European Commission

Effectiveness of Flight Time Limitation (FTL)

ADDENDUM D1 *Definition of the Baseline*

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Scope of the current deliverable

The current Addendum to Deliverable D1 (Definition of the Baseline) provides additions to the following chapters in D1:

- Chapter 3 on the ranking of flight duty periods (FDPs); and
- Chapter 4 on the selection of air transport operators.

Both chapters are presented in total in this Addendum; i.e., including the original (and updated) text from D1.

In this Addendum, the ranking of the six crew FDPs of interest was finalised using the added modelling results of the SAFE model and the survey results.

We updated the selection of airline operators by applying the criterion that operators should operate the two duty periods ranked as the most fatiguing for inclusion to be possible. This particular criterion could only be applied after the ranking of duty periods was completed.

Chapter 3: Ranking of aircrew flight duty periods

This section describes the classification of the six duty periods of interest based on the expected level of fatigue. Three different bio-mathematical models were used to estimate the level of fatigue. In addition, a survey was used to provide for a subjective ranking of the duty periods of interest. The following six FDPs were considered:

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 six);
5. On-call duties such as standby or reserve, followed by flight duties; and
6. Disruptive schedules.

Bio-mathematical modelling

Each of the six duty periods actually describes a range of possible specific schedules. To calculate fatigue levels with bio-mathematical models, we further refined the definitions and determined example duties. Consultation with EASA provided the following clarifications:

1. 'Most favourable time of day' is intended to refer to daytime operations (i.e., between 08:00h and 21:59h);
2. 'Less favourable time of day' is intended to refer to operations that encroach (part of) the night (i.e., the period between 02:00h and 04:59h); and
6. 'Disruptive schedule' refers to repetitive early starts, late finishes, night duties, and combinations thereof.

This information was then used to create scenarios that could be fed into the bio-mathematical models. The scenarios were selected such that they represent realistic (although not necessarily common) flight duties.

For duty type 3 (where crew members are in an unknown state of acclimatisation), it was assumed that the time difference between reference time and local time where the crew starts the next duty is 12 hours, and the time elapsed since reporting at reference time is 48 hours (as specified in Annex II to Regulation 965/2012).

For duty type 4 (high level of sectors), the maximum possible number of sectors 10 was assumed (as specified in Annex II to Regulation 965/2012).

Duty type 6 (disruptive schedules) was assumed to involve four consecutive early starts or four consecutive late finishes.

All times are in reference time (the local time at the reporting point situated in a 2-hour wide time zone band around the local time where a crew member is acclimatised). The assumption was that crews are acclimatised to the local time of the departure time zone, except for flight duty period number 3.

1. Duties of more than 13 hours at the most favourable time of the day. This refers to daytime operations (from 08:00h to 21:59h);
   - Duty started at 08:00h and ended at 20:59h;
2. Duties of more than 10 hours at the less favourable time of the day. This refers to operations that encroach (part of) the night (the period between 02:00h and 04:59h);
   - Duty started at 19:00h and ended next day at 05:59h;

3. Duties of more than 11 hours for crew members in an unknown state of acclimatisation;
   - Crew arrived at 11:00h with a time zone difference +12. Duty started 48 hours later at 11:00h and ends 11 hours later at 21:59h;
4. Duties including a high level of sectors (more than six). This refers to daytime operations (from 08:00h to 21:59h);
   - Duty started at 08:00h and ended at 16:59h. Duty included 10 sectors;
5. On-call duties such as standby or reserve followed by flight duties. This refers to daytime flight duties;
   - Standby started at 06:00h. Duty started at 11:00h and ended at 23:59h.
6. Disruptive schedules. This refers to repetitive early starts, late finishes, night duties, and combinations thereof;
   a. Early starts: Four consecutive flight duties starting at 05:00h and ending at 14:59h;
   b. Late finishes: Four consecutive flight duties starting at 16:00h and ending next day at 01:59h; and
   c. Night duties: Four consecutive flight duties starting at 23:00h and ending next day at 08:59h.

Furthermore, for each specific FDP, fatigue levels were calculated from two initial conditions: (1) Aircrew is fully rested at the start of the duty period and (2) aircrew is pre-fatigued at the start of the duty period. For fully rested crew, the last sleep episode (duration of eight hours) ends two hours before start of duty unless stated otherwise. For pre-fatigued crew, the first three hours of the predicted final sleep episode before the start of duty was regarded as 'awake', resulting in a sleep duration of five hours. Additionally, the following assumptions were made:
- The window of circadian low (WOCL) ranges from 02:00h to 05:59h in the time zone to which a crew member was acclimatised;
- Transfer time from bed to start of the flight duty or from the end of the flight duty to bed was two hours;
- Sleep was assumed to not occur after the start of on-call duty period;
- Application of fatigue risk management (FRM), in-flight rests, and/or augmented flight crew were excluded;
- Extensions and commander's discretion were not used;
- A flight duty included two sectors unless stated otherwise; and
- Quality of sleep was scored with the highest value.

The duties were analysed by using three bio-mathematical models:
1. Boeing Alertness Model (BAM, CrewAlert Pro 3.9.7);
2. Sleep, Activity, Fatigue, and Task Effectiveness, Fatigue Avoidance Scheduling Tool (SAFTE-FAST, v1.2.4.92); and
3. System for Aircrew Fatigue Evaluation (SAFE, v7.0).

BAM predicts alertness on common alertness scale (CAS) from 0 (least alert state) to 10,000 (most alert state). CAS is linearly mapped against the KSS[1] where a KSS value of 9 (very sleepy, great effort to keep awake, fighting sleep) maps to 0 CAS points and KSS of 1 (extremely alert) maps to 10,000 CAS points. The output of the SAFTE model provides a percentage of performance effectiveness (Effect) from 0 (low effectiveness) to 100 (high effectiveness). The output of SAFE provided a Samn-Perelli

[1] KSS is a 9-point scale: 1. Extremely alert, 2. Very Alert, 3. Alert, 4. Rather alert, 5. Neither alert nor sleepy, 6. Some signs of sleepiness, 7. Sleepy, but no difficulty remaining awake, 8. Sleepy, some effort to keep alert, 9. Very sleepy, great effort to keep awake, fighting sleep.

(SP)[2] score ranging from 1 ('fully alert, wide awake') to 7 ('completely exhausted, unable to function effectively').

Survey

A survey was used to provide for a subjective ranking of the duty periods of interest based on the associated fatigue level. The survey was developed in a number of iterations to ensure high-quality questions using a language and format that is easy to understand for the participants. First, the survey outline was designed and a concept survey was developed in a text formatting program for ease of adjustability. This first set-up of the survey was then reviewed by a small committee within the consortium and two commercial pilots working for NLR. The results of this review were discussed and adjustments were made in the next iteration. This next set-up of the survey was reviewed and commented on again by the same committee. After two iterations, the survey was transferred to LimeSurvey to include the sequencing of the questions and to also define the format of the data output. A final review was performed by a group of 20 participants, including commercial pilots and cabin crew, and the full project consortium.

The survey could be accessed with any type of computer or mobile device with internet access. Data was gathered via LimeSurvey which is a software package for surveys. Using LimeSurvey, the data gathered can be saved on a server within the consortium making the data available for the consortium, but not for third parties. The package is relatively easy to use, but hardly limits possibilities for adjustments. Furthermore, the data can be directly imported to most data analysis software packages. The package also allows for anonymous answering.

The survey questions asked aircrew respondents to assign a fatigue rating (using the KSS) for each of the six FDPs they have experienced in the past three years. A rank ordering was derived from the ratings. Experts such as researchers, safety experts and schedulers were presented with a slightly different approach because they are not assumed to have own experience with the different six duty periods. They rank ordered the duty periods from one to six based on their expertise, one being the most fatiguing.

The fact that the survey was anonymized allowed for filling out the survey multiple times. This was countered by gathering IP addresses to be able to inspect if the same address has been used multiple times. If analysis showed that the same IP address was used more than once, the corresponding survey outputs were checked for similarities. In case of high resemblance of the outputs, only a single stream of survey output was used in the data analysis. The IP addresses were used only for the purpose of this inspection and were removed from the dataset after this inspection.

The data analysis started with checking if the gathered sample is a good representation of the entire population base within Europe; i.e., mostly looking at the distribution across Europe. The data was split per group (i.e., pilots, cabin crew, and expert) and for each group counts were done for the various questions and ratings on the duty periods were compared to create an overall input for the ranking for all aircrew duty types. The data set was filtered before data analysis based on the condition that a respondent had filled in at least one rating.

[2] SP is a 7-point scale: 1. Fully alert, wide awake, 2. Very lively, but not at a 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.

Classification of aircrew flight duty periods per source

Output bio-mathematical modelling

Results for BAM reflect the CAS values for the analysed FDP; the lower the values, the lower the level of alertness. Results for the SAFTE model reflect the lowest value of the effectiveness score; the lower the values, the lower level of effectiveness. Results for SAFE reflect the SP scores; the higher the score, the higher level of the fatigue. See Table 2 for the output of the bio-mathematical modelling; the ranking indicated by the model calculations is shown in brackets (1 representing the highest and 8 the lowest).

Table 2 Results from FDP calculations with bio-mathematical models

Flight duty type	***BAM***		***SAFTE model***		***SAFE model***	
	Rested	Pre-fatigued	Rested	Pre-fatigued	Rested	Pre-fatigued
1) > 13 hrs at favourable time	(7) 4709	(7) 4156	(7/8) 95	(7/8) 90	(8) 3.76	(8) 3.96
2) > 10 hrs at unfavourable time	(1) 2403	(1) 1436	(2) 70	(2) 64	(2) 4.57	(1) 4.92
3) > 11 hrs for unknown state	(5) 3560	(5) 2204	(6) 89	(5) 80	(6) 3.89	(6) 4.28
4) High number of sectors	(8) 5738	(8) 5090	(7/8) 95	(7/8) 90	(1) 4.82	(2) 4.87
5) On call duties	(2) 2587	(4) 2103	(5) 83	(6) 85	(4) 4.24	(5) 4.41
6 a) Cumulative early starts	(6) 4502	(6) 3315	(4) 80	(4) 78	(7) 3.81	(7) 4.20
6 b) Cumulative late finishes	(3) 3095	(2) 1905	(3) 79	(3) 70	(5) 4.20	(4) 4.67
6 c) Cumulative night duties	(4) 3132	(3) 1946	(1) 66	(1) 56	(3) 4.40	(3) 4.80

Differences in results of the various models (using the same input) may be explained by different settings for parameter values. Many of the available bio-mathematical models are fundamentally based on the two-process model of sleep regulation that describes the interaction between a homeostatic process and a circadian process[3]. Even when models have a similar basis, different values may be incorporated for the parameters that are used in the equations for describing the homeostatic and circadian process.

When considering the results from Table 2, the following limitations of modelling should be taken into account:

- The contribution of multiple sectors in the models is tuned to the collected data, but is relatively small compared to the main components: time awake, time of day, and prior sleep debt;
- Model outputs represent the population average and may not be accurate for specific individuals;
- Model sleep predictions may not reflect actual sleep which is fundamental to the validity of its output; and
- Models may not take into account the operational context and mitigations.

[3] Mallis, M. M., Meijdal, S., Nguyen, T. T., & Dinges, D. F. (2004). Summary of the key features of seven biomethematical models of human fatigue and performance. *Aviation, Space and Environmental Medicine* 75*(3)*, A4-14.

Output survey

All attempts to open the homepage of the survey were registered. In total 33,259 attempts were made and 29,173 respondents consented to participate. In total, 11,470 respondents filled out the complete survey.

The aircrew responses were filtered and only responses from aircrew working for a European airline, or aircrew not currently working but living in Europe, were included for analysis. All expert responses were included, irrespective of where the expert resided. IP addresses used more than once to fill in the survey were checked for similarities. Furthermore, only respondents who filled out the survey completely or filled out at least one FDP rating were included.

The final dataset used for the FDP rating exercise, consisted of 15,806 respondents – 51.1% of whom were pilots, 48.1% were cabin crew and 0.8% had another occupation, such as researcher, safety expert or scheduler.

The reasons for not filling out the complete survey were not registered, but we assume that this may be due to people taking a glance of the survey before deciding to actually fill out all, or at least part of the questions. Also, even though it was possible to save the results, pause the survey and return later, many participants may have started over again.

The survey results are presented further in Appendix A.

Ratings were performed on the 9-points KSS per experienced FDP; the higher the rating, the higher the level of fatigue. See Table 3 for the output of the survey. The resulting rank order is shown in brackets. The sample in Table 3 pertains to aircrew. Appendix A splits the survey output per responding group (i.e., pilots, cabin crew).

Table 3 Aircrew survey results of FDP ratings

	FDP1 rating	***FDP2 rating***	***FDP3 rating***	***FDP4 rating***	***FDP5 rating***	***FDP6 rating***
Mean	(5) 6.59	(1) 7.21	(2) 7.19	(4) 6.74	(6) 6.42	(3) 7.02
N	9104	10509	4553	1782	7554	7308
St. Error	.019	.016	.025	.045	.022	.020

Table 4 Expert survey results of FDP ratings

	FDP1 rating	***FDP2 rating***	***FDP3 rating***	***FDP4 rating***	***FDP5 rating***	***FDP6 rating***
Mean	(4) 4.69	(2) 5.88	(3) 5.28	(5) 4.36	(6) 3.59	(1) 6.19
N	118	118	118	118	118	118
St. Error	.242	.230	.201	.247	.257	.224

The two duty periods ranked as the most fatiguing

Based on the findings from the bio-mathematical models and the survey, the following ranking of FDPs was compiled:

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

All the applied bio-mathematical models ranked ‘duties of more than 10 hours at the less favourable time of the day’ in their top two. For the three ‘disruptive schedules’ the ranking results differed per model. The output of the survey shows three FDPs (FDP2, FDP3 and FDP6) for which an average KSS rating of higher than 7 was scored. As ‘duties of more than 11 hours for crew members in an unknown state of acclimatisation’ was not in the top three based on calculations with the models, the conclusion was drawn that ‘duties of more than 10 hours at the less favourable time of the day’ and ‘disruptive schedules’ are the two duty periods ranked as the most fatiguing amongst the six FDPs of interest. This was confirmed by the survey rankings of the researchers, safety experts and schedulers. These two FDPs were therefore the focus of phase 1 of the FTL research study.

Rank 4 ‘duties including a high level of sectors (more than six)’ was mainly based on the survey output as the contribution of more than six sectors is not well represented in the BAM and SAFTE models. In SAFE an additional level of workload was added for every sector flown, resulting in a high rank order of this FDP.

Rank 5 ‘duties of more than 13 hours at the most favourable time of the day’ is in line with the bio-mathematical modelling and survey outputs.

Rank 6 ‘on-call duties such as standby or reserve followed by flight duties’ is ranked higher in the models but not in the survey. This could be explained by the fact that standby or reserve was considered ‘time awake’ in the models which is not necessarily the case in real operations. Both aircrew and expert survey results agreed on ranking this duty sixth.

We recognize that using bio-mathematical models for this FDP scoping activity has its limitations. Also, one could argue that more and/or different combinations of rosters should be taken into account within each FDP. The survey approach also has its limitations, as we for example do not know for sure who and with what motives one is providing the answers to the questions asked. Because of these limitations of both sources of information, a multiple source approach was applied to rank the aircrew FDPs.

Relevant scientific findings

The relevance of the top two ranked duty periods was illustrated and supported by the following scientific findings.

Sallinen et al.[4] conducted a field study on a representative sample of airline pilots of a medium-sized airline. Results showed that short- and long-haul duty periods covering the whole domicile night (00:00h - 05:59h at home base) were most consistently associated with reduced sleep-wake ratio and subjective alertness. The results also showed that the pilots tended to increase the use of effective on-duty alertness management strategies (consuming alertness-promoting products and taking strategic naps) in connection with the FDPs that overlapped the domicile night. The results suggest that FDPs covering the whole domicile night should be prioritised over the other duty periods in fatigue management, regardless of whether a duty period is a short- or a long-haul. The finding of reduced sleep sufficiency and subjective alertness especially in connection with whole night FDP is well in line with a number of previous studies conducted on airline pilots and other groups of transport professionals[5,6,7,8]. In addition to the whole night duty period, the short- and long-haul duty periods that covered either the first or second part of the night were, to some extent, associated with a lowered sleep-wake ratio and subjective alertness. This finding is in accordance with previous studies conducted on a wide range of occupational groups[9,10,11].

Samel et al.[12] investigated 2-crew extended range operations during transmeridian flight schedules. The studies were conducted with two airlines on the routes Düsseldorf (DUS) - Atlanta (ATL) and Hamburg (HAM) - Los Angeles (LAX), and on the north-south route Frankfurt (FRA) - Mahe (SEZ) including two consecutive night flights with a short layover. Fatigue ratings exhibited an increasing level with progressing flight duration. Towards the end of long US-Westcoast flights performed at day-time, and in all night flights, fatigue was enhanced compared to the "baseline" ratings collected during the DUS-ATL flights. Fatigue was scored at a critical level by several pilots, particularly during the return flight SEZ - FRA when fatigue was severely pronounced. The subjective fatigue ratings were confirmed by the objective measurements of motor activity, brain-wave activity (occurrences of micro-sleep) and heart rate which indicated drowsiness and a low state of vigilance and alertness during

[4] Sallinen, M., Sihvolaa, M., Puttonena, S., Ketolac, K., Tuoric, A., Härmäa, M., Kecklundd, G., & Åkerstedt, T. (2017). Sleep, alertness and alertness management among commercial airline pilots on short-haul and long-haul flights. *Accident Analysis & Prevention*, *98*, 320-329.

[5] Eriksen, C. A., & Åkerstedt, T. (2006). Aircrew fatigue in trans-Atlantic morning and evening flights. *Chronobiology International*, *23*(4), 843-858.

[6] Gander, P. H., Mulrine, H. M., van den Berg, M. J., Smith, A. A., Signal, T. L., Wu, L. J., & Belenky, G. (2015). Effects of sleep/wake history and circadian phase on proposed pilot fatigue safety performance indicators. *Journal of Sleep Research*, *24*(1), 110-119,

[7] Härmä, M., Sallinen, M., Ranta, R., Mutanen, P., & Müller, K. (2002). The effect of an irregular shift system on sleepiness at work in train drivers and railway traffic controllers. *Journal of Sleep Research*, *11*, 141-151.

[8] Sallinen, M., & Kecklund, G. (2010). Shift work, sleep, and sleepiness –differences between shift schedules and systems. *Scandinavian Journal of Work, Environment & Health*, *36* (2), 121-133.

[9] Sallinen, M., & Hublin, C. (2015). Fatigue-inducing factors in transportation operations. In: Stephen Popkin, M. (Ed.), Reviews of Human Factors and Ergonomics: Worker Fatigue and Transportation Safety, vol. 10. SAGE Publications, pp. 138-173.

[10] Pylkkönen, M., Sihvola, M., Hyvärinen, H. K., Puttonen, S., Hublin, C., & Sallinen, M. (2015). Sleepiness, sleep, and use of sleepiness countermeasures in shift-working long-haul truck drivers. *Accident Analysis & Prevention*. *80*, 201-210.

[11] Roach, G.D., Sargent, C., Darwent, D., & Dawson, D. (2012). Duty periods with early start times restrict the amount of sleep obtained by short-haul airline pilots. *Accident Analysis & Prevention*, *45*, 22-26.

[12] Samel, A., Wegmann, H. M., Vejoda, M., Drescher, E. E. J., Gundel, A., Manzey, D., & Wenzel, J. (1997). Two-crew operations: Stress and fatigue during long-haul night flights. *Aviation, Space, and Environmental Medicine*, *68*(8), 679-687.

all night flights under study. From the findings it is concluded that duty schedules, as conducted on the route HAM - LAX (because of long duty hours) and particularly on the route FRA-SEZ (because of consecutive night duties), are coming close to the limits of mental and physiological capacity.

In their research, Vejvoda et al.[13] demonstrated that short-haul pilots experienced moderate to severe fatigue when finishing FDPs late at night. These fatigue levels exceeded those observed after duty periods with early starts, despite the fact that duty period duration was shorter and prior sleep period time was longer. Pilots on late-finishing FDPs (i.e., duty start after 17:00h) were awake longer by an average of 5.5 hour (6.6 versus 1.1 hour) before commencing their duty than pilots who started early in the morning. Late-finishing flights were associated with long times awake at a time when the circadian system stops promoting alertness, and an increased, previously underestimated fatigue risk. Other studies have identified sleep duration, time of day, number of flights and duty duration to influence pilots' fatigue[14,15].

Furthermore, Spencer and Robertson[16,17] showed that the development of cumulative fatigue tends to increase 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.

[13] Vejvoda, M., Elmenhorst, E.M., Pennig, S.B., Parh, G., Maass, H., Tritschler, K., Basner, M., & Aeschbach, D. (2014). Significance of time awake for predicting pilots' fatigue on short-haul flights: implications for flight duty time regulations. *Journal of Sleep Research*, *23(5)*, 564-567.
[14] Powell, D. M., Spencer, M. B., Holland, D., Broadbent, E. & Petrie, K. J. (2007). Pilot fatigue in short-haul operations: effects of number of sectors, duty length, and time of day. *Aviation, Space, and Environmental Medicine*, *78*, 698-701.
[15] Petrilli, R. M., Roach, G. D., Dawson, D., & Lamond, N. (2006). The sleep, subjective fatigue, and sustained attention of commercial airline pilots during an international pattern. *Chronobiology International*, *23*, 1357-1362.
[16] Spencer, M. B., & Robertson, K. A. (2000). A diary study of aircrew fatigue in short-haul multi-sector operations. DERA Report No. DERA/CHS/PPD/CR00394, Farnborough, UK.
[17] Spencer, M. B., & Robertson, K. A. (2002). Aircrew alertness during short-haul operations, including the impact of early starts. QinetiQ Report No. QINETIQ/CHS/PPD/CRO10406/1.0, Farnborough, UK.

Chapter 4: Characterisation of the selected population

For the purposes of data collection, a representative population of Member States, air transport operators and type of operations was identified.

Selecting a balanced set of EU air operators and operations

Identification of a representative population and relevant types of operations to be used for data collection purposes followed a two-step process:

- Establishment of a subset of Member States representative of conditions in the EU aviation sector as a whole. The country grouping shall encompass the type of air transport operators and related envelope of operations that are typical for the EU aviation market; and
- Definition of criteria for and the conduct of a screening of CAT aeroplane operators to achieve a representative mapping of air operations considering the following set of characteristics (Table 5):

Table 5 Screening criteria of CAT operators

Type	*Flight duration*
Long-haul	More than 5 hours and crossing 3 time zones
Medium-haul	More than 2 hours
Short-haul	Between 1 and 2 hours' duration
Regional	Less than 1 hour
Sole cargo flights	-

The resulting representative set of air operators and operations is to be used in the context of subsequent data gathering activities.

EU aviation ensemble

An overview of CAT operators classified by EASA Member State and sub-classified by type of operation was assembled. Four geographical regions were defined covering Europe: East, West, North, and South (see Table 6). Regarding type of operation, an internet search was performed and expert opinions were gathered to determine the air operators per Member States.

Note that the size of air operations (based on number of aircraft) is the largest within Region 2 West Europe (around 3300 aircraft operational), followed by Region 2 South Europe (with around 850 aircraft) and Region 1 North Europe (with around 550 aircraft) and finally Region 4 East Europe (with around 360 aircraft).

Table 6 Geographical regions within Europe

Region 1 *North Europe*	*Region 2* *West Europe*	*Region 3* *South Europe*	*Region 4* *East Europe*
Denmark	United Kingdom	Italy	Romania
Sweden	Germany	Spain	Slovakia
Norway	Netherlands	Greece	Czech Republic
Finland	Ireland	Cyprus	Bulgaria
Iceland	Austria	Malta	Poland
	Belgium	Portugal	Hungary
	Liechtenstein	Croatia	Estonia
	Luxembourg	Slovenia	Lithuania
	Switzerland		Latvia
	France		

Screening CAT

Criteria were defined to be able to narrow the EU aviation ensemble that was determined. The following criteria were taken into account in the screening of CAT operators:

- Volume of air operations (as a function of the number of aircraft), as this was considered a key determinant of operators' exposure to fatigue. An internet search (airline website, Wikipedia) was performed to determine this; these numbers were gathered and averaged based on the multiple information sources available on the internet;
- The extent to which operators used deviations or derogations from the EU FTL Regulation. This was based on information on deviations and derogations from the EASA website[18]. Airline operators that use such flexibility were excluded; and
- The type of FDPs that are operated by the operators. This information was gathered through expert opinion. The operators should operate (at least) one of the following two duty periods ranked as the most fatiguing with a non-augmented flight crew:
  - Duties of more than 10 hours at the less favourable time of the day; and
  - Disruptive schedules.

With regard to duties of more than 10 hours at the less favourable time of day, it is expected that most long-haul (and some medium-haul) and (sole) cargo operations fulfil this criterion. This was taken into account when selecting the groups of airlines for the study population.

[18] Https://www.easa.europa.eu/document-library/regulations/flexibility-provisions.

Selected population

These criteria (taking into account the specifications on the type of operations per top two ranked FDP) were applied resulting in a set of candidate EU air operators and operations.

Table 7 presents the candidate airline operator selection per four regions for 'duties of more than 10 hours at the less favourable time of day'.

The largest (in number of aircraft) of each suitable operator in the regions are presented first in the selection (i.e., these are the operators to approach first). All selections contain operations from either long-/medium-haul or sole cargo.

Table 7 Airline operator selection 1: Duties of more than 10 hours at less favourable time of day

Selection 1 CAT	*Region*	*Long-haul ops*	*Medium-haul ops*	*Sole cargo ops*
LOT Polish Airlines	East	X	X	
Czech Airlines	East	X	X	
Lufthansa	West	X	X	
British Airways	West	X	X	
KLM	West	X	X	
Air Berlin	West	X	X	
Condor	West	X	X	
ASL Airlines Belgium	West			X
Cargolux	West			X
Lufthansa Cargo	West			X
Scandinavian Airlines	North	X	X	
Icelandair	North	X	X	
Thomas Cook Scan.	North	X	X	
WOW Air	North	X	X	
Alitalia	South	X	X	
Iberia	South	X	X	
TAP Portugal	South	X	X	
Air Europa	South	X	X	

Table 8 presents the candidate airline operator selection per four regions for FDP 'disruptive schedules'.

Again, the largest (in number of aircraft) of each suitable operator in the regions are presented first in the selection (i.e., these are the operators to approach first). All selections contain operations from long-, medium-, short-haul, and/or regional, or sole cargo.

Table 8 Airline operator selection 2: Disruptive schedules

Selection 2 CAT	***Region***	***Long-haul ops***	***Medium-haul ops***	***Short-haul ops***	***Regional ops***	***Sole cargo ops***
WIZZ Air	East		X	X		
LOT Polish Airlines	East	X	X	X	X	
Air Baltic	East		X	X		
TAROM	East		X	X	X	
Czech Airlines	East	X	X	X		
Smartwings	East		X	X		
Lufthansa	West	X	X	X	X	
Ryanair	West		X	X		
British Airways	West	X	X	X		
KLM	West	X	X	X		
Air Berlin	West	X	X	X	X	
Flybe	West			X	X	
Condor	West	X	X			
ASL Airlines Belgium	West					X
Cargolux	West					X
Lufthansa Cargo	West					X
Scandinavian Airlines	North	X	X	X	X	
Norwegian Air Shuttle	North		X	X		
Norwegian Air Int.	North	X	X	X		
Icelandair	North	X	X	X		
Thomas Cook Scan.	North	X	X	X		
WOW Air	North	X	X	X		
BRA Braathens	North				X	
Vueling	South		X	X		
Alitalia	South	X	X	X		
Iberia	South	X	X	X		
TAP Portugal	South	X	X	X		
Air Europa	South	X	X	X		
Aegean Airlines	South		X	X		
Air Nostrum	South				X	

The candidate airline operators were approached and asked to participate in the planned data gathering activities. Depending on the willingness of the operators and aircrews to participate, the exact fit to the specific FDPs (to be verified by the airlines and national authorities), and the number of aircrew volunteering per operator[19], the operators were included.

[19] In Deliverable 2.2 (Definition of Data Collection Process) the required sample size of aircrew for the data collection campaign was calculated.

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List of abbreviations

Abbreviations	***Description***
AOC	Air Operator Certificate
BAM	Boeing Alertness Model
CAT	Commercial Air Transport
D	Deliverable
EASA	European Aviation Safety Agency
EC	European Commission
EU	European Union
FAST	Fatigue Avoidance Scheduling Tool
FDP	Flight Duty Period
FRM	Fatigue Risk Management
FTL	Flight Time Limitation
KSS	Karolinska Sleepiness Scale
NASA	National Aeronautics and Space Administration
SAFE	System for Aircrew Fatigue Evaluation
SAFTE	Sleep, Activity, Fatigue, and Task Effectiveness
SP	Samn-Perelli
WOCL	Window Of Circadian Low

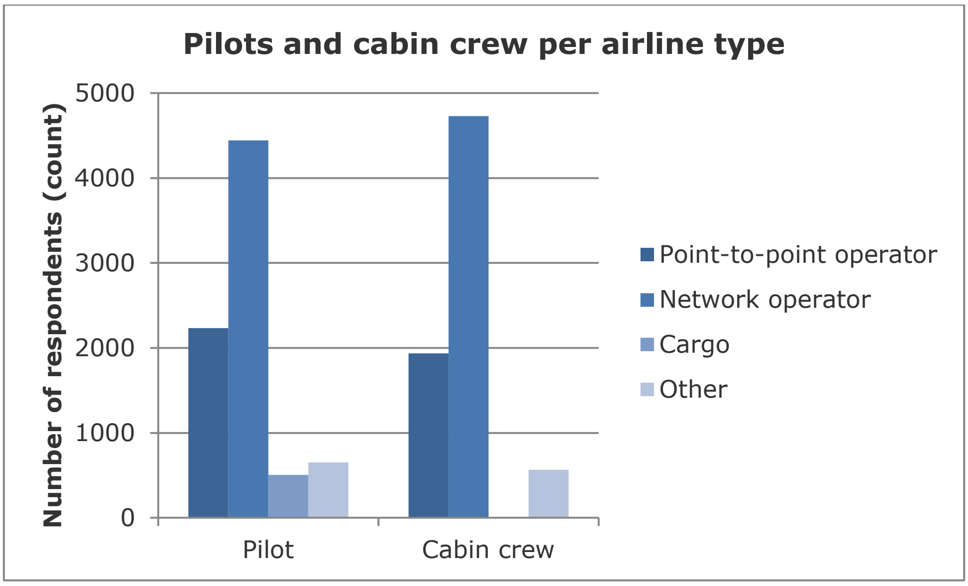
Appendix A: Survey results

Demographics

The total number of aircrew respondents was 15,680 (28.4% female). Of these respondents 58.2% was pilot (4.5% female) and 41.8% cabin crew (61.5% female). The mean age of all aircrew respondents was 41 years and 8 months old (range 17-75). The mean age for pilots was 42 years and 4 months and for cabin crew 40 years and 10 months.

Type of operator

Of the aircrew respondents 27.5% works for a point-to-point operator; 61% works for a network operator; 3.3% for a cargo operator; and 8.1% for another type of airline. In the figure below the number (n) of pilots and cabin crew working for a certain type of operator is presented.



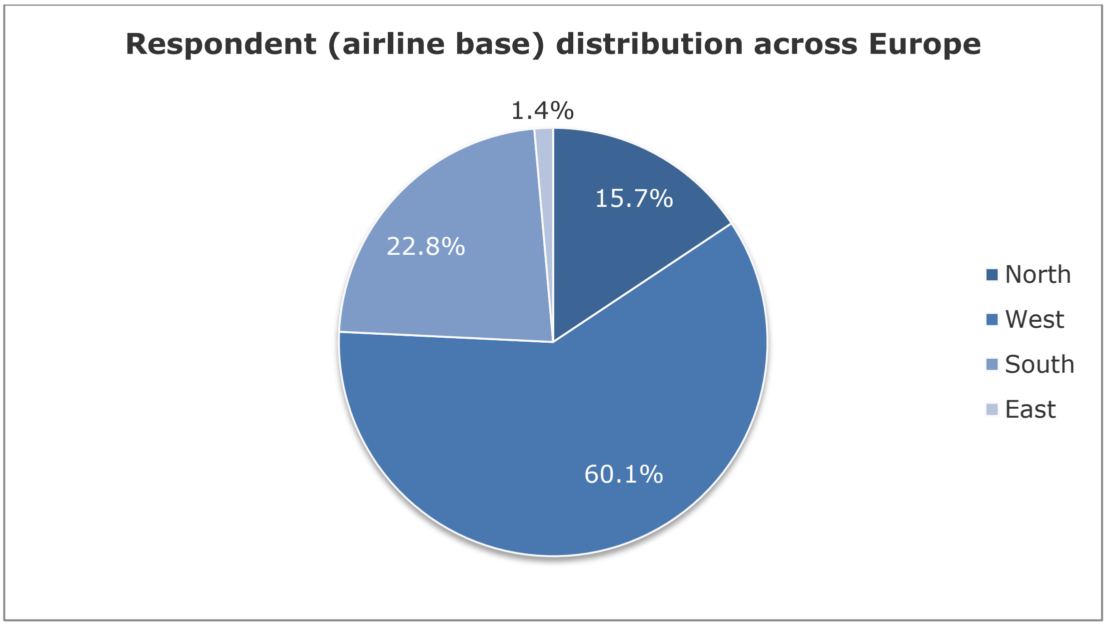
Travel time from residence

Mean travel time from residence to work for the aircrew is 1 hour and 10 minutes (ranging from 5 minutes to 10 hours); i.e., 1 hour and 10 minutes for pilots and 1 hour and 9 minutes for cabin crew.

Operator base

The distribution of aircrew respondents across Europe is illustrated in the figure below. The underlying survey question was: "In which country is your airline based?".

Note that Deliverable 2.2 Definition of the Data Collection Process describes the European population base for this FTL research. Based on this population base, it can be stated that the survey sample of aircrew is a fairly good representation of the entire population base when looking at the distribution across Europe. Only the representation of East Europe in the survey sample is smaller than in the entire population base.



In the table below the distribution of pilots and cabin crew is presented separately.

	North Europe	***West Europe***	***South Europe***	***East Europe***
Pilots	14.35%	58.13%	25.77%	1.76%
Cabin crew	17.07%	62.24%	19.66%	1.03%

FDP rating

In the table below the survey FDP ratings of the pilots are presented.

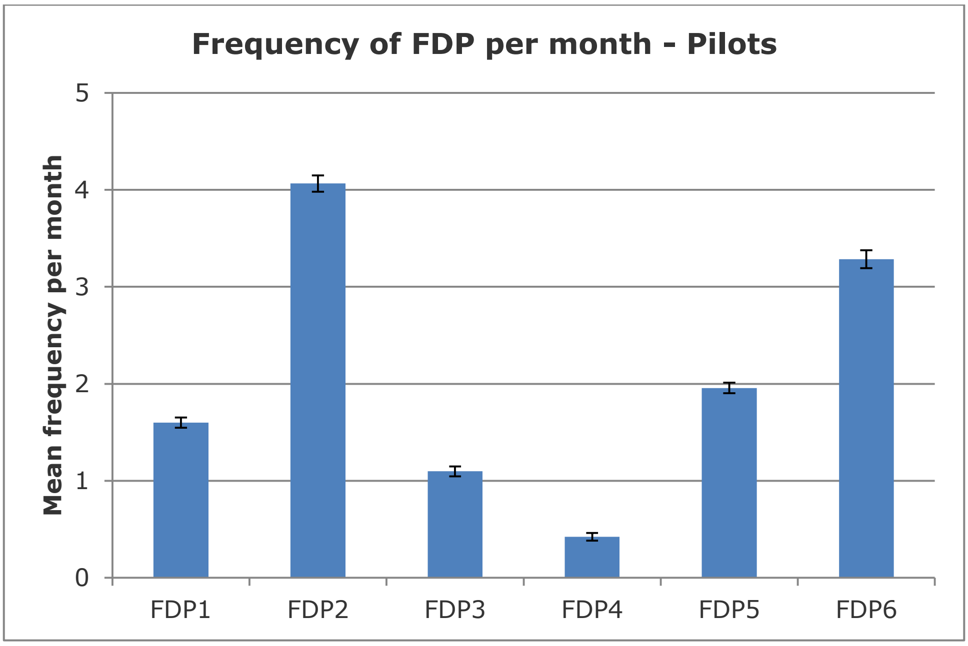
	FDP1 rating	***FDP2 rating***	***FDP3 rating***	***FDP4 rating***	***FDP5 rating***	***FDP6 rating***
Mean	(5) 6.75	(1) 7.48	(2) 7.44	(4) 6.87	(6) 6.64	(3) 7.28
N	4734	5727	2213	674	4248	4432
St. Error of the mean	.025	0.020	0.032	.069	.028	.023
Count of 8 or 9 scores on KSS	1650	3240	1238	269	1485	2232
% of KSS score counts above 7	35%	57%	56%	40%	35%	50%

In the table below the survey FDP ratings of the cabin crews are presented.

	FDP1 rating	***FDP2 rating***	***FDP3 rating***	***FDP4 rating***	***FDP5 rating***	***FDP6 rating***
Mean	(5) 6.41	(2) 6.88	(1) 6.96	(3) 6.66	(5) 6.14	(4) 6.64
N	4370	4782	2340	1108	3306	2876
St. Error of the mean	.029	.027	0.038	.058	.035	.035
Count of 8 or 9 scores on KSS	1275	1904	1029	404	831	1013
% of KSS score counts above 7	29%	40%	44%	36%	25%	35%

FDP frequency

In the figure below the mean frequency of FDP per month is presented for the pilots. The underlying survey question for each FDP experienced was: "How many times per month do you typically meet the Flight Duty Periods?".

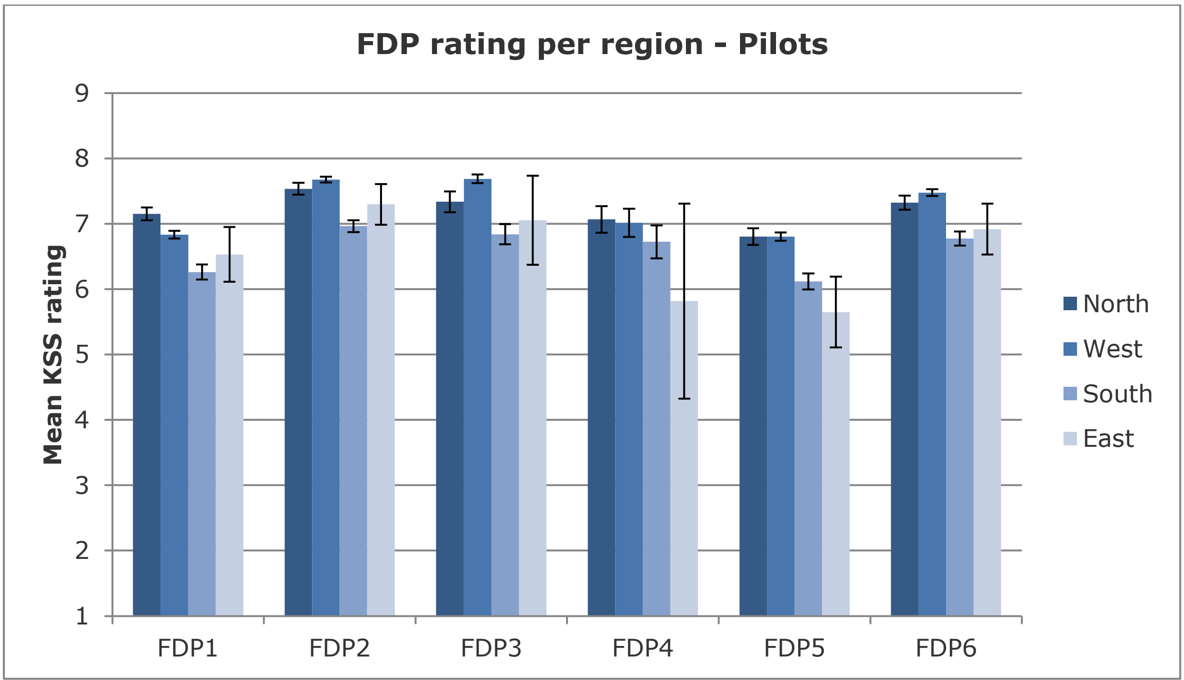


Cabin crew was asked: Please indicate how often you typically encounter this type of Flight Duty Period". The results are displayed in the following table.

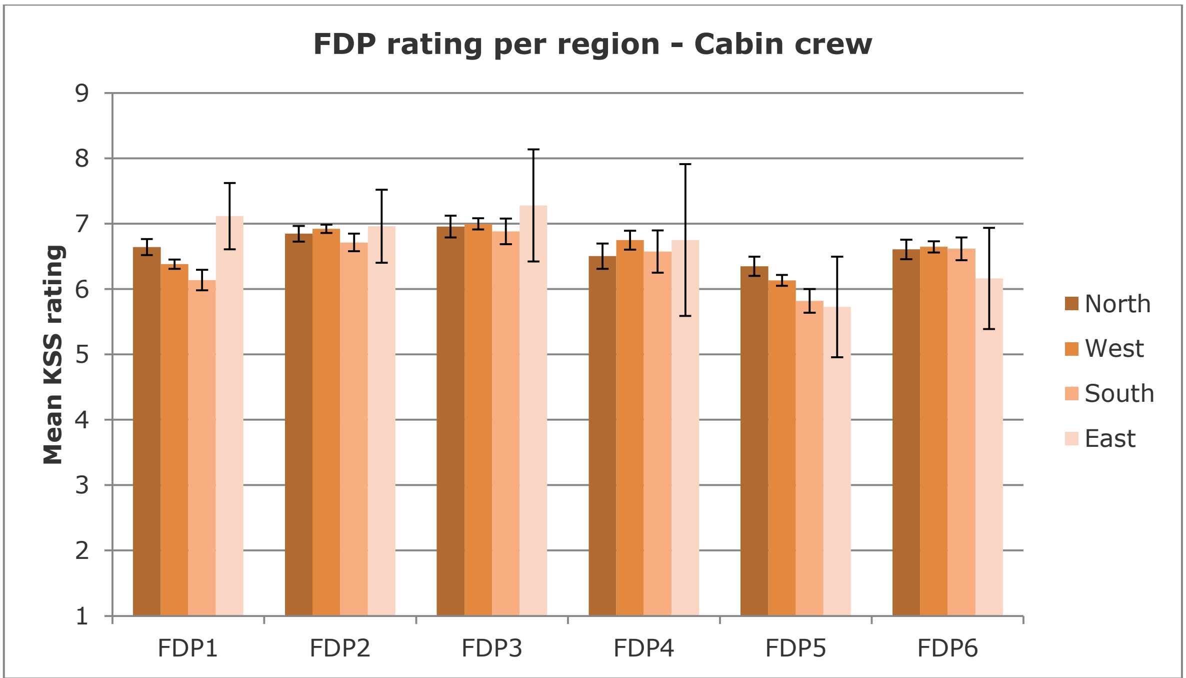
	FDP 1	***FDP 2***	***FDP 3***	***FDP 4***	***FDP 5***	***FDP 6***
Several times a week	12%	28%	13%	18%	12%	16%
Between once a week and once a month	50%	52%	55%	51%	35%	36%
Between once a month annually	32%	13%	28%	26%	44%	43%

FDP rating per region

In the figure below the mean FDP ratings by pilots are presented per European region[20].



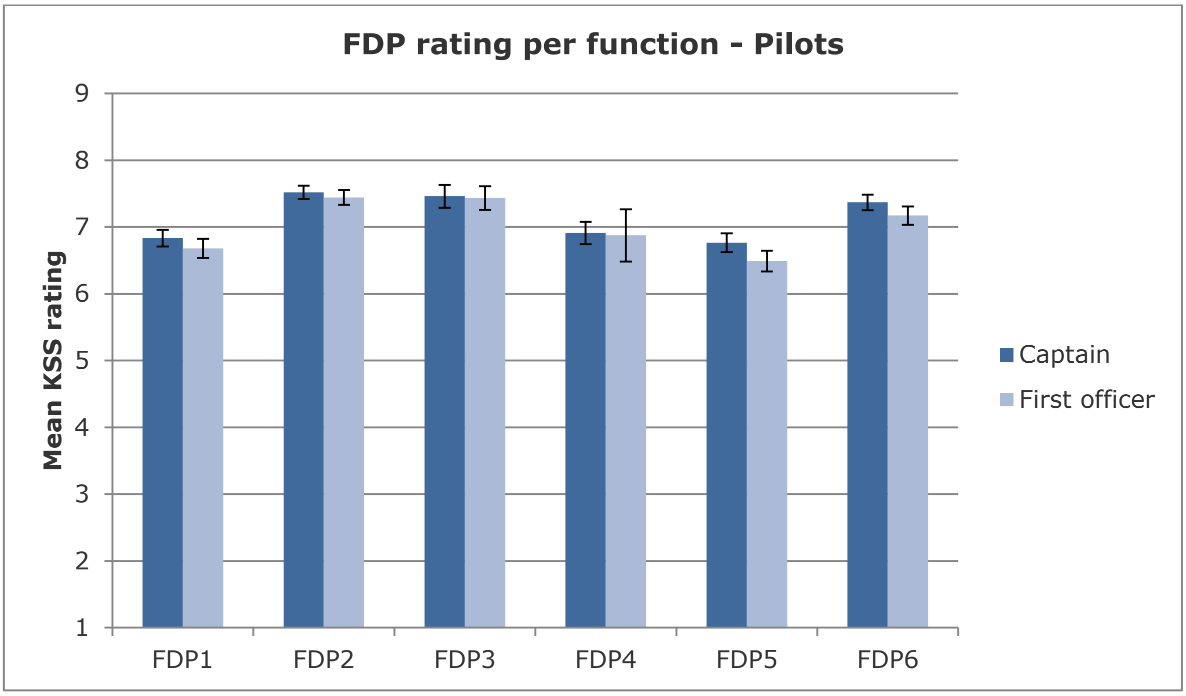
In the figure below the mean FDP ratings by cabin crew are presented per European region.



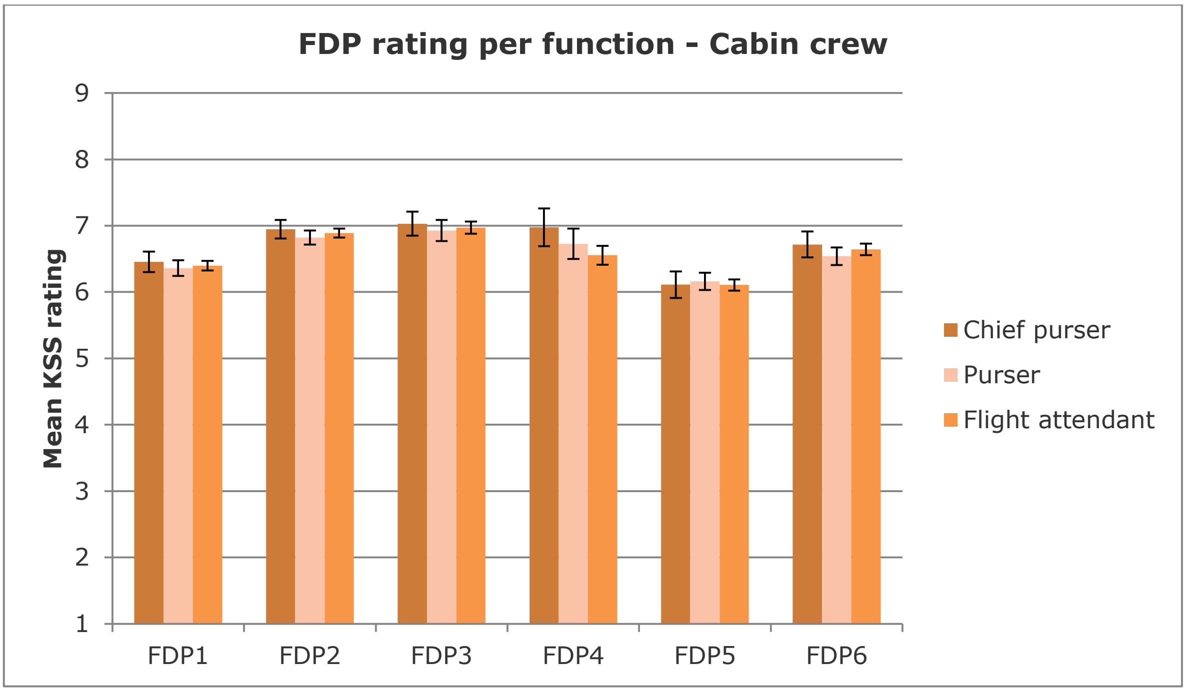
FDP rating per function

[20] The graph displays the mean KSS ratings including error bars representing the confidence intervals at 95%.

In the figure below the mean FDP ratings by pilots are presented per function (captain or first officer).



In the figure below the mean FDP ratings by cabin crews are presented per function (chief purser, purser and flight attendant).



European Commission