Sleepiness at Top of Descent - Influence of Time of Day, End Time, Duration and Sectors in a Large European Sample of Aircrew

Selected results from:

Effectiveness of Flight Time Limitation (FTL)

Procured by


EASA
European Aviation Safety Agency


European
Commission

Consortium

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Other groups

- Scientific committee
  - Barbara Stone, Alex Holmes, Steven Hursh, Philippe Cabon, Kristjof Tritschler
- Mirror group
  - Representatives of airlines, labor unions, and aviation authorities

Objectives

- ***To perform a review of the effectiveness of the provisions concerning flight and duty time limitations and rest requirements contained in Annexes II and III of Commission Regulation (EU) Nº 965/2012***

The top 2 ranked FDPs based on expected fatigue levels

1. **Duties of more than 10 hours at the less favourable time of the day**
   This refers to operations that encroach (part of) the night (between 02:00h and 04:59h (modified) (WOCL)

2. **Disruptive schedules**
   This refers to (consecutive) early starts, late finishes, night duties and combinations thereof

3. **Identification of "hotspots"**
   This refers to conditions that lead to high fatigue/sleepiness

Particularly central FTL points

- 13h is the maximum flight duty period for day flights
- 10 h is the maximum if flight duty period (FDP) encroaches on the WOCL (“night flight”)
- Many sectors (“legs”) will reduce the duration of the FDP further

Approaches

- Literature review
- Survey of 16000 EU pilots
- Modeling of duty rosters
- Field study with crowd-sourcing

Definitions of outcome concepts (”effectiveness”)

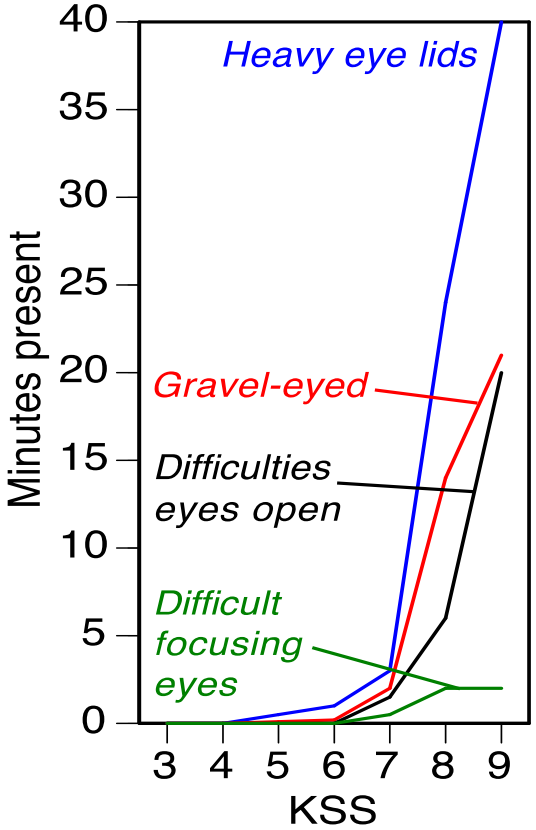
- Sleepiness – a drive to fall asleep
  - EEG measures possible, but not feasible in large studies, and with limited validity
  - Performance measures possible, but of limited value in unsupervised field studies
  - Sleepiness ratings, high validity
- Fatigue – inability to muster energy to carry out tasks
  - No objective measures available
  - Performance measures possible, but of limited value in unsupervised field studies
  - Rating scales valid, for example Samn-Pirelli scale

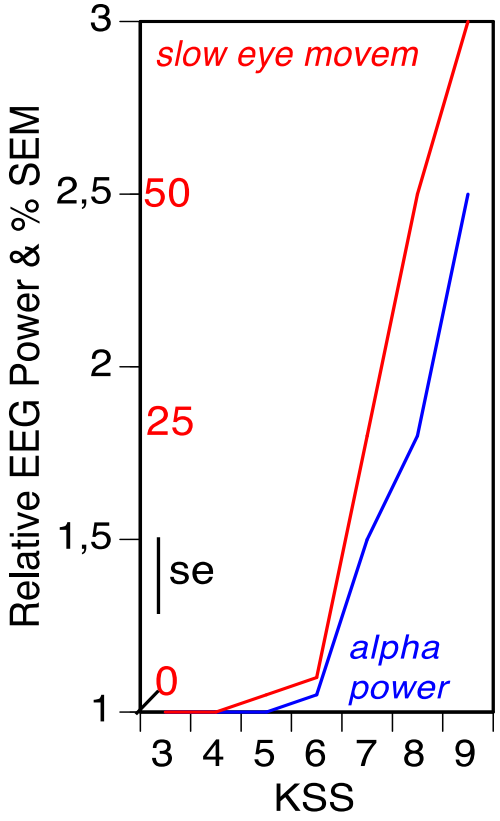
Karolinska Sleepiness Scale (KSS)

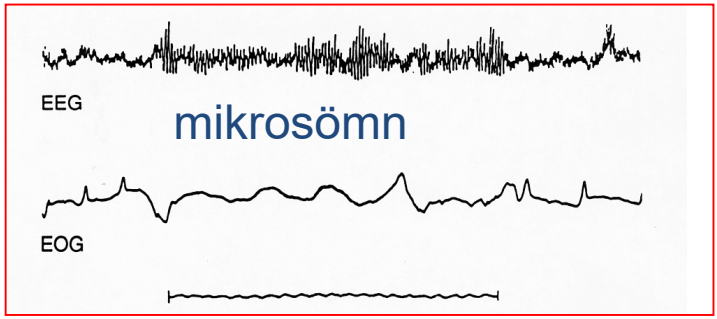
1 Extremely alert
2 Very alert
3 Alert
4 Rather alert
5 Neither alert nor sleepy
6 Some signs of sleepiness
7 Sleepy, but no effort to remaining awake
8 Sleepy, some effort to remain awake
9 Very sleepy, great effort stay awake, fighting sleep

1.T Åkerstedt, M Gillberg. Subjective and objective sleepiness in the active individual. International Journal of Neuroscience. 1990; 52: 29-37.
T Akerstedt, A Anund, J Axelsson, G Kecklund. Subjective sleepiness is a sensitive indicator of insufficient sleep and impaired waking function. Journal of sleep research. 2014; 23 (3): 240-252.

KSS vs ratings and EEG/EOG

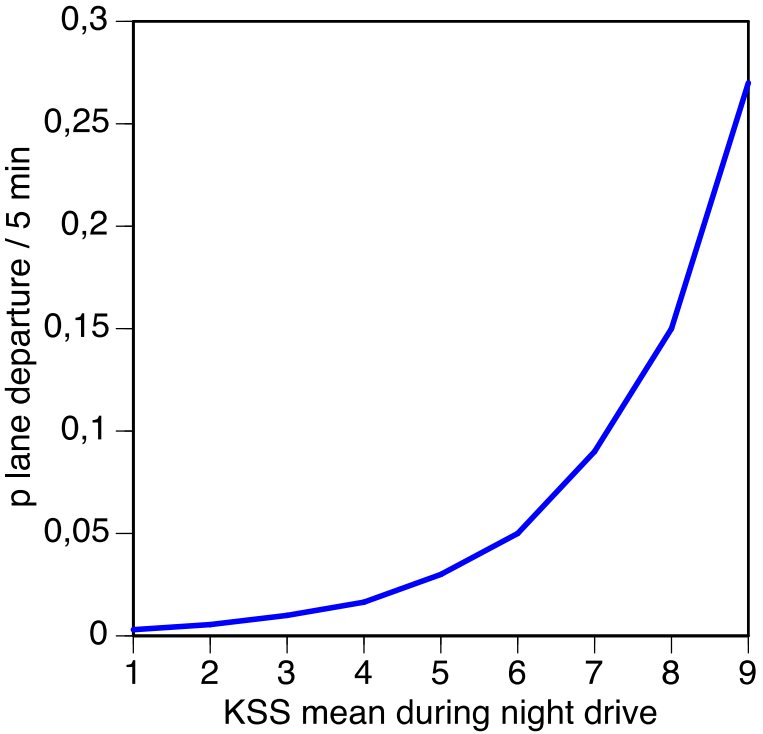






Sleepiness and the probability of crossing a lane marker (real driving) during the next 5 minutes

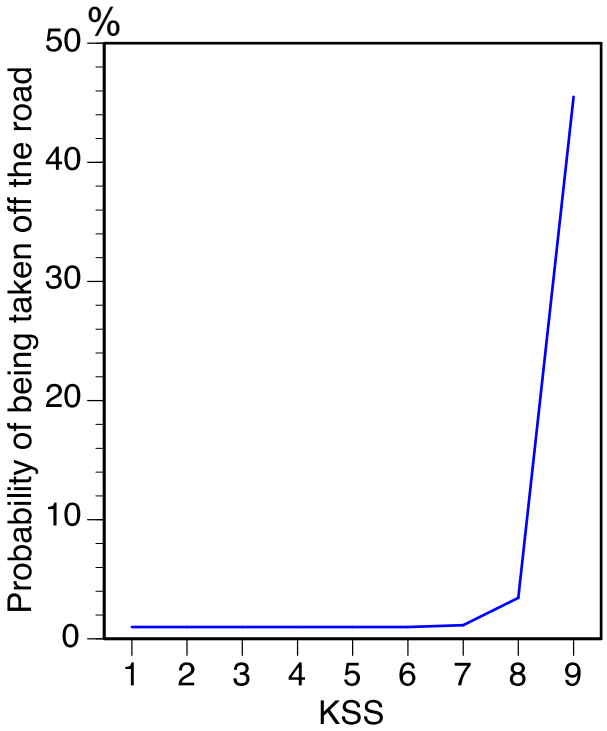
N=39



EEG and EOG are far less consistent

Sandberg et al 2014

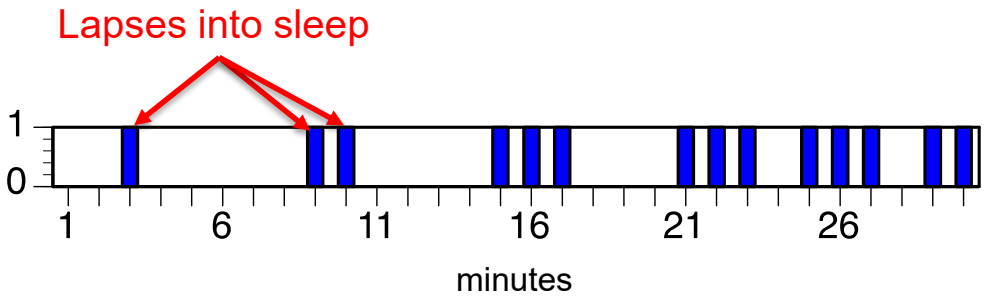
Probability of being taken off the road and immediately preceding KSS (real motorway driving)



EEG and EOG
are far less consistent

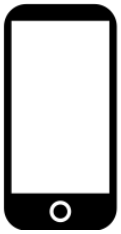
Åkerstedt et al 2013

Sleepiness is frequency modulated



Aircrew measures

Field study



- Data collection blocks of 14 days per crew member

- Measures
  - Actigraph
  - Data collection app on smartphone or tablet
    - KSS, SP, PVT, workload, hassle factors, sleep logs, rosters
    - Aircrew normally to assess the app at duty start and 15 min prior to TOD

High level data analysis steps

Field study

- To identify whether or not high fatigue scores (KSS>7) occurred in the FDPs of interest
- To compare fatigue scores between the FDPs of interest and its control FDP categories (i.e. “day” FDPs)
- To determine clusters of FDP-related characteristics (or predictors) under which high levels of fatigue occur (which predictors are most important)
- Or: bring out the factors that predict high fatigue and identify what’s wrong in FTL (TÅ:s interpretation)

Results

Predicting high fatigue in night flights (vs day flights)

	Model 1 *Unadjusted OR (CI)*	*p*	***Model 2*** *All var OR (CI)*	*p*
FDP duration	1.08 (1.01;1.16)	.037	0.97 (0.88;1.07)	.561
WOCL	3.00 (1.69;5.33)	.000	3.20 (1.11;9.19)	.047
Sleep 24h pre TOD	0.84 (0.76;0.91)	.000	0.86 (0.77;0.96)	.009
FDP start time	1.06 (1.02;1.10)	.003	#	

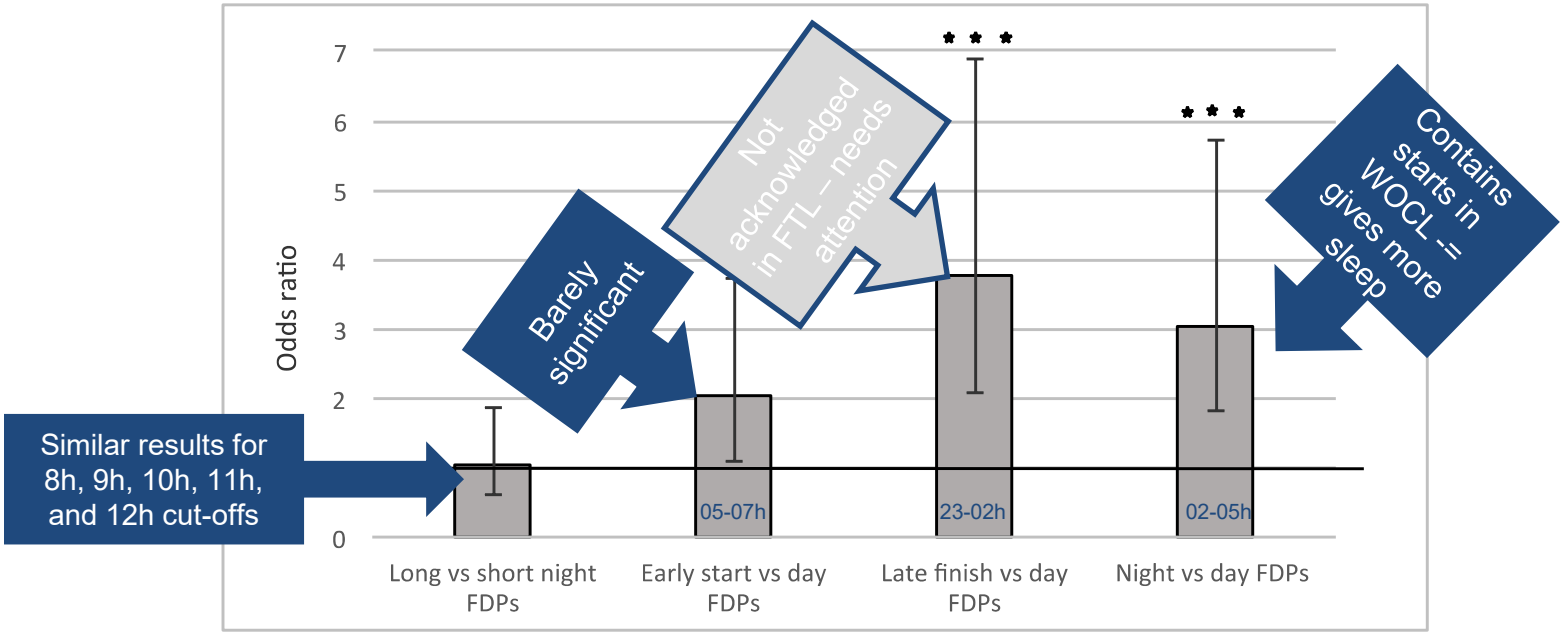
.

Non-significant variables in unadjusted: Pilot/cabin crew, Gender, Age, Napping in flight, Time zones crossed WE, Time zones crossed EW, Start time, *Number of sectors*, Time awake prior to TOD

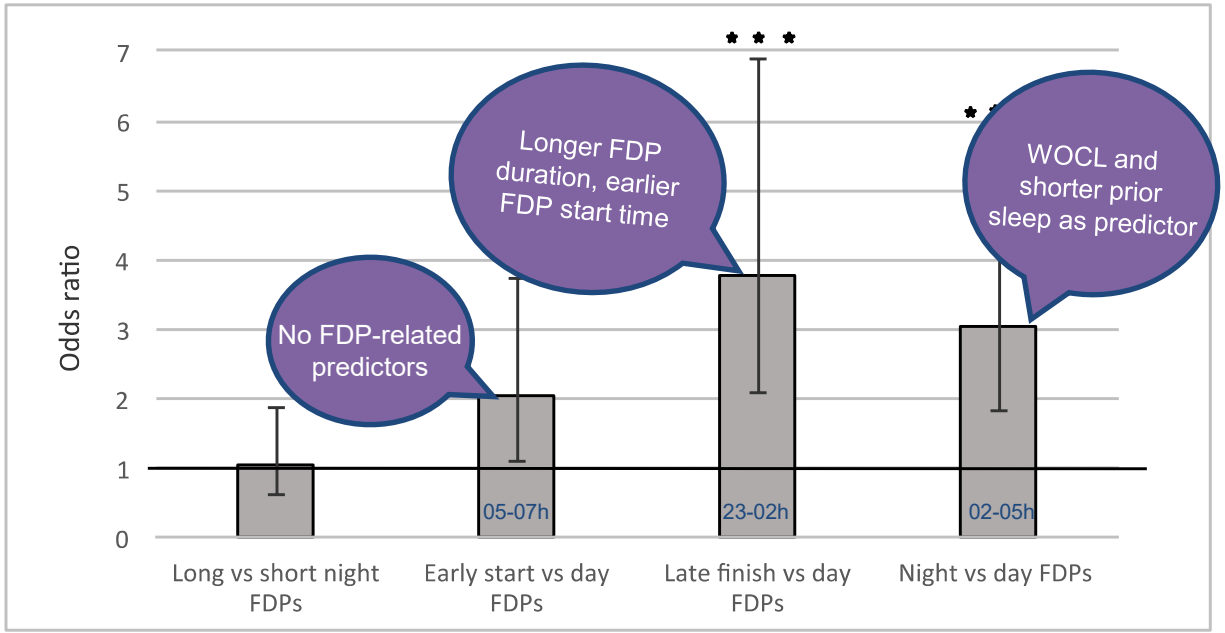
FDP types and fatigue with present critical FTL categories

Odds ratios for reporting high fatigue at TOD (using present classification of "difficult FDPs"

KSS≥7



The predictors of high fatigue at TOD



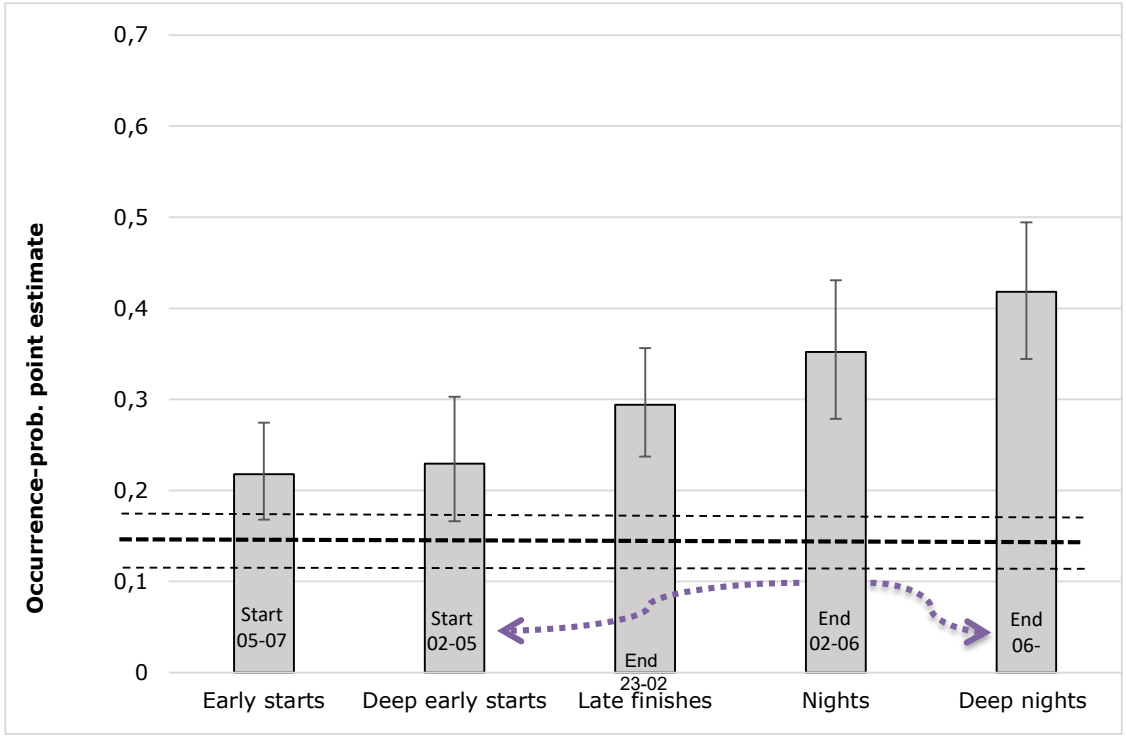
WOCL, FDP duration and sleep

- Note that prior sleep duration is predicted by
  - WOCL: 1h less sleep for each hour of FDP in WOCL
  - FDP duration: 7 min less sleep for each hour of FDP duration

Predicting high sleepiness – Night FDPs only (WOCL removed)

- The significant variables became:
  - Sleep in 24 hours prior TOD (OR = 0.84 (CI = 0.75; 0.94), p = .002)
  - Cabin crew (vs pilots) (OR = 1.89 (CI = 1.07; 3.36), p = .029).

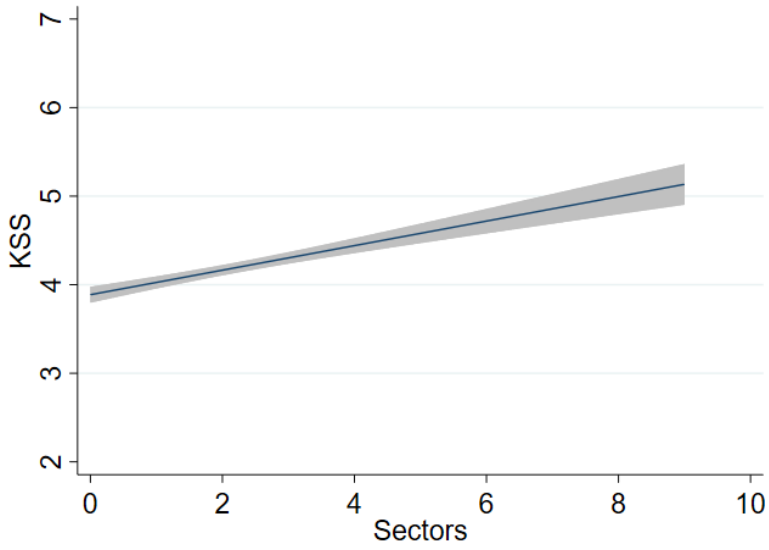
An alternative classification of FDPs based on present results

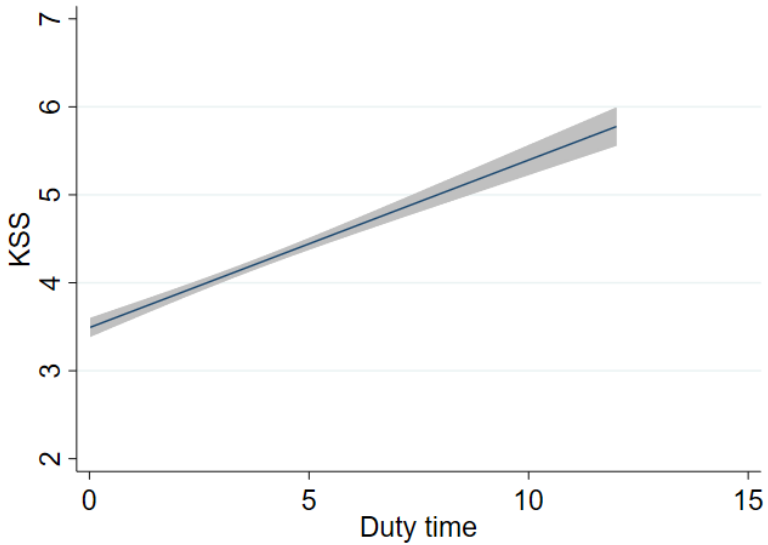


Napping (controlled rest)

- 27% of night FDPs of more than 10 hours contained naps
- 20.2% of night + late finish FDPs contained naps
- Not significantly lower fatigue for nap FDPs
  - Note that the design is not suited for studying effects of naps (should be before/after)

A digression – many sectors with ultra-short FDPs





N=106

Akerstedt et al 2021

Conclusions

Night FDPs, both those longer and shorter than 10 hours, were associated with a high probability of high fatigue at TOD

- This is not fully reflected in the current FTL

Our results suggest that late finish and night FDPs are more fatiguing than early start FDPs. In addition, deep night FDPs seem to be more of a concern than late finish and night FDPs

Our view is that the current definitions of FDPs typical of disruptive schedules could be more closely aligned to an established and science-based model used to predict fatigue. This revision would probably pave the way to better management of fatigue

Mina slutsatser

- Viktigaste trötthetsfaktorn är FDP som inkluderar hela WOCL (deep night)
- Sena kvällsflygningar medför ökad trötthet och behöver mer uppmärksamhet
- Viss trötthetseffekt av tidiga morgonflygningar
- Viktigaste mekanismen för ovan är förkortad sömn
- Ingen trötthetsökning av att (måttligt) överskrida 10 tim FDP (jämfört med t.ex 9, 8 el 7 timmar)
- Över hela spannet av FDP-längder finns dock ett visst samband med trötthet
- Ingen effekt av antal sektorer (men för begränsat spann)

The new FTL(2) project focuses on

- Duties of more than 13 hours at the most favorable times of the day
- Duties of more than 11 hours for crew members in an unknown state of acclimatization
- Duties including a high level of sectors (more than 6)
- On-call duties such as standby or reserve followed by flight duties

Questions?

Coordinator

Six recommendations

Recommendation 1

Within the FDPs that are defined as ‘night’ FDPs in the current regulation, three subgroups can be distinguished based on the occurrence probability of high fatigue at TOD:

1. FDPs with a start time between 02:00h and 04:59h
2. FDPs with an end time between 02:00h and 05:59h and a start at 01:59h or earlier
3. FDPs with an end time of 06:00h or later and a start time at 01:59h or earlier

It is recommended that these subtypes be included in the definition of night FDPs to help operators to tailor effective fatigue risk management strategies

Recommendation 2

The analysis provides evidence of high fatigue at TOD during late finish FDPs

It is recommended that operators be required to apply appropriate fatigue risk management to mitigate the fatiguing effect of late finish FDPs, regardless of FDP duration

Recommendation 3

The analysis provides evidence of high fatigue at TOD during night FDPs of both long duration (> 10h) and shorter duration (≤ 10h)

It is recommended that operators be required to apply appropriate fatigue risk management to mitigate the fatiguing effect of *all* night FDPs, regardless of FDP duration

Recommendation 4

Within night FDPs, duty periods that end at 06:00h or later combined with a start at 01:59h or earlier show the greatest probability of high fatigue at TOD

It is recommended that the regulation defines this category of FDP and require operators to pay specific attention to these FDPs when applying fatigue risk management for *all* night FDPs as proposed in recommendation 3.

Recommendation 5

The analysis found shorter prior sleep to be a predictor of high fatigue at TOD for all night FDPs

The current guidance materials for night duties (GM1 CS FTL.1.205) stipulate that it is ‘critical for the crew member to obtain sufficient sleep’ for night duties of more than 10 hours

It is recommended that the GM be amended to state that it is critical for the crew member to obtain sufficient sleep before *all* night duties, regardless of FDP duration

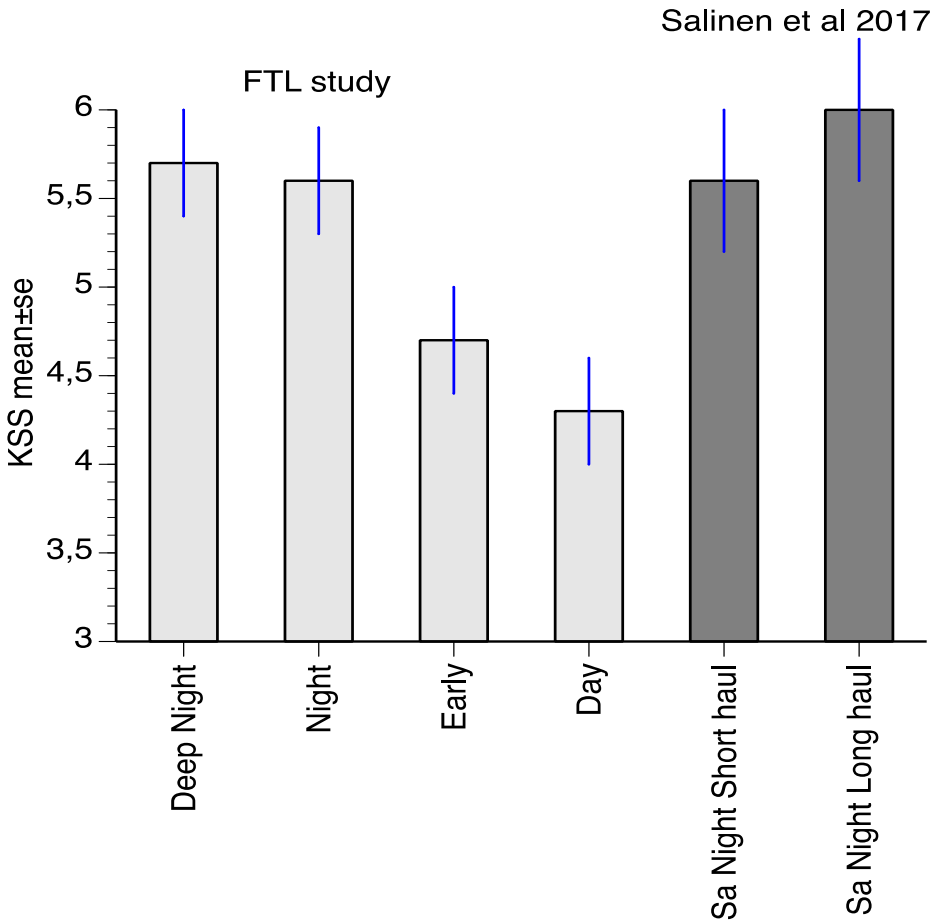
Recommendation 6

The analysis provides evidence of high fatigue at TOD during night FDPs. This phenomenon seems to be fairly independent of FDP characteristics (e.g., start and end times, duration), as long as the FDP in question meets the criteria for a night FDP

Prior sleep is the main predictor of eventual fatigue

We therefore recommend that for night FDPs, operators should be required to promote optimum use of sleep opportunities (i.e., before reporting and during the FDP)

How do our KSS values compare to other studies? *Field study –*



Consecutive disruptive schedules

- No significant difference in fatigue at TOD was found between the first and second consecutive disruptive FDPs
- Longer sequences of consecutive disruptive schedules could not be tested because they were very infrequent (also in the roster data)
  - This might be the result of the current FTL

A reminder

- Note that fatigue ratings are made at TOD of the final sector of an FDP
- We did not measure the length of time participants were fatigued

How to implement these recommendations?

For night FDPs operators should be required to promote optimum use of sleep opportunities

Providing rest facilities for crew members at or near the airport would improve the probability of obtaining sleep as close as possible to the start of the night duty

That might imply providing suitable accommodation at the reporting point for napping in the afternoon prior to a night duty

A way of improving opportunities for *in-flight* sleep is the use of an augmented crew

Research has shown that additional in-flight sleep effectively mitigated fatigue on longer flights

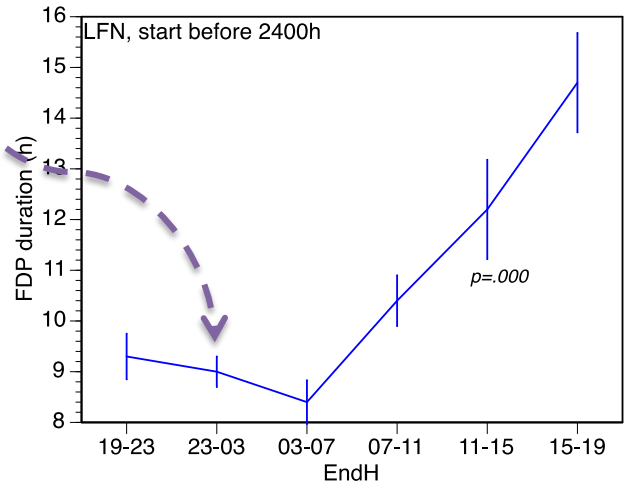
Our data show that napping is quite frequent during night duties. Controlled rest is not pro-active fatigue management and may be performed only to manage unexpected fatigue

We suggest promoting the development and use of controlled rest procedures to enable pilots and cabin crew to take a nap during night FDPs to manage unexpected fatigue

We also suggest operators to track the use of controlled rest as it is a very useful indication of where additional more effective controls may be necessary

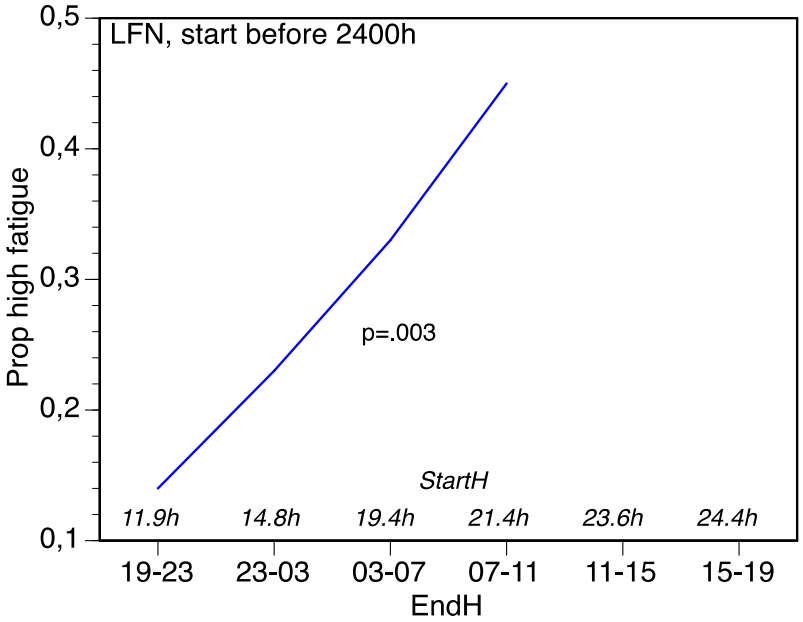
FDP duration - why not significant during night FDPs?

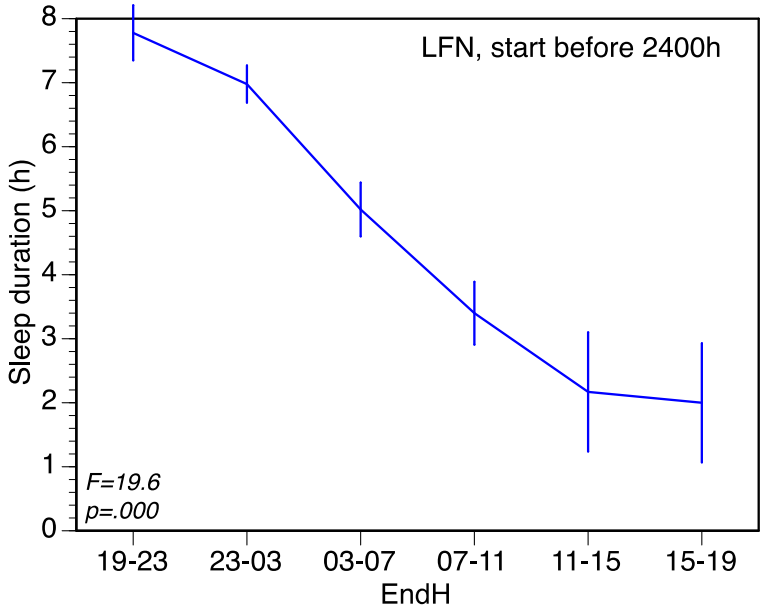
- FDP duration is not significantly associated with high fatigue in night FDPs
- Significantly, but weakly associated with high fatigue during day FDPs
- But, short FDPs are very scarce in night FDPs – reduces the possibility to find significant effects
- And, FDPs ending during the night hours are short
  - Apparently the night flight limitations work



End times vs high fatigue and prior sleep duration

Fatigue at TOD during the FDPs of interest – (covariates with an influence)





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