passengers and cabin illumination by at least a dark curtain. The seat should offer sufficient leg and foot support and should have sufficient pitch and width to rest comfortably [Simons M & Spencer M, 2007]. A flight deck / other seat should be a seat in the cockpit or in the passenger cabin reclining to at least 40° from the vertical and providing sufficient leg and foot support [Simons M & Spencer M, 2007; Nicholson AN & Stone BM, 1987]. No data are available of comparative studies of seating arrangements; more detailed requirements may await the results of future comparative studies.

The recommendations above are based on studies in cockpit crew. No data are available about the relation between seating accommodation and sleep in cabin crew. Although it is assumed that physiological characteristics and needs of cabin crew are similar to those of cockpit crew, their work and augmentation schedules differ considerably from those of cockpit crew. Therefore, it is recommended to conduct studies of the above-mentioned issues in cabin crew in order to define specific requirements.

6 see definition page 37

Question 13

What provisions are needed for cabin crew regarding extended FDP operations with in-flight rest and/or time zone crossings (re. EU OPS 1.1115 para 1.2)?

EU OPS 1.1115 para 1.2 reads: "the Authority shall set the requirements in connection with the minimum in-flight rest by cabin crew member(s) when the FDP goes beyond the limitations in OPS 1.1105".

From the viewpoint of general health, physiological needs, and required levels of alertness, the same requirements for cockpit and cabin crew should be applied. In principle, the requirements for minimum in-flight rest, in case of an extended FDP, as well as the provisions needed for operations with time zone crossings should be the same for cabin crew and cockpit crew (see Question 5, 7, 11 and 12). However, due to differences in workloads between cabin and cockpit crew, specific adjustments of rest requirements may apply.

There are no specific data concerning the total number of flight attendants needed in case of an extended FDP and there are no specific data of in-flight rotation practices. Therefore, we cannot give a science-based recommendation. In this area further studies would be useful. Airline companies should implement a FRMS to monitor and evaluate fatigue and alertness levels of cabin crew exposed to extended FDPs with augmentation and/or time zone crossings.

Question 14

What provisions are needed for the calculation of maximum FDP when called out from airport standby (re. EU OPS 1.1125 para 1.3)?

It is well established that the homeostatic component of fatigue increases over periods of wakefulness, even when the individuals concerned are not required to work, and is then dissipated during the subsequent sleep [Åkerstedt T *et al*, 2004]. It is also unlikely that crews would normally be able to sleep when on airport standby in view of the lack of suitable facilities. In the light of this it is clear that airport standby should not be considered as "rest" when calculating the maximum flight duty period. It is also the case that we know of no scientific evidence to suggest that airport standby should be considered as any less fatiguing than flight duty and that further research is needed in this area. In the meantime it would appear reasonable to propose that time spent in airport standby should normally count 100% as flight duty when calculating the maximum FDP.

If a company wishes to use a lower figure than this they would need to have an FRMS in place and to provide sleeping facilities away from public areas. Under these circumstances it may be possible to reduce the percentage by up to 50% depending on the adequacy and isolation of the sleeping facilities.

We would also suggest that no more than one consecutive duty should involve airport standby and that companies should avoid using airport standby when onerous duties are involved.

Question 15

What provisions are needed for the calculation of maximum FDP and minimum post duty rest when called out from other forms of standby (re. EU OPS 1.1125 para 2.1.4)?

We have interpreted "other forms of standby" to mean standby at home or at a hotel and our response is limited to these two situations. Thus we assume that the individuals concerned are potentially able to sleep when on these other forms of standby. Scientific research has established that sleep taken when on "standby" or "on call" is shorter and of poorer quality than normal sleep [Torsvall L & Åkerstedt T, 1988], although there is a need for further research on this topic.

It is also clearly the case that the longer the period of standby the more likely it is to interfere with sleep. In the light of this, it would seem reasonable to propose that a sliding scale should be used in which the longer the crew has been on standby the greater should the contribution towards the maximum FDP and minimum post duty rest period. Thus, for example, the first three hours spent on standby might contribute X% towards the maximum FDP and minimum post duty rest period, the next three hours might contribute Y%, and subsequent hours Z%.

We would, however, emphasize that we know of no scientific evidence to suggest what the values of X, Y & Z should actually be.

Question 16

What guidelines are needed for the counting of standby times for cumulative duty hours (re. EU OPS 1.1125 para 2.1.5)?

We know of no scientific evidence to enable us to address this question and feel that it would be difficult to undertake studies in this area.

Question 17

What guidelines are needed for the provision of a meal and drink opportunity, in particular for cabin crew (re. EU OPS 1.1130)?

There are two scientific components to the need for a meal and drink opportunity. The first relates to the need for sustenance and to avoid dehydration, and the second to the need for occasional breaks from periods of continuous work.

It is well established that performance decreases and that fatigue and risk increase over periods of continuous duty, and that these changes may be reduced by the provision of breaks (Tucker P, 2003; Tucker P *et al*, 2003). As a general principle, it would appear that frequent short breaks are more advantageous than occasional long ones.

With respect to meal and drink opportunities, it has been reported that quick turn rounds in some airlines have encroached upon the meal breaks for cabin crew. This practice should be avoided or compensated with time during the flight to eat. As a minimum, cabin crew should be provided with a 20-minute meal break for each six hours of work, as mandated by the European Working Time Directive. The Directive also specifies that the break should be taken away from the work area, though for most cabin and aircrew this would be impractical. It is also recognised that cabin crew spend long periods on their feet and there is a need for a break from physical activities. It is therefore proposed that the mandated 20-minute meal break should be extended to 30-minutes for each six hours on duty. Airlines should be encouraged to provide meals and an area to sit down during the break.

In addition to the 30-minute meal break in a six hour period, it is proposed that cabin crew are given adequate short breaks to ensure that they remain hydrated and as a break from continuous duty. Therefore, it is recommended that 10 minute breaks are provided in each three hour period that does not contain a meal break.

Question 18

The possibility of alterations to Subpart Q for operations which are exclusively based on nighttime operations, particularly regarding the number of consecutive night duties and FDP provisions (ref. EU OPS Article 1 Recital 9a).

We interpret this question as referring to freight operations, as these are the only operations that are currently carried out almost exclusively overnight.

When duties are carried out over several successive nights, the possibility arises that crews may adapt to the changed pattern of work and rest. However, a recent comprehensive review of permanent night workers [Folkard S, 2008] has shown that, with the exception of oil-rig workers, only a small percentage adapt sufficiently to gain any practical benefit. Whether this is true for night freight operations has yet to be established.

In one of the few studies so far carried out of cargo operations [Spencer MB *et al* 2004], fatigue levels on the first night were higher than on nights two, three and four, in contrast to the slight increase over three consecutive nights on passenger charter flights [Spencer MB & Robertson KA, 2000]. In the same cargo study, it was suggested that the workload or 'hassle' level was lower than on passenger operations and that this would permit some relaxation in the flight duty limits for this particular cargo operation. However, it is not clear whether this conclusion would apply more generally.

In addition, and in contrast to passenger operations, the crews are normally based in a hotel close to the airport, and this should be beneficial for their daytime rest and recovery. Nevertheless, there is insufficient evidence at this stage to propose any modification of the rules for these specific operations. Such a modification may indeed be possible in the future, but it would depend on the results of further research. In the meantime, operations beyond the current limits may be permissible if supported by a suitable FRMS.

Acclimatization

Air operations often expose crews to time zone transitions, which may result in changes in alertness and performance. Acclimatization is one term commonly used to refer to the process whereby personnel become synchronised / adapted to the local time zone. A number of questions include reference to time zone crossings or our responses refer to adaptation following time zone crossings (e.g. 7, 11, 12). For these reasons we consider that acclimatization, though we would prefer to use the term synchronised and non-synchronised, should be included as one of the provisions within EU OPS.

There are many factors that influence the direction and time taken to adapt to a new time zone. For ease of use and as a general rule, the rate of resynchronization could be approximated by the use of a factor that assumes a one-hour adjustment per day. In many cases this may overestimate the recovery time, particularly for the longer transitions, but it is a useful practical approximation.

FRMS

The potential use of FRMSs has been highlighted in several of our responses. The incorporation of a FRMS with an operator's Safety Management System provides a more flexible alternative to a prescriptive FTL scheme. However, in adopting such an approach, operators should be provided with guidance on the essential elements that an FRMS must contain. The recent ICAO working paper [ICAO, 2008] provides a comprehensive guide on the development of a FRMS and its key features.

Conclusions

This review has addressed a number of questions on different topics that all involved aspects of flight time limitation associated with potential effects on fatigue and safety. Our responses are based on the available scientific knowledge which, briefly, finds that fatigue is increased by extended time awake, reduced prior sleep, the window of circadian low, and task load, and that these effects are modified by changes of time zones and rest provisions. Some of the present rules or proposed modifications of rules are in violation with one or more of these factors. We have tried to indicate this and the consequences thereof. In particular, we see problems with:

- a large number of duty hours in a short time;
- long duty hours (which are not only directly fatigue inducing but which also may interfere with rest periods);
- split duty (which creates similar problems to those of long duty periods);
- night duty (which combines duty at circadian low with extended waking and suboptimal temporal position of rest periods);
- early start of duty (which negates the value of the prior rest period);
- rest periods given outside the window of circadian low (which reduces the recuperative value);
- recovery time after time zone flights (that have induced shifts in the circadian system);
- standby duty (which often is as fatigue inducing as actual duty);
- the recuperative value of rest facilities (bunk-seat-environment-standby).

A central idea in our responses has been to counteract the effects of a violation immediately, and to ensure that combinations of violations are avoided. Several of the questions presented cannot be answered in detail because of a lack of scientific evidence. In these cases, we have only presented a general view and indicated the need for additional research. Though the questions posed often require detailed and complicated explanation we have, nevertheless, attempted to summarize our responses as follows:

- The permissible maximum of 180 duty hours in 3 consecutive weeks allows for a high density of work hours in a short period of time and should be limited through an additional provision for a maximum of 100 duty hours in 14 consecutive days (Q1);
- The maximum daily flight duty period (13/14 hours) exceeds reasonable limits especially under exacerbating circumstances (e.g. high workload, night flying, acclimatization) and should be reduced. Also, extensions to the maximum FDP should not be permitted (Q2 & 3). Night duties need special provisions and must not be combined with other sources of fatigue (Q4);
- In general, the same duty/rest rules should apply to cabin crew as to cockpit crew – the fatigue of the former is often very high (Q5 & 13);
- Split duty often combines several sources of fatigue (early starts, long periods of wakefulness, late bedtimes) and should be used only outside the WOCL and for a maximum of 14 hours (start of first sub-duty to end of last sub-duty) (Q6);
- Home base recovery days after time zone crossings should be provided according to the number of time zones crossed and the duration of the layover (see Table 1) (Q7);
- Reduced rest periods (<12 hours) should be avoided and, if used, be applied

within a FRMS, and then only if the entire WOCL is included in the rest period (Q8);

- Permitting (as an exception) a FDP to start at 04:00h after a rest period would negate the effect of the rest period and should be omitted from EU OPS (Q9);
- The format of rest periods should include a provision for "local night", defined as 10 hours between 22:00h and 10:00h to ensure proper rest. The length of the rest period needed after a number of consecutive days on duty is not possible to answer in a detailed way because of a lack of scientific data, but the present provision of a weekly rest period after 168 hours of duty falls short of reasonable requirements (Q10);
- To maintain alertness during extended FDP operations, augmented crews should be allowed to take in-flight rest. The quality of on-board rest conditions (e.g. bunk-economy seat) will determine the recuperative value of the rest period and will be modified by acclimatization level (Table 2) (Q11 & 12);
- Airport standby time carries approximately the same fatigue load as work and should count as FDP unless a FRMS is applied with proper rest facilities (14). Standby time with proper rest facilities is still likely to involve reduced recuperative value because of anticipatory stress influences (of imminent duty), but the quantitative effects cannot be determined because of a lack of scientific data (Q15 & 16);
- With respect to breaks there is a large body of research and regulation – a 20 minute meal break for each 6 hours of work may be a lower limit but for cabin crew the physical load should raise this to 30 minutes for every 6 hours of duty. To avoid dehydration problems, an additional 10 minute break should be provided in each 3 hour period that does not contain a meal break (Q17);
- Permanent or a large number of successive night duties should not be exempt from the present rules, since adaptation to night work probably does not occur. However, data relating to aircrew are limited (Q18).

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Disclosure statement

Some members of ECASS provide advice on FTL issues to regulatory authorities, to individual airlines and to pilot and cabin crew unions. Further details can be provided, if required.

[illegible] Current activities

As this concludes the project, all activities have been suspended and the project team dissolved.

4 Management and Administration

4.1 Project Structure

The project team consited of three main parties working to achieve a common goal. Project oversight was with EASA, project management was with MOEBUS Aviation and project content expertise was with an internationaly recognized panel of experts.

From EASA, three personnel were represented by;

- Mr. Herbert Meyer – as the Focal point for the EASA FTL study
- Ms. Betty Lecouturier – Rulemaking Operations Officer
- Dr. Virgilijus Valentukevicius – Rulemaking Operations Officer specialist in Human Factors

From MOEBUS Aviaiton, two personnel were represented by:

- Mr. Philipp Moebus - as a project manager for "Scientific and medical evaluation of Flight Time Limitation".
- Ms. Keiko Moebus – as a project member and a quality management.

From the FTL expert panel, the members were composed of:

Dr. Barbara Stone	QinetiQ, UK
Dr. Karen Robertson	QinetiQ, UK
Dr.Alexander Gundel	DLR, Germany
Mr. Martin Vejvoda	DLR, Germany
Dr. Mick Spencer	Human Factor Investigation
Prof. Dr. Torbjorn Ackerstedt	Karolinska Institue, Sweden
Dr. Ries Simons	TNO, The Netherlands
Dr. Philipp Cabon	Université Paris Descartes, France
Prof. Dr. Régis Mollard	Université Paris Descartes, France
Prof. Dr. Simon Folkard	Swansea University, UK

The group of scientists above reflected the primary composition of the ECASS (European Committee for Aircrew Scheduling and Safety) group which has provided scientific and medical FTL work and reviews on behalf of airlines and authorities around the world as well as the initial nomination submitted to the EASA tender evaluation committee from MA.

4.2 Project Monitoring

During Phase 3, MA has kept close contact with the ECASS group though Dr. Barbara Stone of QinetiQ acting as the groups focal point. Communication between ECASS and MA was usually based on email exchanges and on average took place two or three times a month.

An expert meeting was help in Cologne, Germany on 4th and 5th September 2008 in order to discuss the current findings of the open issues amongst the panel.

4.3 Change Management

1. No changes had been requested by any of the projects member groups.

5. Conclusions

5.1 Major Accomplishment in Phase 3

MOEBUS Aviation and the experts of the ECASS group are pleased to have produced an unbiased medical and scientific evaluation to 18 open issues of light time limitations.

The 18 open issues have been analysed and draft responses have been collected by the groups focal point from all members of the group. Finally, a final report has been populated.

5.2 Project Review

The task with which MOEBUS Aviation has been entrusted by EASA was not an easy one. Due to the high quality of medical and scientific analysis required for this project, it was apparent that only a very limited group of experts were capable of satisfying the demands. MOEBUS Aviation was fortunate to gain the cooperation of the ECASS group for this special task. Although some administrative problems arose due to minor misunderstandings in the first phase of the project, all issues were resolved. This, amongst an already tight timeframe lead to a delay in the project, which had been coordinated with the project owner and approved by the agency by a proper change management request.

The remainder of the project however, was conducted smoothly and in accordance with the expectations of the contract. MOEBUS Aviation and the ECASS group believe to have provided the agency with a report of highest quality standards.

It has been a pleasure for us to carry out this project and we would like to express our thanks to Herbert Meyer of EASA, the ECASS group and in particular Dr. Barbara Stone of QinetiQ, UK.