Extended Flight Duty Periods and Flight Safety
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TNO Onboard Crew Rest Study – July 2008

Extended duties: base-to-base flight schedules – 3 legs
average FDP 14:00 hr
1 pilot augmented

B 737-800
When max. permissible FDPs are extended, alertness and vigilance may reach unacceptably low levels.

Extended FDPs require crew augmentation with in-flight relief in order to reduce the negative effects of extended time-on-task on alertness and vigilance to acceptable levels. (e.g. levels found at TOD during permissible FDPs).

**Aim of the Study**

- Assess quality and effects of the in-flight rest on fatigue and alertness on extended-FDP trips
- Enable a scientifically based advice concerning flight safety
Method

- Flight crew participation: 40

- Pilots scheduled on one extended-FDP duty in their normal 3-4 days duty roster. Test sessions: during one complete duty roster and related days off

- Test sessions: after wake up, pre-duty, before and after in-flight rest period, at TOD, and after reporting off duty

**Method**

- Actiwatch
- Vigilance and Track Task
- Questionnaires/rating scales

### 7-point Siem-Parrish Fatigue Scale (SPFS)

<table>
<thead>
<tr>
<th>Rate</th>
<th>Verbal descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>fully alert, wide awake</td>
</tr>
<tr>
<td>2</td>
<td>very lively, responsive but not at peak</td>
</tr>
<tr>
<td>3</td>
<td>okay, somewhat fresh</td>
</tr>
<tr>
<td>4</td>
<td>a little tired, less than fresh</td>
</tr>
<tr>
<td>5</td>
<td>moderately tired, list down</td>
</tr>
<tr>
<td>6</td>
<td>extremely tired, very difficult to concentrate</td>
</tr>
<tr>
<td>7</td>
<td>completely exhausted, unable to function effectively</td>
</tr>
</tbody>
</table>

### 7-point Karolinska Sleepiness Scale (KSS 9 ratings)

<table>
<thead>
<tr>
<th>Rate</th>
<th>Verbal descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>extremely alert</td>
</tr>
<tr>
<td>2</td>
<td>very alert</td>
</tr>
<tr>
<td>3</td>
<td>alert</td>
</tr>
<tr>
<td>4</td>
<td>rather alert</td>
</tr>
<tr>
<td>5</td>
<td>neither alert nor sleepy</td>
</tr>
<tr>
<td>6</td>
<td>some signs of sleepiness</td>
</tr>
<tr>
<td>7</td>
<td>sleepy, but no effort to keep alert</td>
</tr>
<tr>
<td>8</td>
<td>sleepy, some effort to keep alert</td>
</tr>
<tr>
<td>9</td>
<td>very sleepy, great effort to keep alert, falling sleep</td>
</tr>
</tbody>
</table>
Results

Data sets of 36 pilots: 33 male, 3 female; 21 captains and 15 FOs

- Regular duties: mean FDP 9:43 hr (range 3:30-13:40)

- Extended-FDP duties: mean FDP 13:58 hr (range 12:45-15:55)
  - start between 11:20-15:00 h
  - end between 01:35-06:15 h

Results: Pre-Duty sleep

<table>
<thead>
<tr>
<th>GSQS</th>
<th>bedtime</th>
<th>Wake up time</th>
<th>TST subjective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 (0-12)</td>
<td>01:49 (22:15-07:00)</td>
<td>09:29 (05:00-14:00)</td>
<td>7:17 (2:00-11:00)</td>
</tr>
<tr>
<td>Regular Duty</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7 (0-12)</td>
<td>00:06 (19:00-04:30)</td>
<td>07:40 (01:00-12:15)</td>
<td>6:50 (2:00-10:00)</td>
</tr>
<tr>
<td>Extended Duty</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 (0-12)</td>
<td>00:42 (21:00-04:00)</td>
<td>08:40 (02:50-11:35)</td>
<td>7:41 (03:20-11:40)</td>
</tr>
</tbody>
</table>
Results: In-flight sleep

- Mean period available for sleep: 135 min
- Pilots, who slept longer, had lower fatigue and sleepiness levels and better vigilance performance at TOD

42% of the pilots did not sleep at all

Sleep efficiency (16-37%) was much lower than found in literature of in-flight rest (50-70%)

Reported sleep disturbing factors:
- rest facility not comfortable*
- insufficient ventilation
- light, noise, surrounding pax
- lack of privacy in relation to pax

\{ Facility conditions not conducive to sleep \}

some pilots: rest period during circadian activity phase
Results: In-flight sleep

*Discomfort issues reported:
- lack of back and neck support
- sticking out of seat belt attachments
- insufficiently reclining arm rests
- cushions too thin

Results: Fatigue & Sleepiness during FDP

Fatigue

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wake Up</td>
<td>Fully alert, wide awake</td>
</tr>
<tr>
<td>Pre-Duty</td>
<td>Very lively, responsive but not at peak</td>
</tr>
<tr>
<td>Before Rest</td>
<td>Okay, somewhat fresh</td>
</tr>
<tr>
<td>After Rest</td>
<td>A little tired, less than fresh</td>
</tr>
<tr>
<td>Before TOD</td>
<td>Moderately tired, let down</td>
</tr>
<tr>
<td>Post-Duty</td>
<td>Extremely tired, very difficult to concentrate</td>
</tr>
</tbody>
</table>

SP level 5 categorised as “Fatigue Class II”, described as ‘Moderate to severe fatigue. Some performance impairment probably occurring. Flying duty permissible but not recommended.’
Results: Vigilance during FDP

At TOD: 32% increase of tracking error compared with pre-duty
11% increase of reaction time compared with pre-duty

Results: Fatigue, Sleepiness, Vigilance during FDP

- Pre-duty fatigue, sleepiness, and vigilance levels equal in regular and extended-FDP duties
- Extended-FDP: significant impairment in rest period
- Longer FDP on extended duties: higher fatigue and sleepiness levels and more vigilance impairment at TOD
- Extended-FDP: circadian phase affected sleepiness levels at TOD and End duty.
- Circadian effects on sleepiness will increase when pilots have no recuperative in-flight sleep.
Conclusions (1)

- Extended-FDPs: no reduction of negative effects of long time-on-task and working during circadian sleep phase.

- Large increases in sleepiness, fatigue, and impairment of vigilance performance related to:
  - long time-on-task
  - non-recuperative in-flight rest
  - flying during the circadian sleep phase

Conclusions (2)

- Conditions of crew rest facility are not conducive to sleep

- Present in-flight rest is not effective:
  - Rest, or sleep, in rest facility not recuperative
  - No benefit for vigilance, fatigue and sleepiness
Conclusions (3)

TOD:

- Impairment of alertness at TOD did not exceed limits associated with unacceptable increase of flight safety risk.
- Vigilance indicators come close to the safety limits.
- Safe flight performance may be at risk in a subgroup of pilots.

Frequency distribution of fatigue scores at TOD

20% of the pilots: ‘Extremely tired, very difficult to concentrate’
**Post Duty:**

61% of pilots should take a taxi home or sleep in airport hotel

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**Recommendations (1)**

- Improve efficacy of in-flight rest:
  - Better separation from passengers
  - Adapted seats allowing comfortable horizontal sleeping surface
  - More space around the seat(s) or berth
  - Noise, Light, Climate control
  - Use noise & light reducing devices
Recommendations (2)

- Optimize alertness during an extended FDP:
  - Promote optimal use of rest facility
  - Promote sufficient pre-duty sleep at home
  - Combat sleep inertia by resuming flight tasks 15-20 min after rest
  - Promote post duty opportunities provided:
    - Take a taxi, or stay in an airport hotel

Recommendations (3)

- If no feasible solution can be found to realize recuperative in-flight sleep: reschedule present extended operations and provide crew with sufficient sleep at slipping station before the return flight

- Implement a Fatigue Risk Management System (FRMS) to better match operational needs and fatigue-related flight safety considerations