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EBAA/ECA Study of Fatigue in Air Taxi, Emergency Medical Service Commercial Air Operations

Presentation to EASA
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Contents

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1.0 INTRODUCTION

Background

Purpose:

a. Study work-rest patterns and levels of fatigue

- Air Taxi (AT) and Emergency Medical Services (EMS)(fixed wing only)
- Single pilot operations originally included in the ITT but not part of the study

b. Assist in the development of Flight Time Limitation and rest requirements being considered by the European Aviation Safety Agency (EASA)

Sponsor: European Business Aviation Association (EBAA) in collaboration with the European Cockpit Association (ECA)

Specific problems identified linked to FTL Implementing rule

1. Air Taxi pilots fly fewer hours and have fewer duty days than their commercial equivalents (less than 30 hours flying and around 10 duty days per month)
2. Non-scheduled operations require more flexibility
3. Last minute changes occur at short notice making planning difficult

Specific problems identified linked to FTL Implementing rule

4. Reduction in maximum daily FDP poses a problem for the 3rd sector as three sectors are common in Air Taxi (one of three is often a positioning flight)
5. Definition of acclimatised is an issue, as application and calculation is difficult when planning at short notice
6. Rest time after TZ crossing, combined with days of inactivity
7. Standby is said to be more relaxed than airline standby

2.0 STUDY OBJECTIVES AND METHODOLOGY

2.1 Tender requirements

Tender requirements for The European Business Aviation Association (EBAA)/ European Cockpit Association (ECA) study :

2. 1.1 To research a dataset of the fatigue/alertness changes and levels of pilots on real world flight duties in the context of real world schedules in business aviation.

2.1 Tender requirements

2.1.2. Separately:

a. To analyse this dataset to determine the effects of the different aspects of unscheduled duties and rostering (unscheduled flights are typical for business operations) on pilot fatigue/alertness

b. To propose scientifically based mitigation measures to prevent fatigue from reducing alertness to unsafe levels or adversely affecting the health of aircrew.

c. Compare the dataset with a commercially available fatigue model

2.2 FRMSc Approach

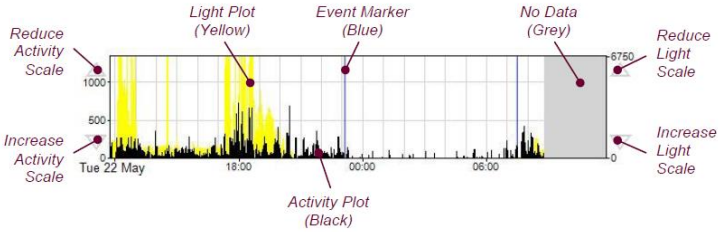
Objective 1

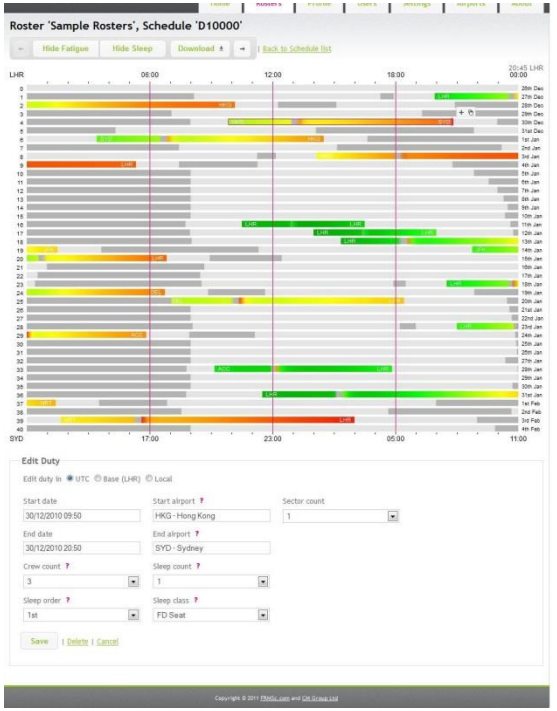
- Fatigue and sleep patterns were measured in volunteer pilots from EBAA members during one month of duties.
- Volunteers were recruited from both **Air Taxi** and **Emergency Medical Service** operations.
- Air Taxi operations included some pilots operating across more than three time zones in order to measure the effect of transient, cumulative and circadian fatigue
- Measurement methods included actiwatch recordings that are validated against EEG measures

2.2 FRMSc Approach

Objective 2

- Sleep patterns were measured subjectively (diary) and objectively (actigraphy)
- Circadian rhythms were measured by assessment of sleep adaptation following time zone changes
- Comparison of the data with a bio mathematical model (SAFE) has been made





2.2 FRMSc Approach

Objective 3

The fatigue and alertness levels experienced by pilots carrying out their operations was measured using diaries.

2.2 FRMSc Approach

Objective 4

The differences between the impact of Business Aviation and CAT operations on alertness levels, transient and cumulative fatigue have been identified.

2.2 FRMSc Approach

Objective 5

The major fatigue risks affecting Business Aviation operations have been identified and scientifically based mitigation measures have been proposed.

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2.3 Volunteers

Eligibility

- Home base in Europe
- Operate an aircraft with a MOPSC of 19 or less
- Not a management pilot
- Pilots from non-commercial Operators were eligible, provided the Operator follows the EU-Ops (Subpart Q) Regulations or similar National FTL rules
- Volunteers included those from large and small operators and no more than **10 pilots** from one company to provide objective data
- iPad owner or have daily access for a month
  - Paper diaries introduced in order to increase number of volunteers

2.3 Volunteers

Recruitment

- Recruitment by invitation from EBAA and ECA to its members
- Members responded & FRMSc followed up to determine numbers
- EBAA validated suitable volunteer organisations
- Equipment and instructions sent out by FRMSc

2.4 Data collection tools

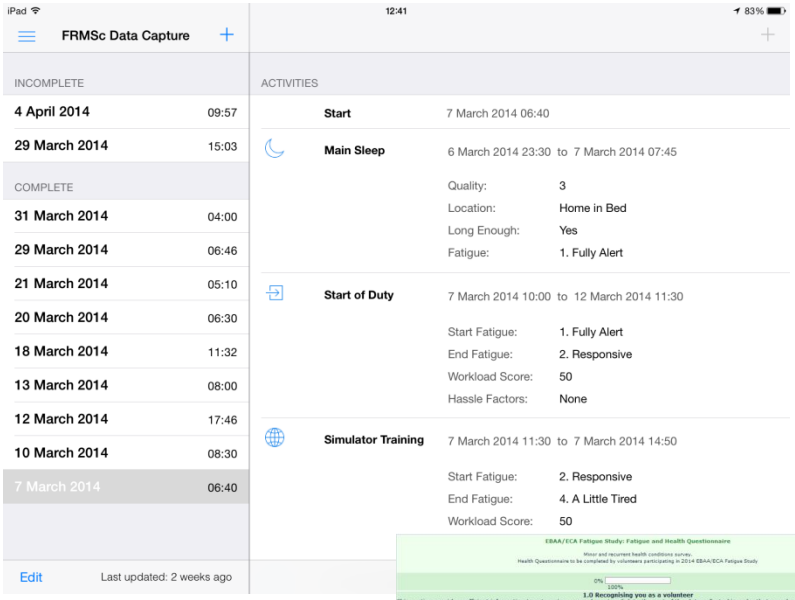
Subjective

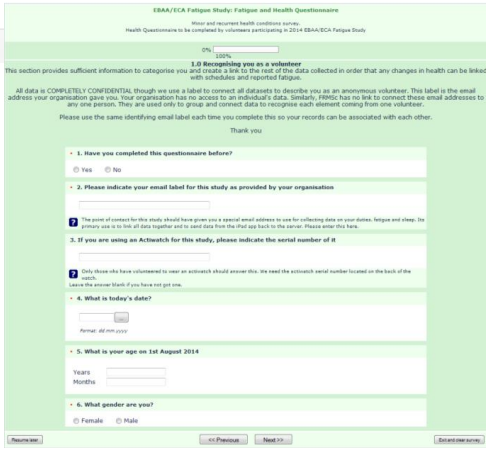
Electronic diary (iPad 'app')

- Self-rate level of fatigue, workload, timing of duty (including standby), flights, and sleep
- Complete for one month

Questionnaire (on-line)

- Optional questions about health
- Monitor any changes in relation to work-rest patterns/levels of fatigue
  - Complete at start, middle & end of study





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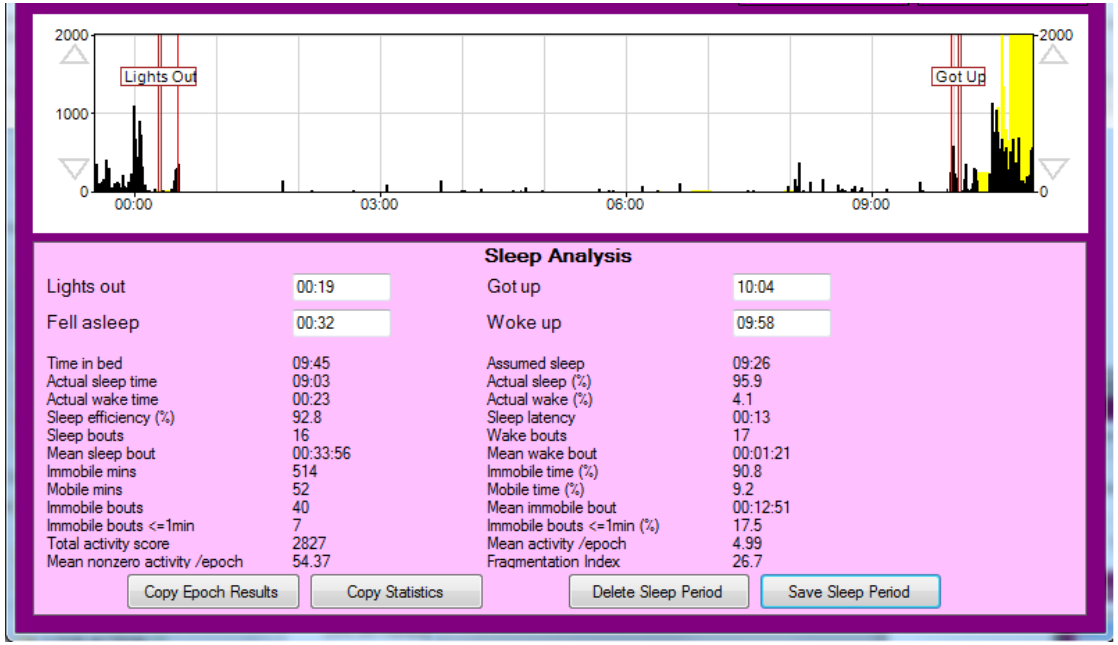
2.4 Data collection tools

Objective: Sleep

Actiwatch

- Tri-axial accelerometer measures activity and estimates sleep duration
- Wear for one month

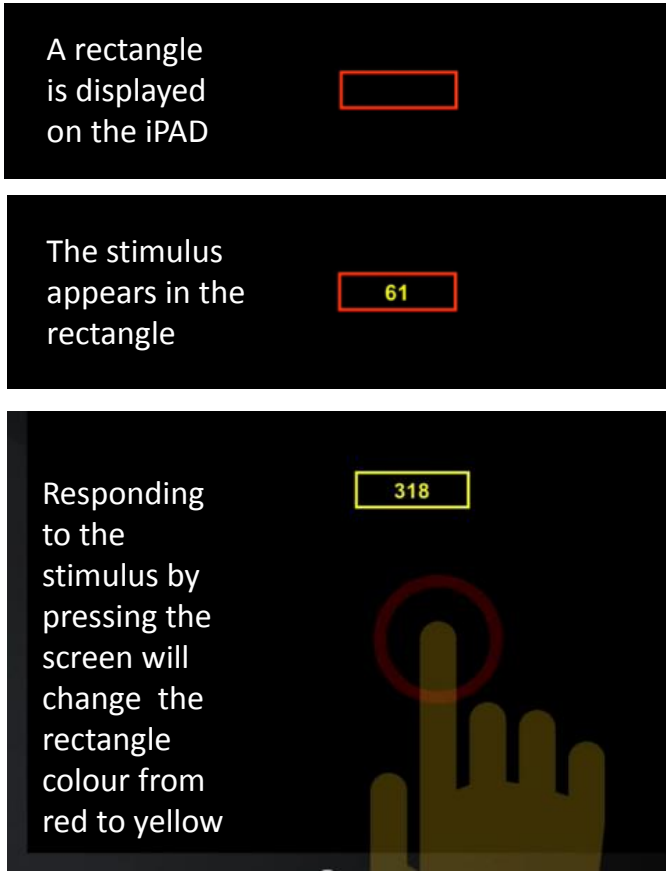


2.4 Data collection tools

Objective: Performance

Psychomotor Vigilance Task

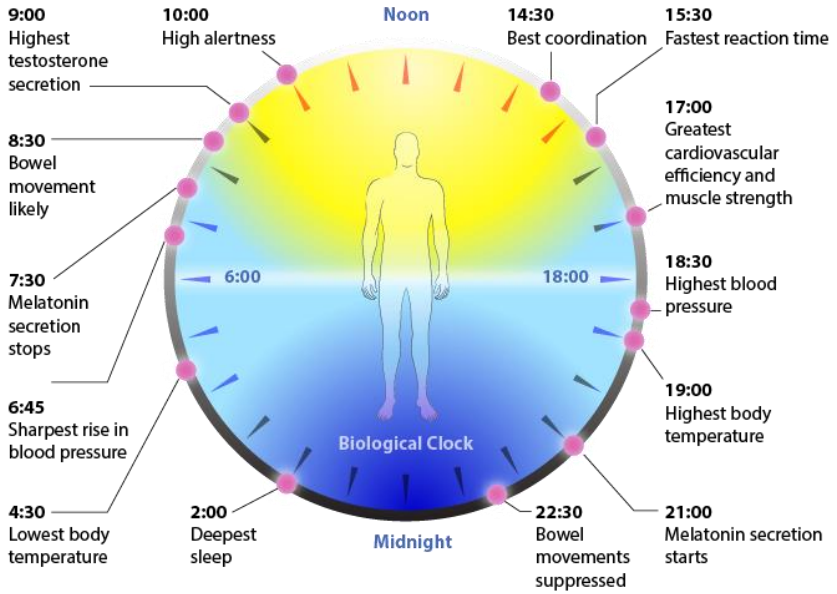
- Measures reaction time using an iPad app
- 3 minute task
- Practice before study
  - Three occasions
- During the study
  - On report
  - Before top of descent of each sector



2.5 Circadian adaptation to time zone changes

Monitor the internal 'body clock' after time zone changes of more than 3 hours

- Planned to measure melatonin levels in urine
  - Insufficient volunteers
- Revised to an assessment of the adaptation of sleep patterns
  - Paper diary survey of sleep on returning home after >3 h time zone change & until the next flight



2.6 Considerations

Anonymity

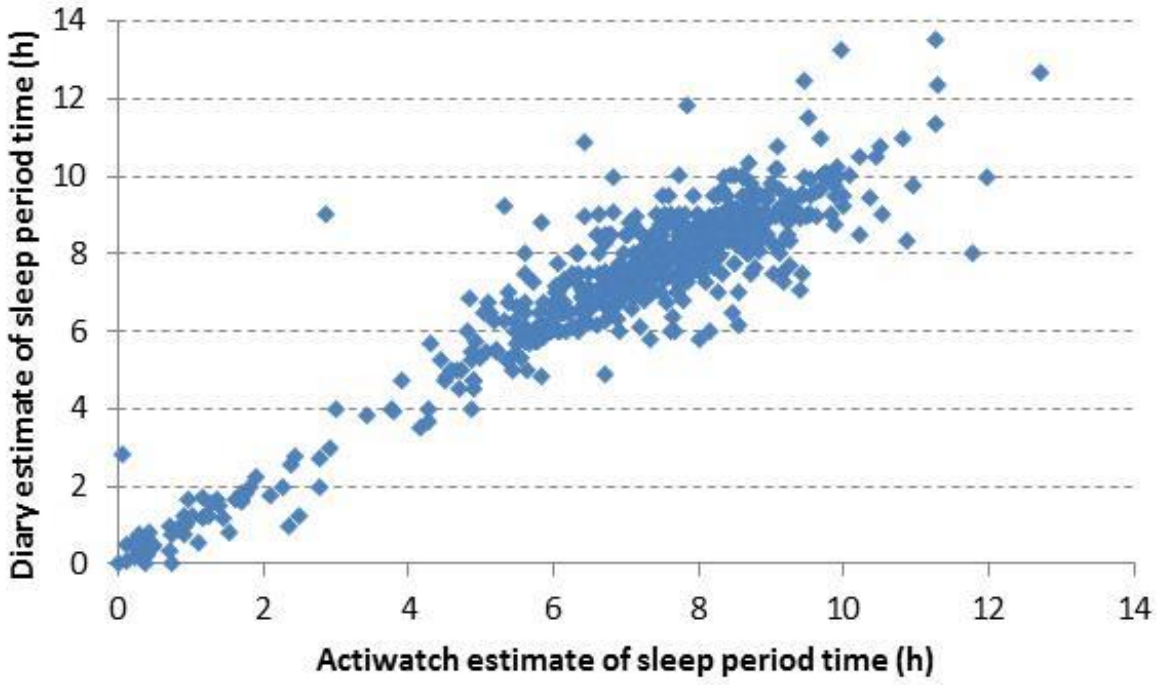
- Ensures that data cannot be traced back to an individual
- Increase the quality and quantity of data collected

3.0 RESULTS – OBJECTIVE DATA

3.1 Sleep

Actiwatches were provided to 57 pilots, of these, 35 pilots (14 EMS) submitted usable watch & diary data (with 619 sleep periods recorded in both the watch & diary)

- Sleep period time (SPT) was over-estimated in the diary by 17 minutes on average, compared with actigraphy (mean diary SPT of 7.27 h; mean watch SPT of 6.99 h)
- Overall, there was a good linear fit (R^2 = 0.865) between the two sources of data



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3.2 Performance

34 pilots (17 EMS) with usable diary data also volunteered to carry out the PVT

- Only 14 pilots (6 EMS) completed at least one PVT in-flight
- There were insufficient data to analyse as the proportion of PVTs completed in-flight was less than one third of the total number of flights operated by these pilots

Several logistical issues affected PVT usability and contributed to the lack of data

- Some pilots considered that the PVT was not compatible with piloting an aircraft, particularly when operating multiple, short-duration flights
- Pilots found the PVT App cumbersome e.g. input of the username and password each time the task was carried out
- Data were not readily transmitted when in range of an internet connection

Recent research suggests that the PVT is not a sensitive measure of aircrew performance, contrary to previous publications, as pilots maintain a fast response speed even after sleep loss (Gander et al, J Sleep Res, 2015; 24(1):110-119)

4.0 RESULTS – SUBJECTIVE DATA

4.1 FATIGUE AND HEALTH SURVEY

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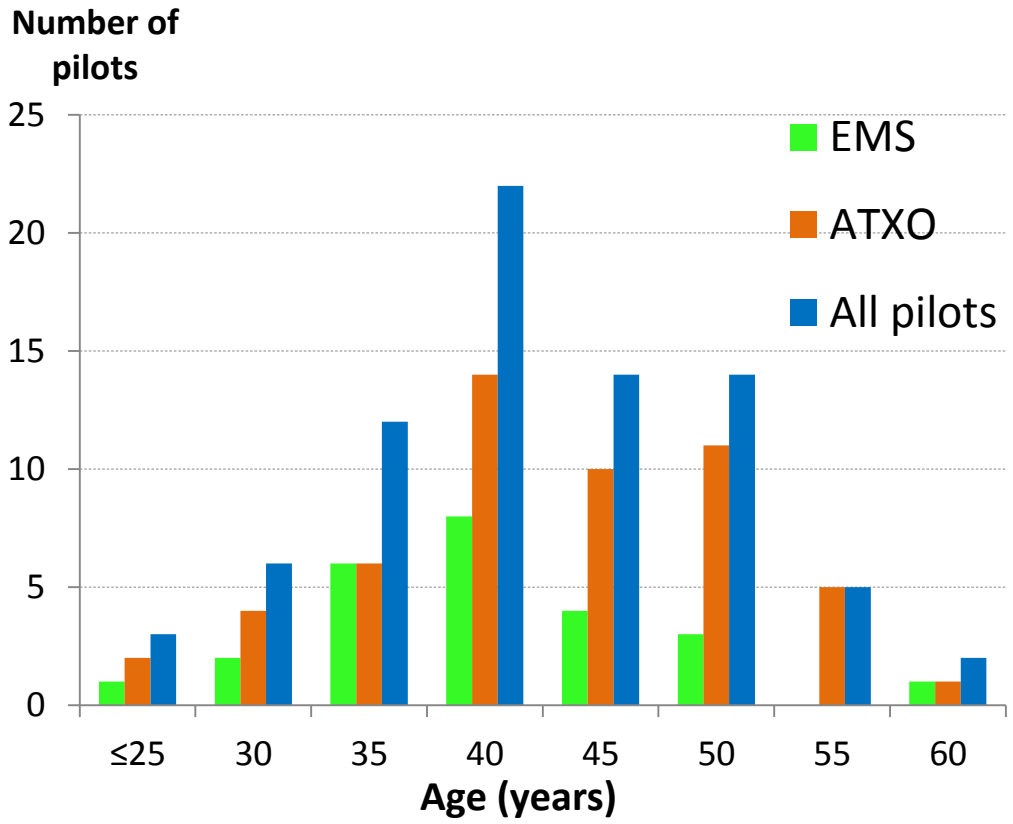
Demographics

Questionnaire completed by 78 pilots, of which, 71 completed a diary

- Approx. one third were EMS pilots
- The majority (94%) were male
  - 73 males (24 EMS pilots)
  - 5 females (1 EMS pilot)
- Age 40.4 years on average
  - Half of AT pilots >40 years
  - One third of EMS >40 years

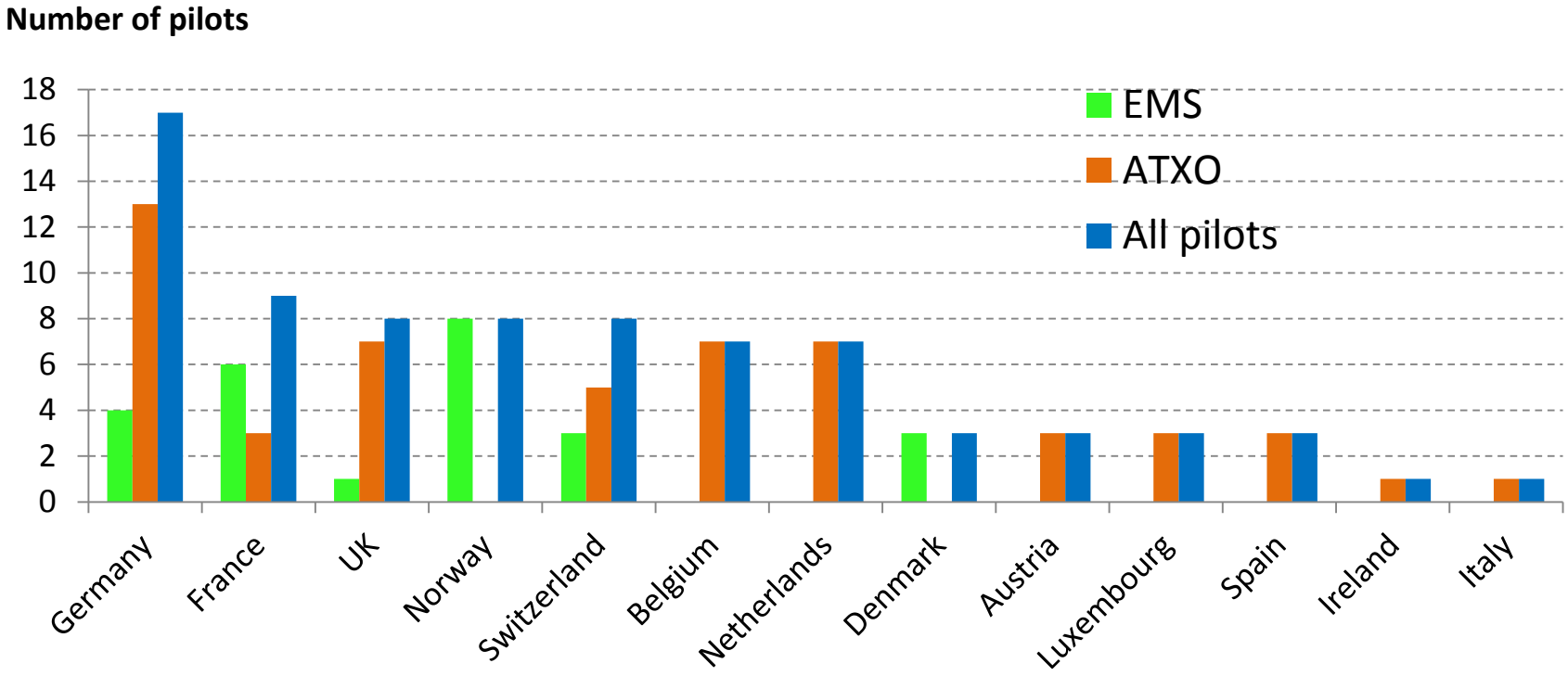
	N	Mean (years)	Range (years)
EMS	25	38.8	25 – 59
Air taxi	53	41.1	24 – 58
All pilots	**78**	**40.4**	**24 – 59**



Home bases of the pilots

Pilots were based across 38 airports in 13 European countries

- Majority (87.2%) based in CET time zone (68 pilots; 24 EMS)
- Others in UTC (10 pilots; 1 EMS)



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Experience in pilot role

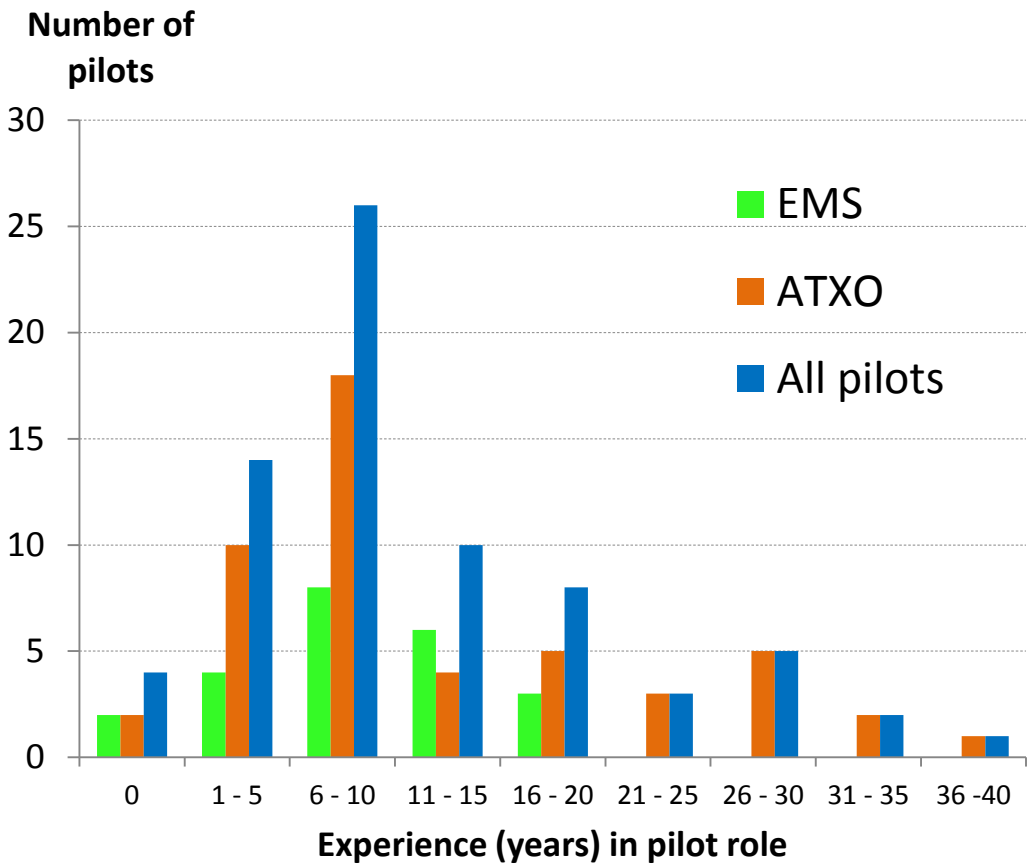
AT pilots reported being more experienced in the pilot role

- 20% reported > 20 years' experience

	N	Mean (years)	Range (years)
EMS	23	8.8	0 – 18
Air taxi	50	13.2	0 – 38
All pilots	**73**	**11.8**	**0 – 38**

Data source

- Diary data from 73 pilots
- Three of these pilots did not provide any work/rest data



Commuting time

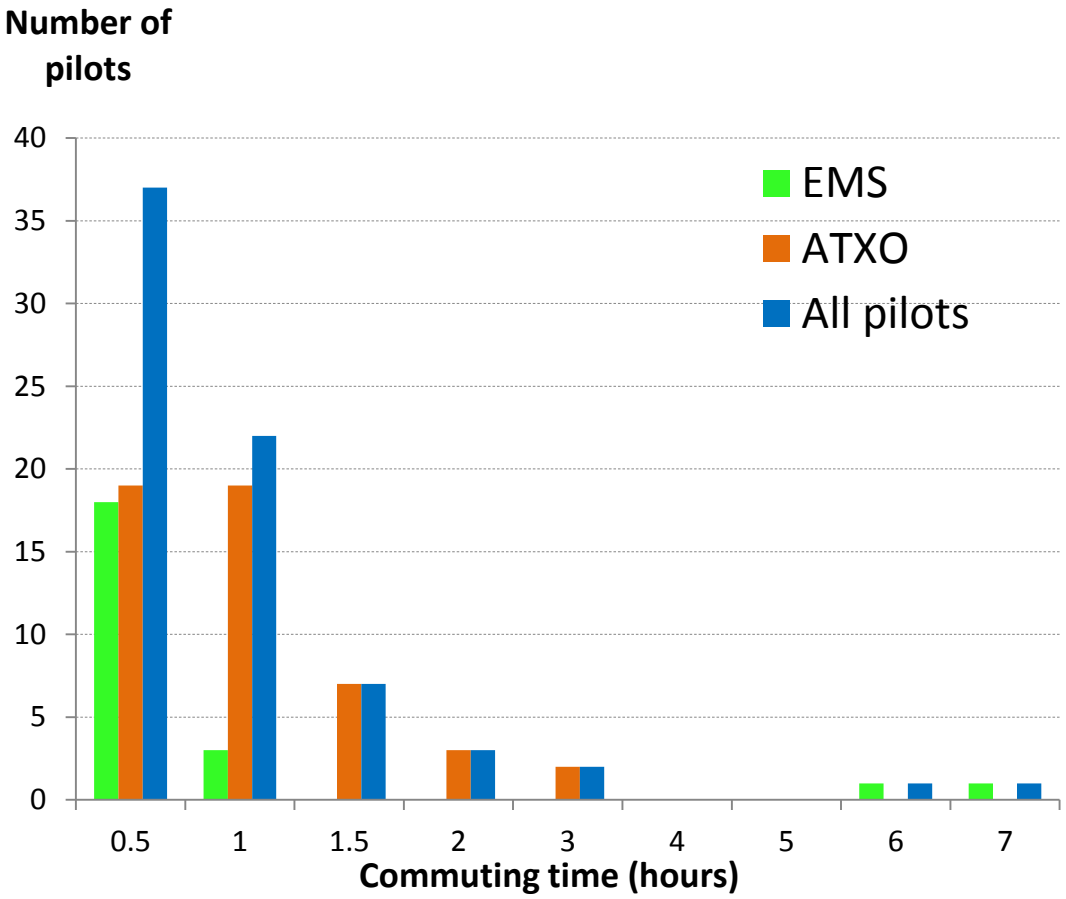
Typical commute to home base

- ≤ 30 minutes for ~80% of EMS
- ≤ 1 hour for ~75% of AT
- Long commutes (6 to 7 hours) for two EMS pilots, who stayed on base

	N	Mean (hours)	Range (hours)
EMS	23	0.9	0–7
Air taxi	50	0.9	0.1–3
All	**73**	**0.9**	**0– 7**

Data source

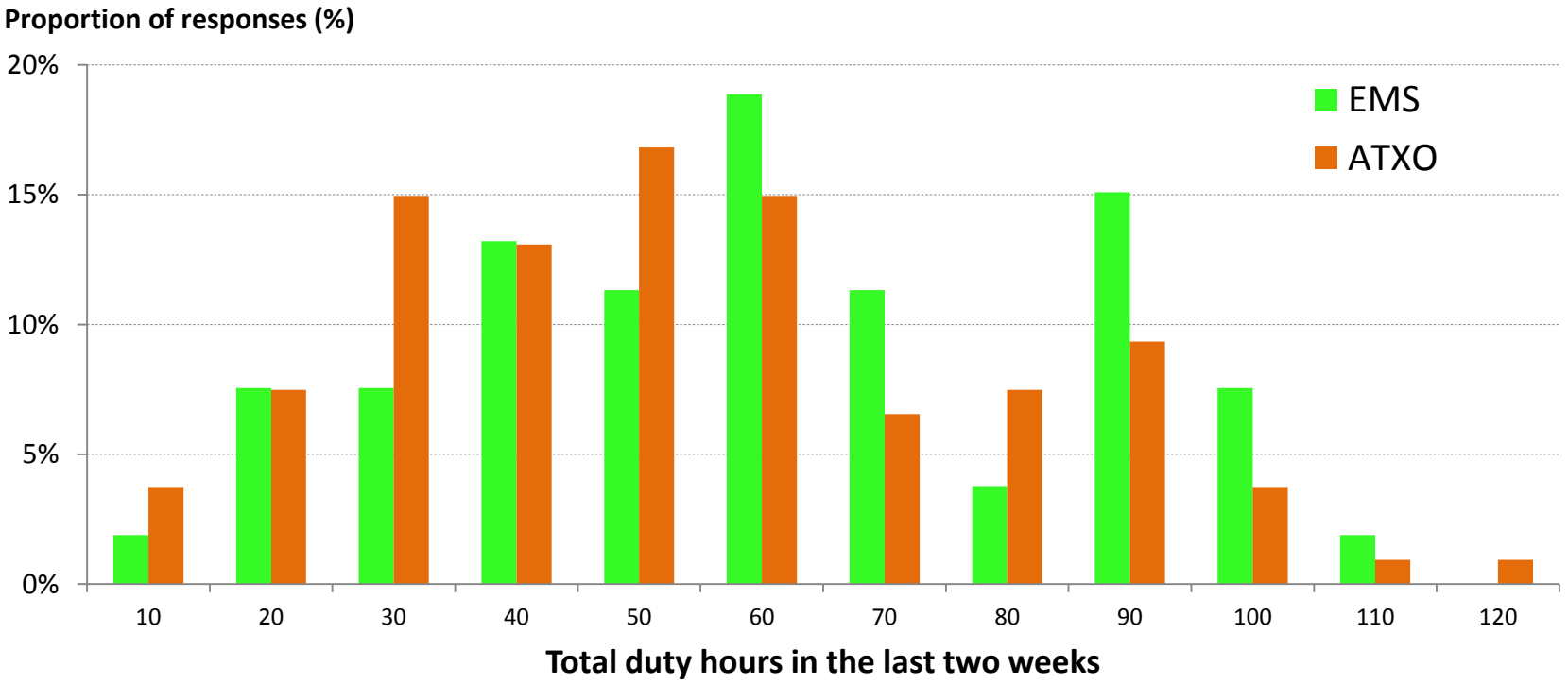
- Diary data from 73 pilots
- Three of these pilots did not provide any work/rest data



Total duty hours – last two weeks

> 30 and < 70 duty hours in the last two weeks
- 55% of the EMS and half of the AT samples

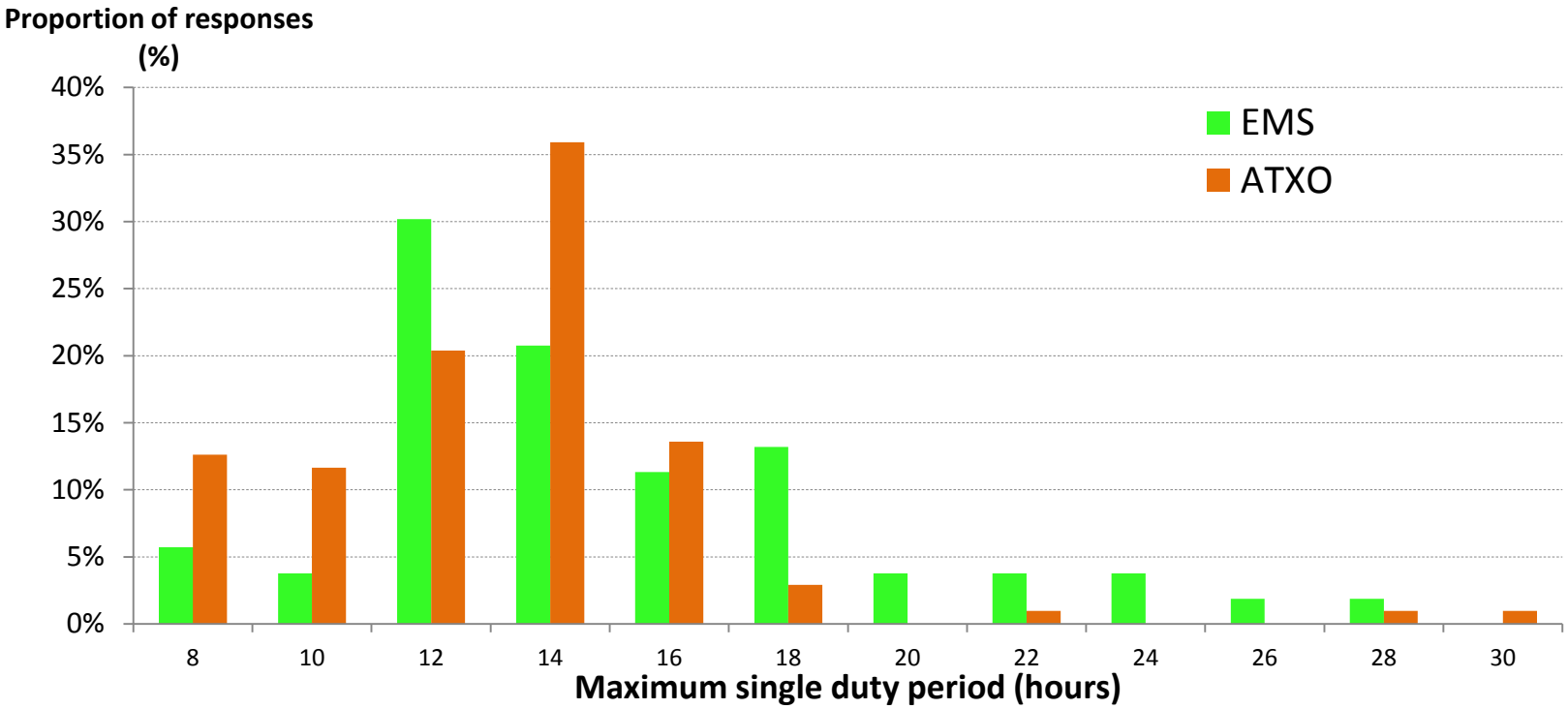
> 70 hours duty hours in the last two weeks
- 15% of the EMS and 22% of the AT samples



Maximum hours on duty at any one time

The maximum single duty period (excluding Standby) in the last two weeks

- >10 and <20 hours in 75.5% and 72.8% of the EMS and AT samples, respectively
- The longest single duty period was 28.25 hours, which involved positioning flights



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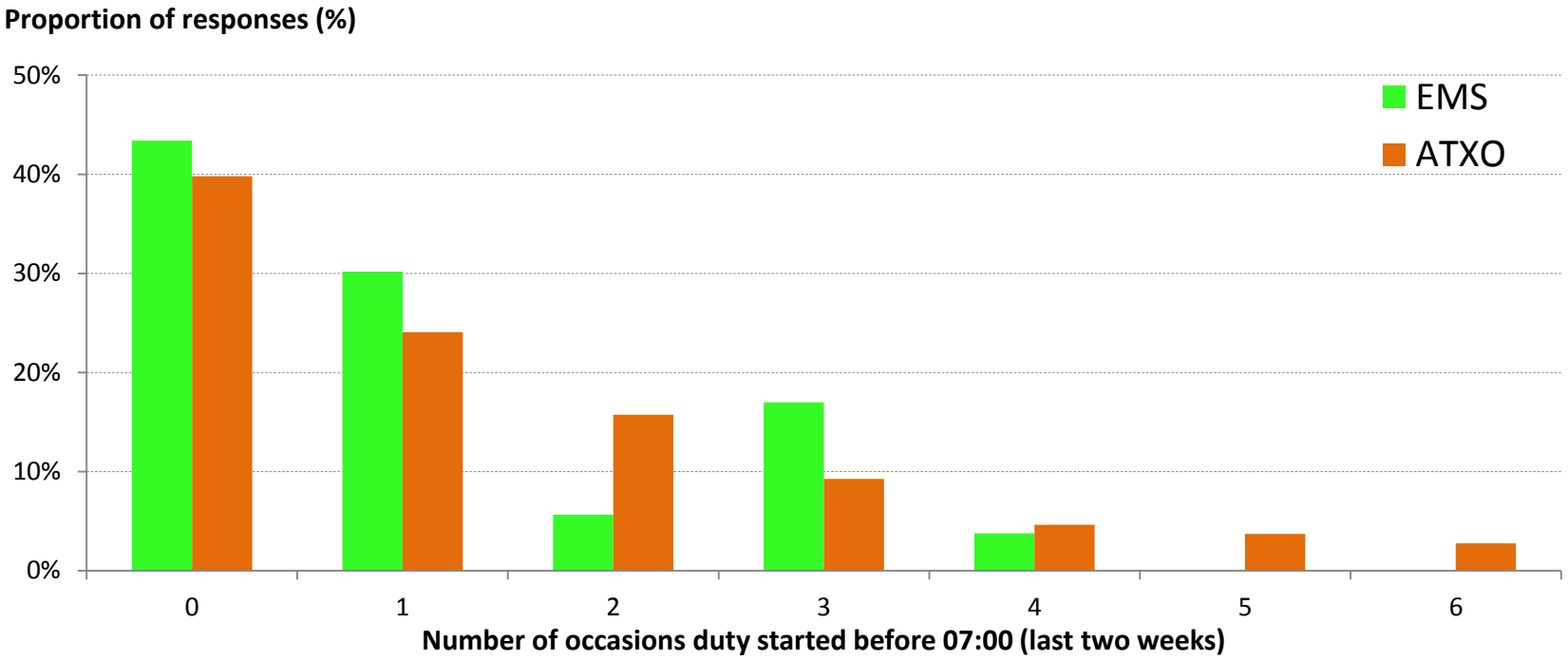
Duties starting before 07:00 (local time)

- Early starts were reported by 56.6% of EMS and 60.2% of AT samples
- Approx. half of the total sample reported one to three such duties in the last two weeks



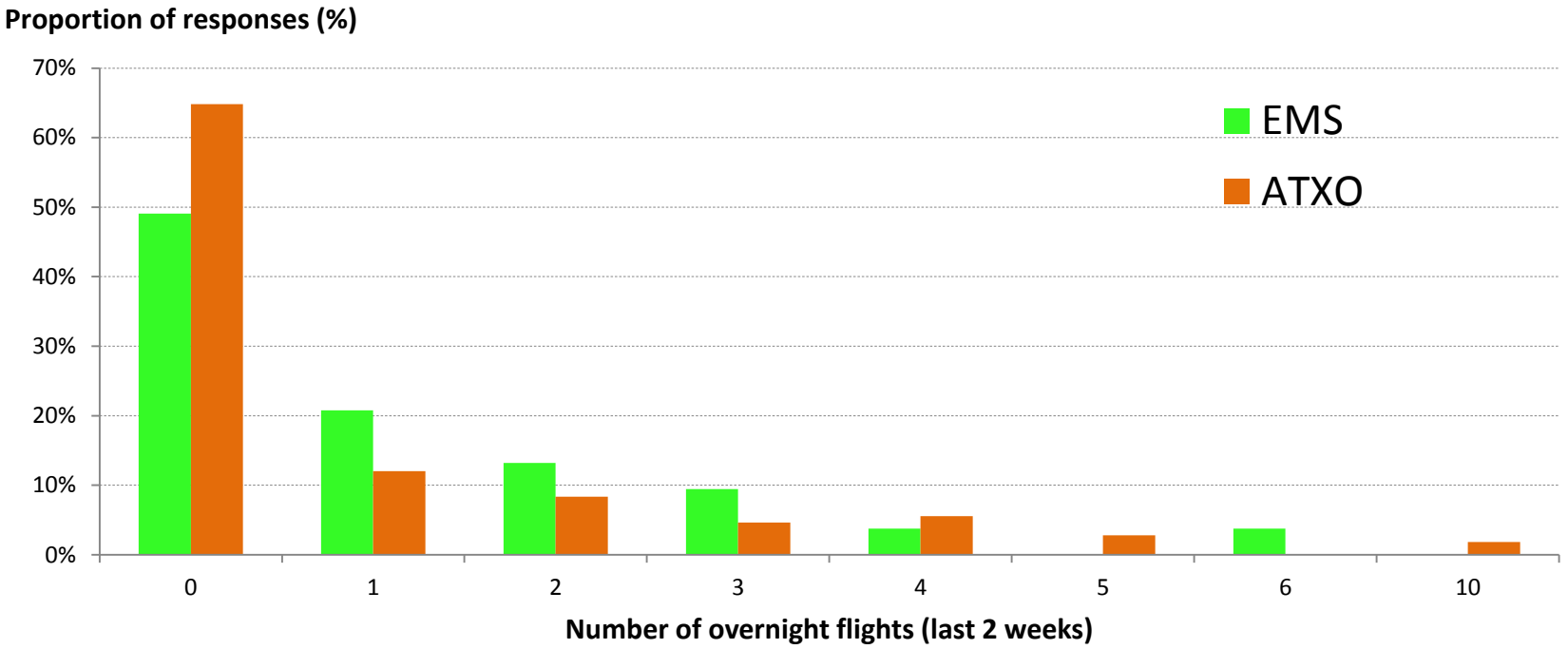
Duties finishing after 23:00 (local)

Late finishes were reported in around half of the questionnaires

- 43.4% of the EMS and 46.3% of the AT samples reported one to three such duties in the last two weeks

Number of overnight flights

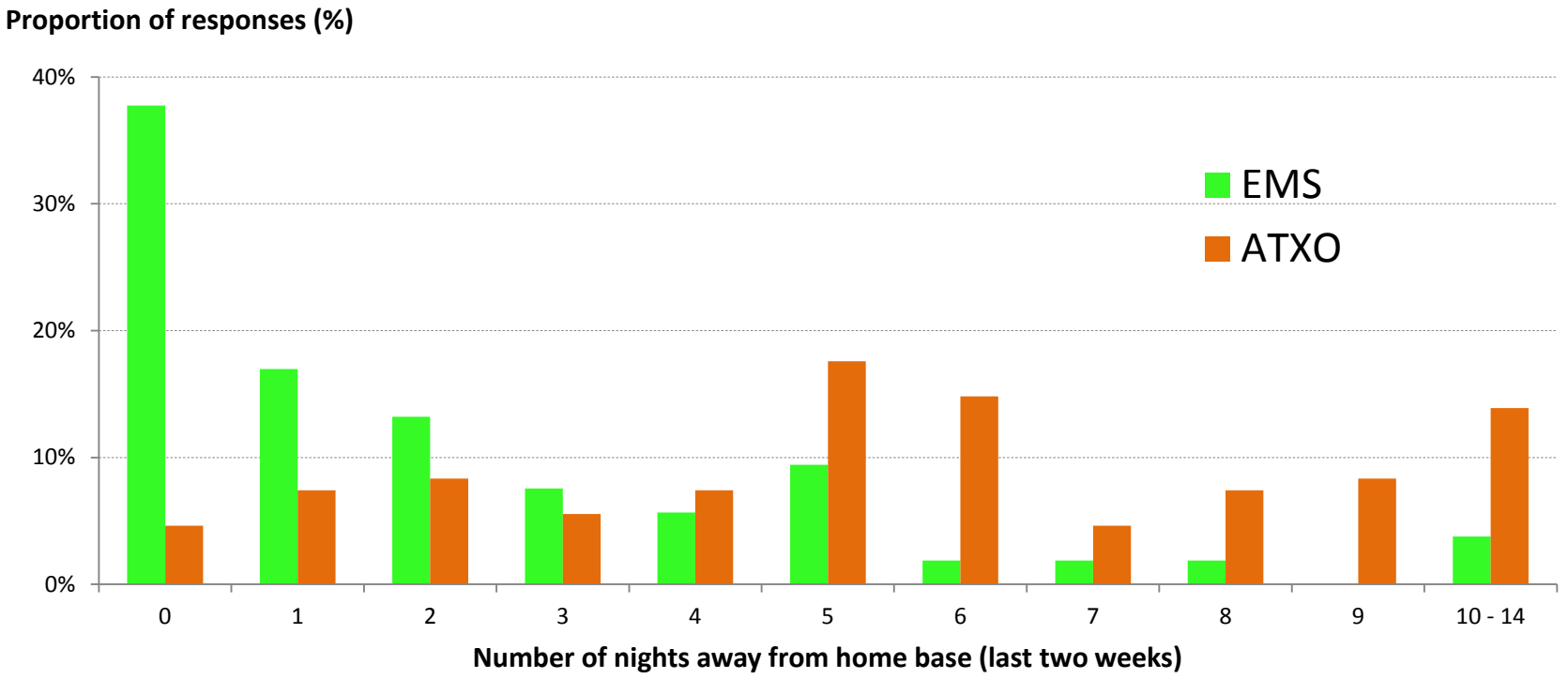
- No overnight flights* were reported by approximately half of EMS and nearly two thirds of AT samples



* Any duty partially or fully overlapping the hours 02:00 – 05:59

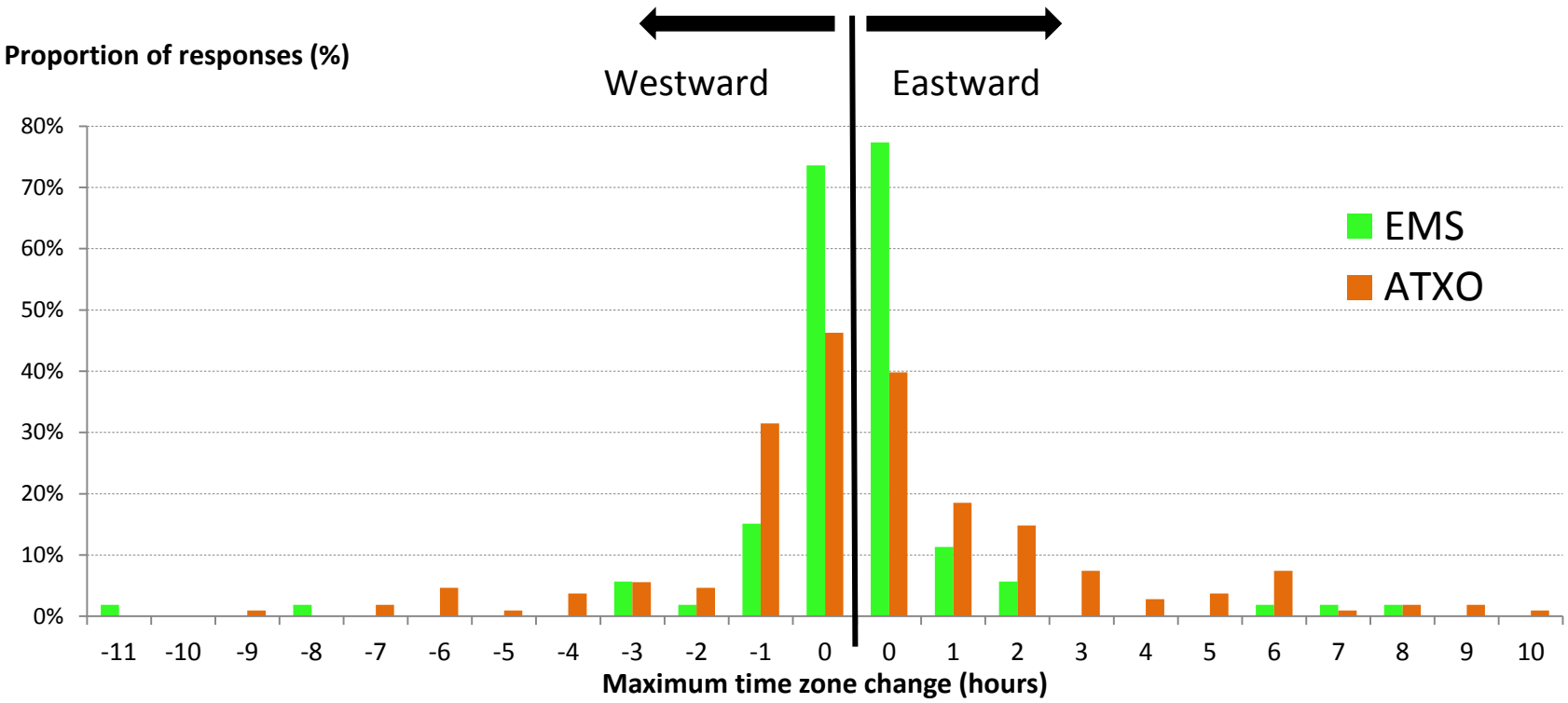
Nights away from home base

- More than one third of the EMS sample were never away from home base overnight
- Two thirds of the AT sample were away from home base for 5 – 14 nights



Maximum time zone change

- 1 to 3 hour TZ change reported in approx. 20% of EMS and 40% of AT samples
- > 4 hour TZ change reported approx. three times more frequently in AT than EMS (12% of AT westward and 19.4% of AT eastward)



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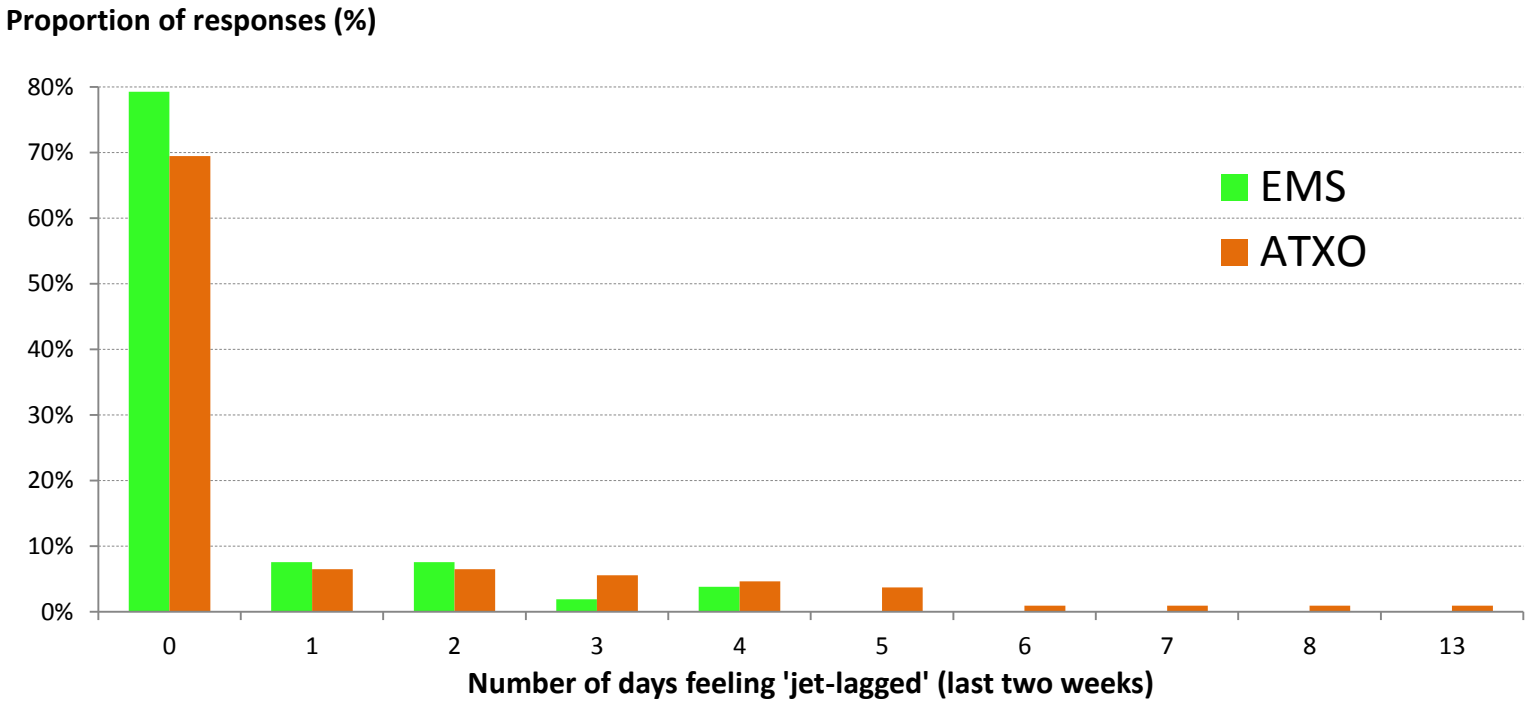
Number of days feeling ‘jet-lagged’

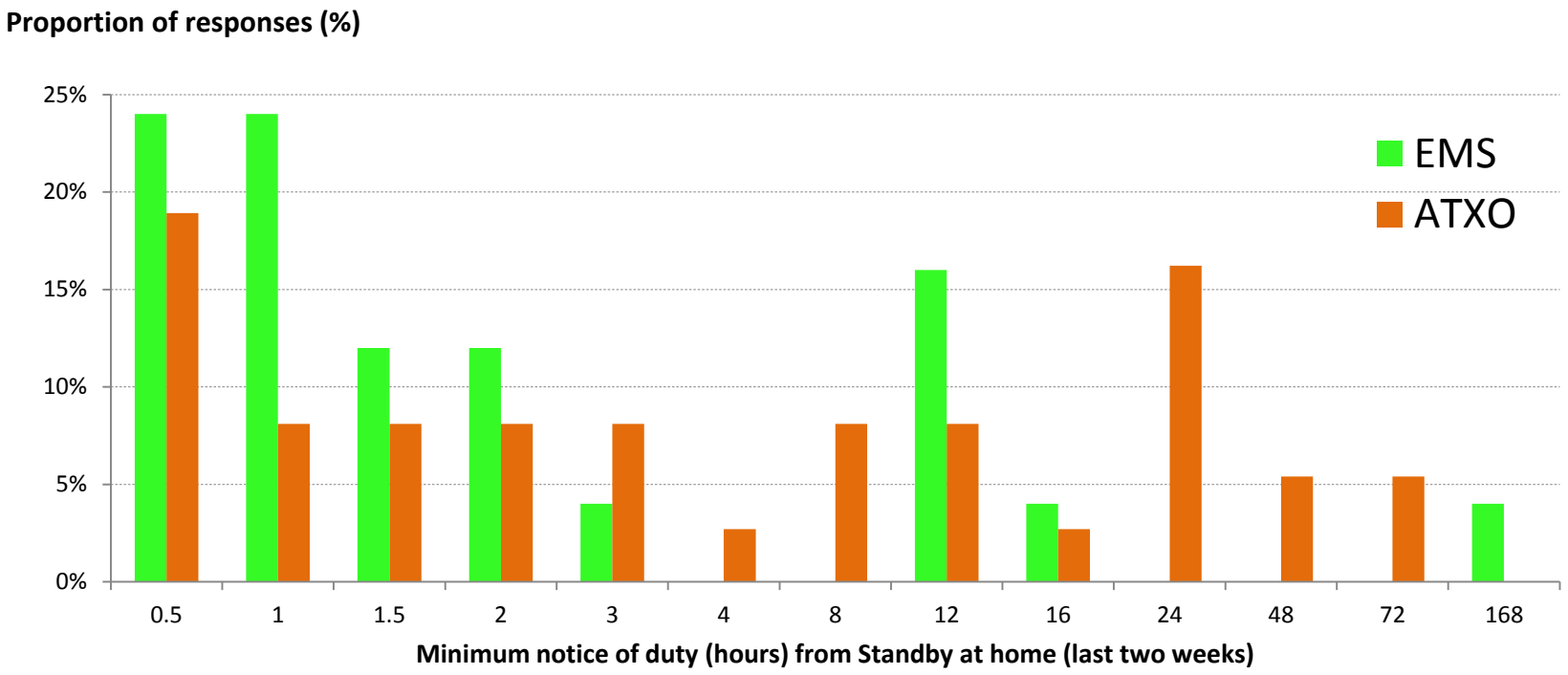
- Around one fifth reported feeling ‘jet-lagged’ for 1 – 4 days in the last two weeks
- A longer period of ‘jet-lag’ (5 to 13 days) was reported by 7.4% of the AT sample



Minimum notice of duty from Standby at home

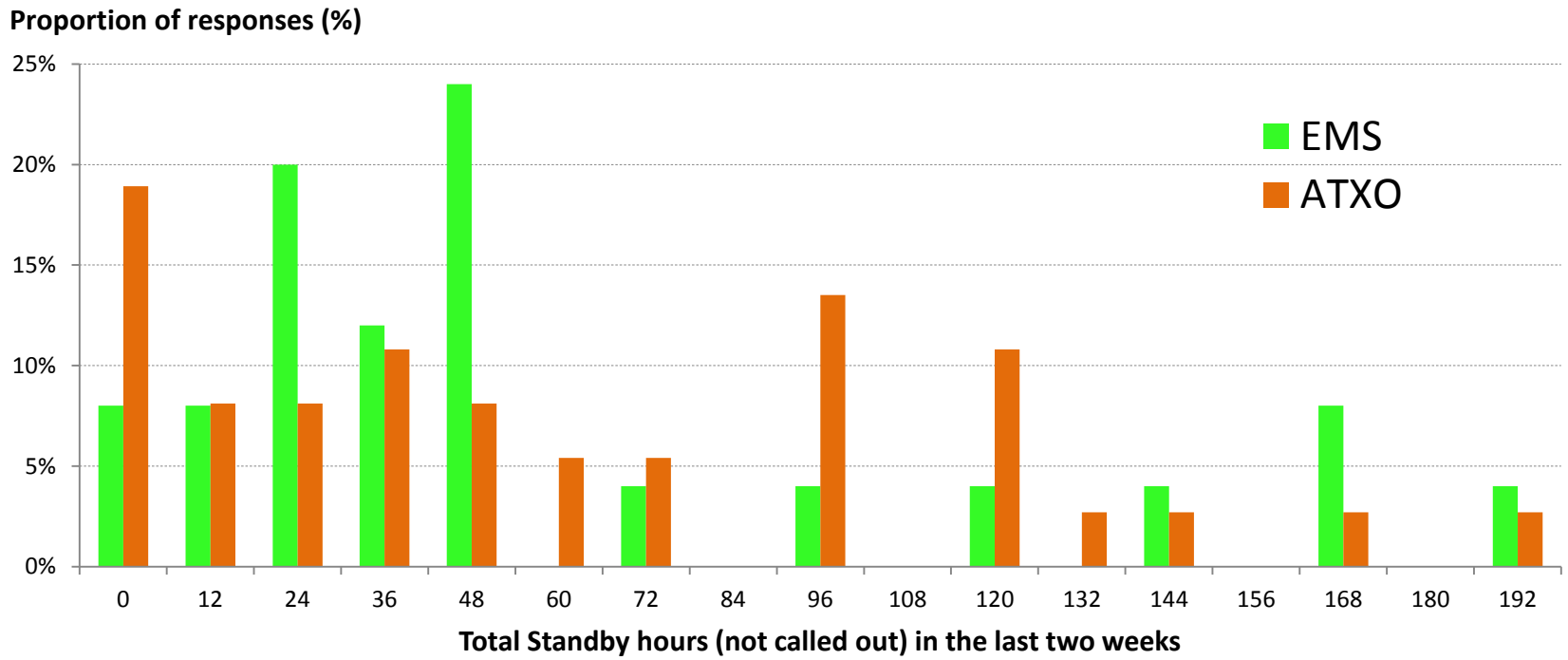
Standby was reported in approx. one third of the total sample

- ≤ 0.5 hours' notice in nearly a quarter of EMS (N=25 responses from 12 pilots)
  - These pilots either stayed on base or lived within a 15 minute commute to base
- ≤ 0.5 hours' notice in one fifth of the AT (N = 37 responses from 25 pilots)
  - Three of the six pilots were ≤ 0.5 hour commute to base



Standby hours – not called out

- ≤ 48 hours in approx. one third of EMS and nearly two thirds of the AT samples
- Next most frequently reported period of time spent on Standby in previous 2 weeks
  - EMS pilots: 120 and 192 hours (20% of the sample)
  - AT pilots: ≥ 48 and ≤ 96 hours (~25%); 120 to 192 hours (~20%)



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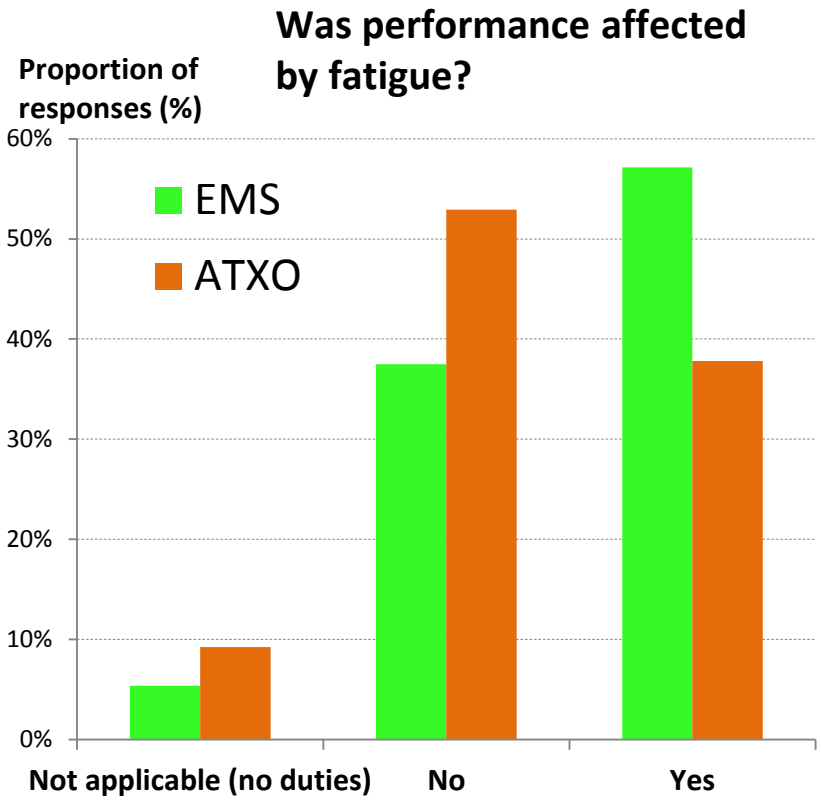
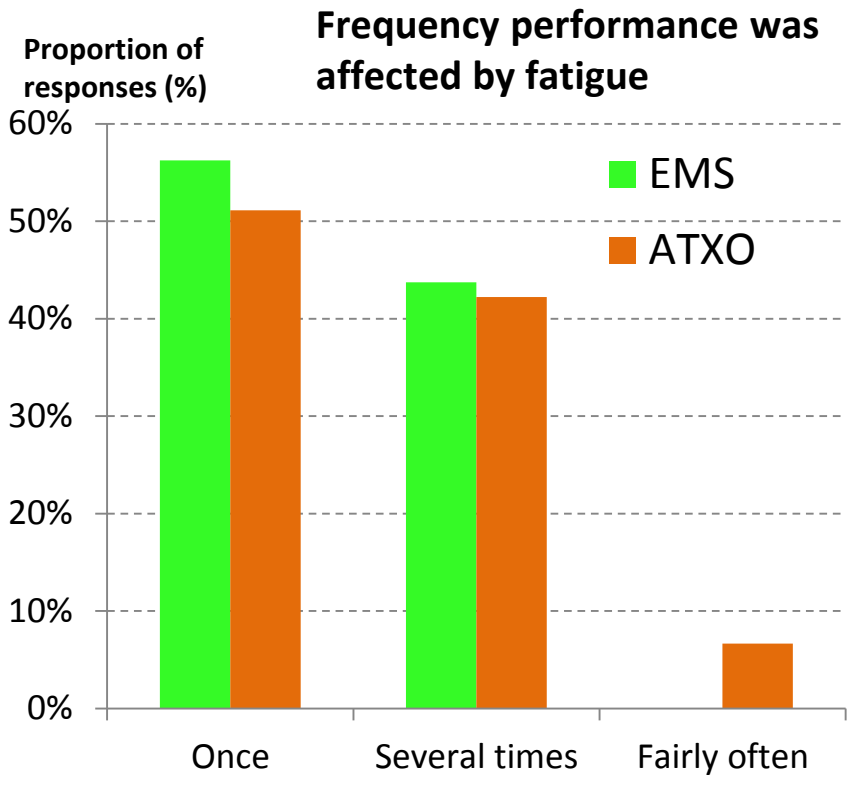
Performance affected by fatigue

- 60% of EMS and ~40% of the AT considered performance was affected by fatigue
- More than half reported this occurred once and approx. 40% reported that it happened several times





Factors contributing to fatigue

In both EMS & Air Taxi

- Long duty hours were cited most frequently (~15%)
- 2nd was poor sleep (~10%)
- Within the five most reported factors, were night duty and high workload

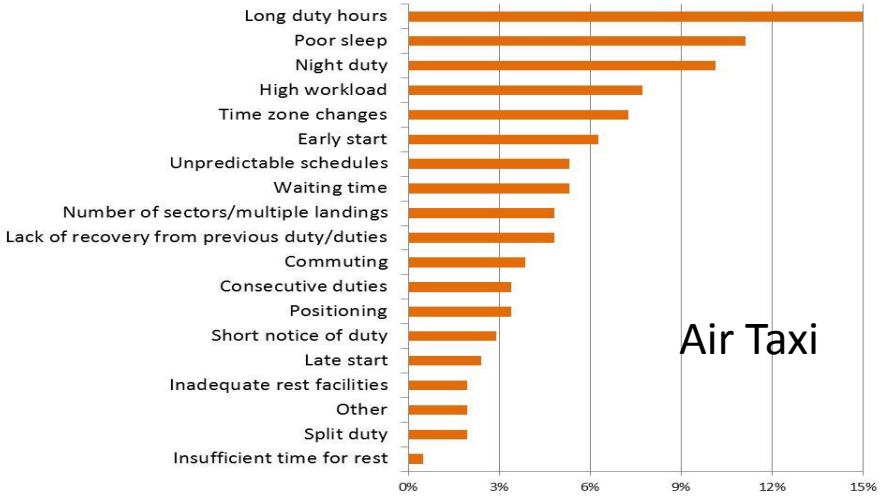
Only EMS pilots reported

- Early starts and the number of sectors/multiple landings among the top five factors

Only AT pilots cited

- Time zone changes among the top five factors

The latter two findings reflect the different nature of the two operations



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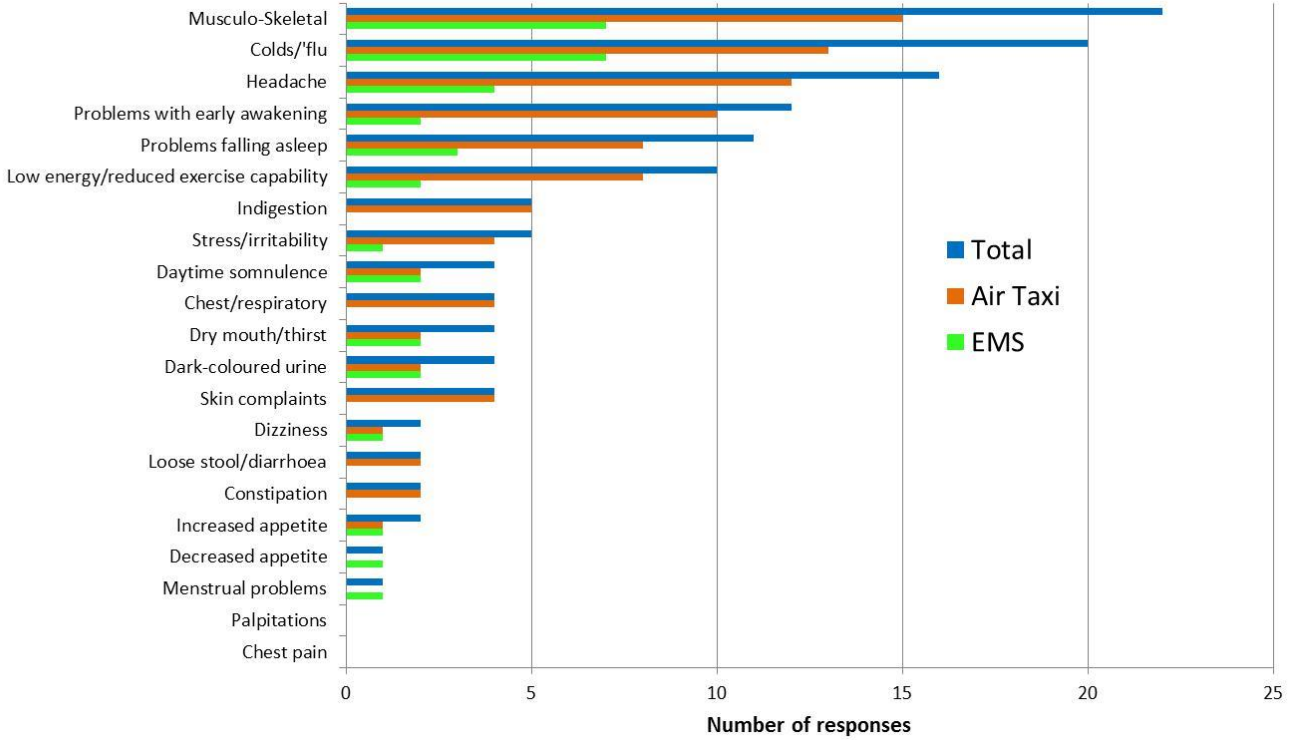
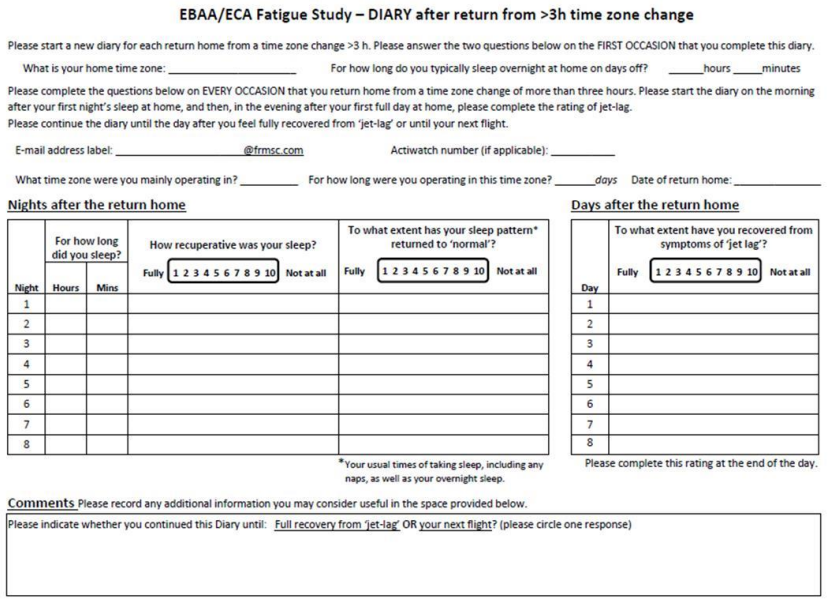
Health questionnaire

- Medication to assist sleep was taken by a small proportion (8.2%) of the sample (170 questionnaires received from respondents willing to answer this question)
- Two types of medication were cited
  - Sleep promoting
    - zolpidem (prescription drug); melatonin (synthetic hormone); diphenhydramine and doxylamine (antihistamines)
  - Pain relief
    - paracetamol and ibuprofen
- Pilots agreed to answer questions about their health on the majority (93%) of occasions (of 175 questionnaires received)
- However, two thirds did not follow the instructions to review all of the symptoms/conditions listed and indicate whether any applied
- It was therefore not possible to assess any changes to these symptoms/conditions during the study to explore whether they were affected by the pattern of duty

Health questionnaire – symptoms reported

- The symptoms/conditions were reviewed by 31 pilots (8 EMS); 4 had no symptoms
- The five most frequently reported symptoms/conditions were
  - Musculo-skeletal conditions, colds/'flu, headaches/migraines, problems with early awakening and problems falling asleep





EBAA/ECA Fatigue Study – DIARY after return from >3h time zone change

Please start a new diary for each return home from a time zone change >3 h. Please answer the two questions below on the FIRST OCCASION that you complete this diary.

What is your home time zone: _____ For how long do you typically sleep overnight at home on days off? _____hours _____minutes

Please complete the questions below on EVERY OCCASION that you return home from a time zone change of more than three hours. Please start the diary on the morning after your first night's sleep at home, and then, in the evening after your first full day at home, please complete the rating of jet-lag.
Please continue the diary until the day after you feel fully recovered from 'jet-lag' or until your next flight.

E-mail address label: _____@frmsc.com Actiwatch number (if applicable): _____

What time zone were you mainly operating in? _____ For how long were you operating in this time zone? _____*days* Date of return home: _____

Nights after the return home

Night	For how long did you sleep? Hours	Mins	How recuperative was your sleep? Fully 1 2 3 4 5 6 7 8 9 10 Not at all	To what extent has your sleep pattern* returned to 'normal'? Fully 1 2 3 4 5 6 7 8 9 10 Not at all
1				
2				
3				
4				
5				
6				
7				
8				

*Your usual times of taking sleep, including any naps, as well as your overnight sleep.

Days after the return home

Day	To what extent have you recovered from symptoms of 'jet lag'? Fully 1 2 3 4 5 6 7 8 9 10 Not at all
1	
2	
3	
4	
5	
6	
7	
8	

Please complete this rating at the end of the day.

Comments Please record any additional information you may consider useful in the space provided below.

Please indicate whether you continued this Diary until: Full recovery from 'jet-lag' OR your next flight? (please circle one response)

4.2 CIRCADIAN RHYTHM

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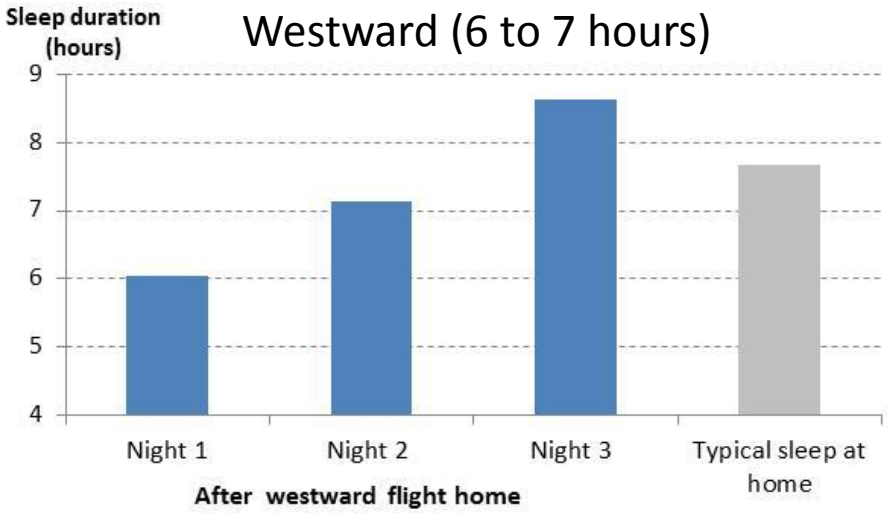
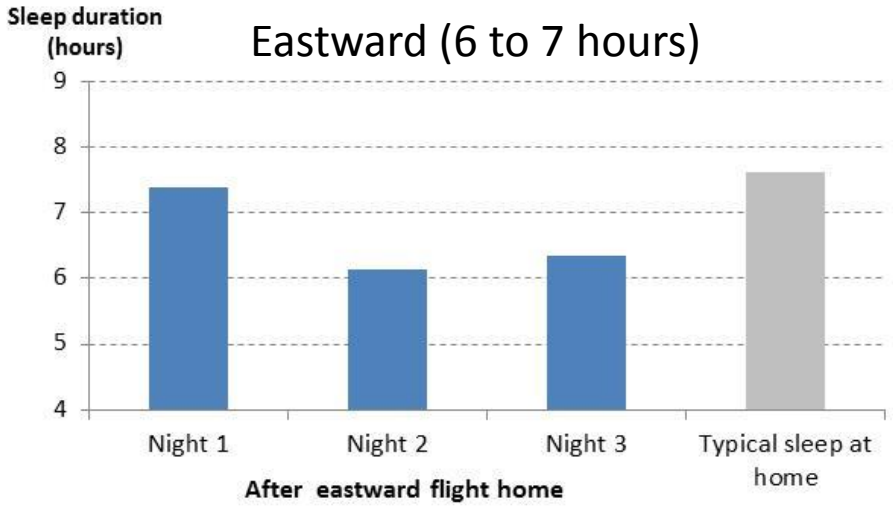
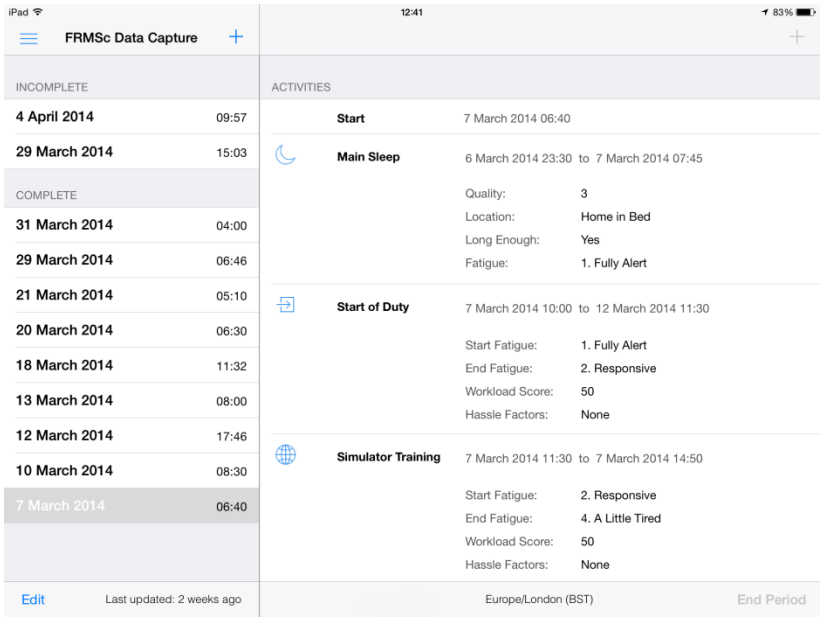
Jet-lag questionnaire

There were insufficient long-range flights to carry out a meaningful analysis

- The descriptive results from the usable data (14 questionnaires from 9 pilots), show the typical pattern of a more rapid adaptation of sleep after the westward return
  - Westward return (6-7 hours) after 5.5 days away (range 1-11 days)
  - Eastward return (6-7 hours after 4.1 days away (range 2-11 days)







4.3 ANALYSIS OF THE SUBJECTIVE DIARY DATA

The sample

- Data were collected from 87 pilots, from the following three main groups:
  - Emergency Medical Services (EMS) – 33 pilots
  - Air Taxi – 43 pilots
  - Air Taxi (non-commercial) – 11 pilots
- 79 pilots completed the app, and 8 (3 Air Taxi and 5 EMS) returned a paper diary
- The analysis has been based on all three groups combined, except where there were significant or substantial differences between the individual groups.

Numbers of days and FDPs covered

- Information was obtained from 837 flight duty periods (FDPs) during a total of 2610 elapsed days.
- The breakdown among the three groups was as follows:

	EMS	Air Taxi	Air Taxi (nc)
FDPs	280	443	114
Days	714	1448	448

Total FDP and other duty hours

	EMS	Air Taxi	Air Taxi (nc)	Total
Total FDP hours	2820	3621	920	7361
Standby unspecified	919	435	213	1567
Standby hotel	34	1506*	26	1566
Standby home	366	866	23	1255
Other activity	460	266	418	1144
Commuting	204	669	128	1001
Check in	34	154	54	242
Standby at airport	200	27	0	227
Simulator Training	31	163	22	217
Positioning	4	118	2	123
Waiting	3	25	0	28
Check out	1	10	1	12
Total	5076	7860	1807	14744

*including 1206 hours away from base

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Rates of working

- Based on the elapsed number of days in the data set, the overall average number of flying hours per day was 1.4, in FDPs averaging 2.8 hours, with 1.8 hours of standby:

Hours per day	EMS	Air Taxi	Air Taxi (nc)
Flying	2.04	1.15	1.09
FDPs	3.95	2.50	2.05
Standby	2.13	1.96	0.58

- The equivalent rates per year were as follows:

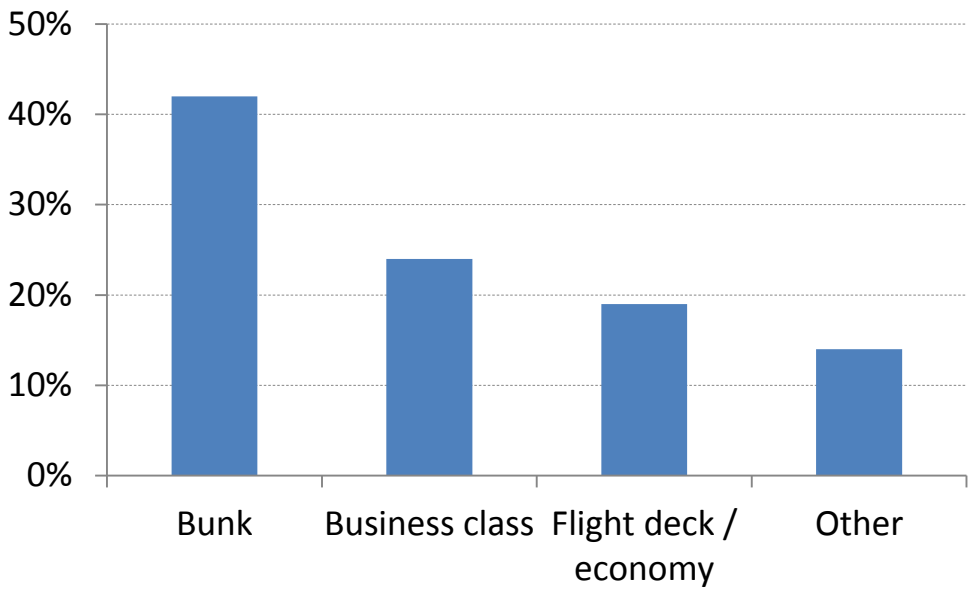
Hours per year	EMS	Air Taxi	Air Taxi (nc)
Flying hours	743	419	399
FDP hours	1443	913	750
Standby	777	715	213

Average hours per FDP

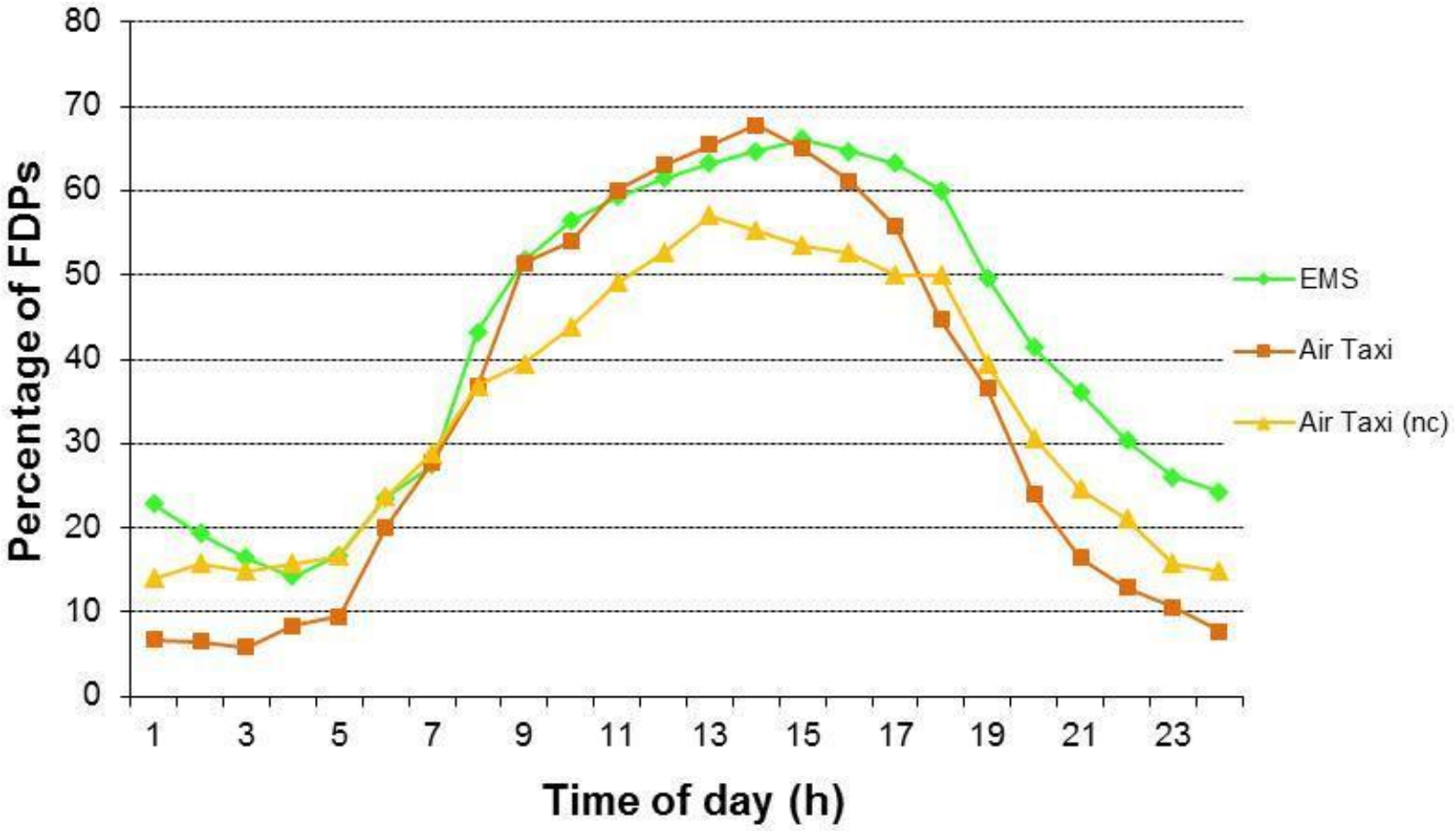
	EMS	Air Taxi	Air Taxi (nc)	Combined
Flights	5.19	3.75	4.29	4.30
Check in	0.63	0.83	0.96	0.78
Waiting	0.39	0.58	0.71	0.53
Check out	0.14	0.33	0.42	0.28
Other activity	0.30	0.13	0.55	0.24
Standby unspecified	0.60	0.09	0.00	0.24
Standby at airport	0.39	0.08	0.00	0.17
Positioning Type A	0.02	0.34	0.00	0.19
Positioning Type B	0.06	0.09	0.01	0.07
Standby home	0.34	0.01	0.00	0.12
Standby hotel	0.05	0.02	0.00	0.03
Unspecified hours	1.96	1.92	1.23	1.84
Total	**10.07**	**8.18**	**8.17**	**8.80**

Sleep during the FDP

- Naps were recorded during 58 (7%) of the 839 FDPs, of which 29 were in-flight.
- In-flight naps were mostly on Air Taxi (17) or non-commercial (nine) operations.
- In-flight nap duration was 74 minutes on average.
- The duration of the flights on which naps occurred was 7.6 hours on average.



Distribution of FDPs over the 24-hour day



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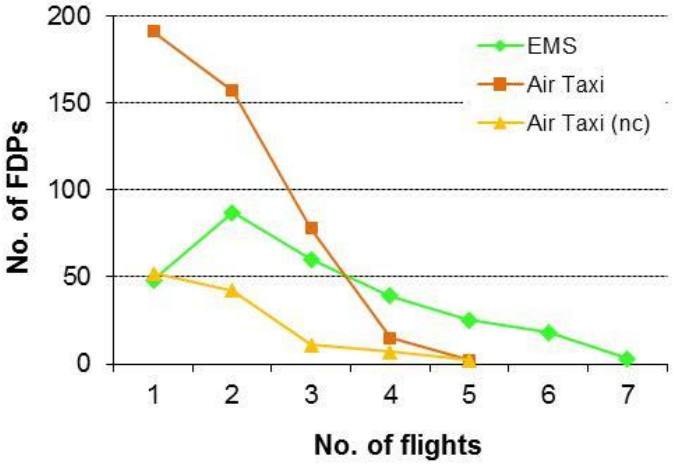
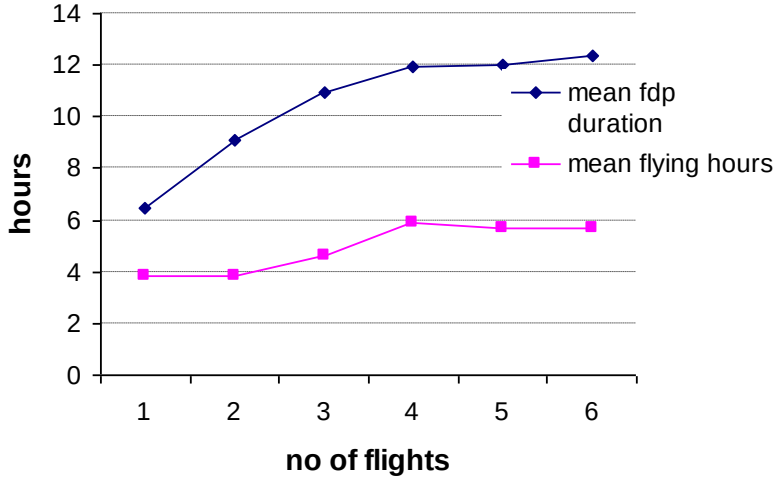
Multiple sector duties

- Approximately 35% of all FDPs were single sector, and approximately 34% two sector.
- Six per cent were more than four sector.
- EMS operations had a relatively small proportion of single-sector duties (17%).
- Mean duty hours increased from six (single-sector) to 12 (four or more sectors).
- Mean total flying hours varied between four and six.





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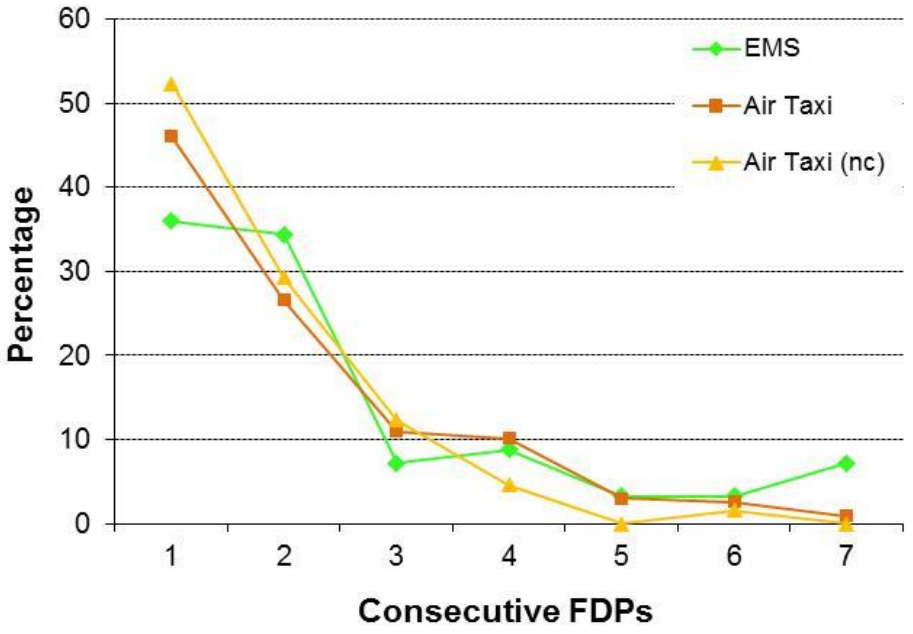
Sequences of consecutive FDPs

- 44% of all sequences consisted of a single FDP.
- Single FDPs were slightly less common in EMS operations.
- Four or more consecutive duties accounted for 17% of all sequences.



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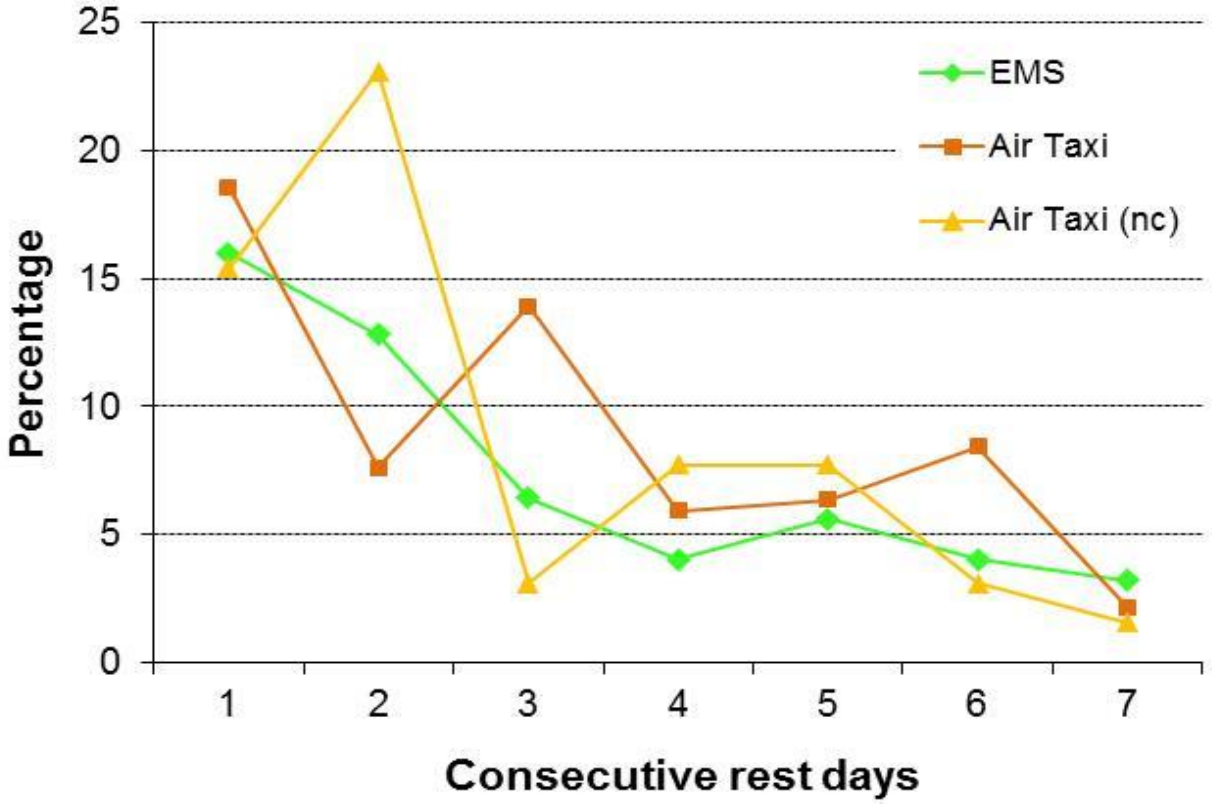
Sequences of consecutive rest days



- One rest day defined as 30 hours off, including two local nights.

Number of schedules with time-zone crossings

Maximum time-zone change (hours)	No. of schedules	
	East	West
3	7	3
4	4	2
5	2	3
6	3	3
7	1	5
8	3	0
9	0	0
10	1	0
11	0	1
Total No. of schedules	**21**	**17**

- There was a wide variety in the types of schedule:
  - direction (east / west)
  - number of time zones crossed
  - time of day of the flights
  - the length of time away from base
  - the total number of flights undertaken
- Hence the data are insufficient to draw clear conclusions

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Recovery (app only)

- Pilots were asked, at the start of each FDP, to assess the extent they had recovered from the previous duty or sequence of duties.
- Responses were on a 10-point scale, where 'one' represented fully recovered.
- The table shows the replies as percentages within each group.
- A large majority in every group (particularly Air Taxi) reported being fully recovered.

Extent of recovery ('1' = Fully recovered)	Proportion (%) of responses			
	EMS	Air Taxi	Air Taxi (nc)	Combined
1	73.9	83.2	92.8	81.4
2 to 4	19.3	11.2	2.9	12.8
>4	6.8	5.6	4.3	5.8

Workload (app only)

- Pilots were asked to assess the workload of each activity they carried out.
- Responses were on a 100-point scale, where 'one' represented the lowest workload, and the default value was 50.
- The table shows the replies as percentages within each group for the workload of each flight.

Workload '1' (low) to '100' (high)	Proportion (%) of responses			
	EMS	Air Taxi	Air Taxi (nc)	Combined
<50	6.6	2.5	0.0	3.8
50	70.3	69.5	93.7	73.4
51 to 69	11.1	12.1	3.4	10.4
≥70	12.0	15.9	2.9	12.4

Hassle factors

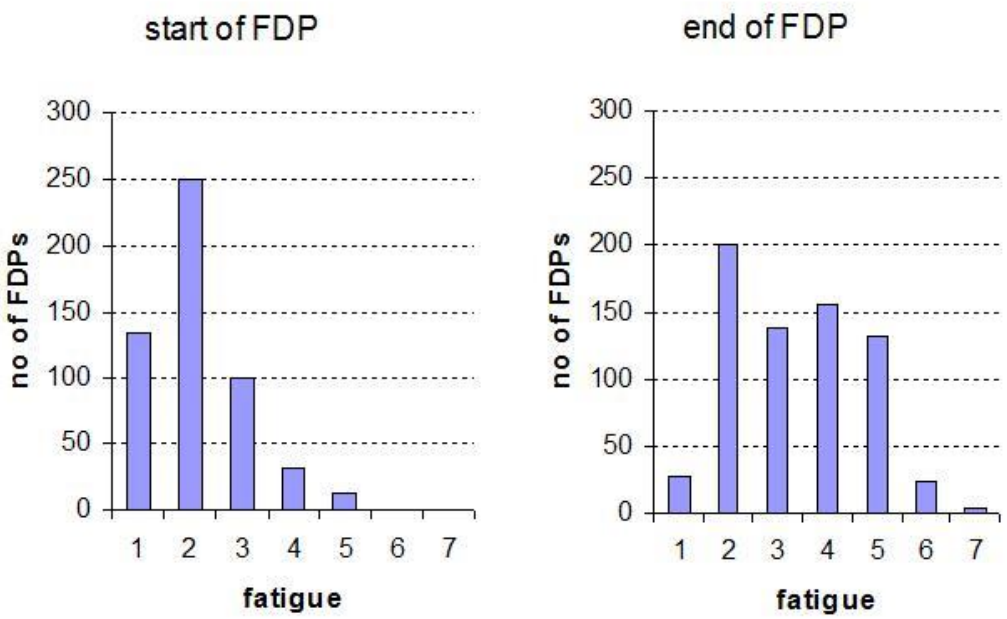
- Pilots were asked whether there were any significant hassle factors associated with a particular duty.
- The percentage of flights associated with individual hassle factors are shown in the table.

Hassle factor	Proportion (%) of flights			
	EMS	Air Taxi	Air Taxi (nc)	Combined
Weather	24.7	12.3	1.9	16.1
Time pressure	6.8	11.6	2.9	8.5
Terrain	13.4	3.2	0.0	7.0
Air Traffic Control	6.5	5.1	1.4	5.2
Aircraft or Equipment	5.3	6.2	1.4	5.2
Delay	3.6	7.3	0.0	4.8
Visibility	7.4	1.4	0.0	3.7
Human factors	2.3	4.5	1.9	3.3
Team factors	2.0	3.3	0.5	2.4
Air Traffic congestion	2.1	2.6	0.5	2.1
Inexperience	1.5	1.4	0.0	1.3
Other	3.8	5.3	1.0	4.1

Fatigue

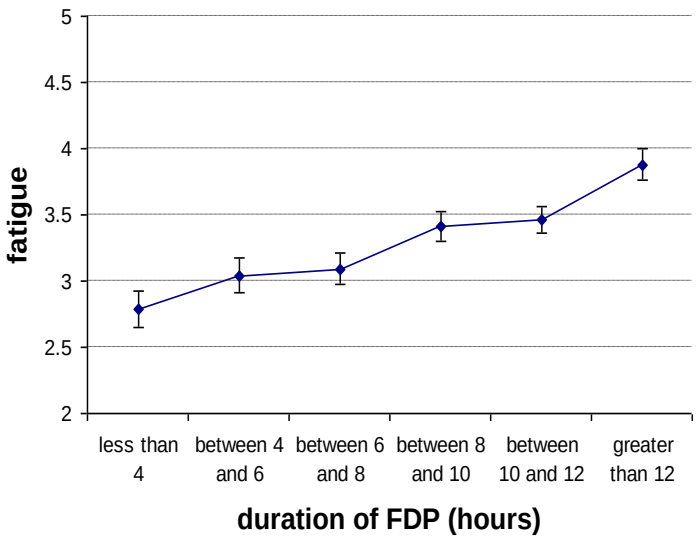
- At the start and end of every activity, pilots were asked to assess their level of fatigue on a the seven-point Samn-Perelli (SP) fatigue scale, from 1: fully alert, wide awake, to 7: completely exhausted, unable to function effectively.
- This scale has been used extensively on aircrew fatigue studies.
- In the internet application, the default value was set to 1.

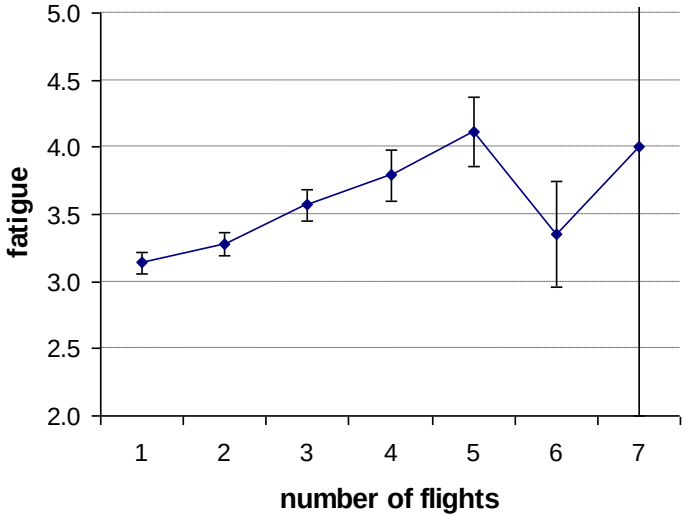
Fatigue at the start and end of an FDP



- Mean values at the start were similar across the three groups (2.09, 2.13, 2.20 for EMS, AT and ATnc respectively.
- Mean values at the end were 3.52, 3.37 and 2.96 respectively.

Fatigue related to duty length and number of flights





- There was a rising trend in fatigue related to the length of duty and (less clearly) to the number of individual flights.
- These are raw means, uncorrected for other factors (e.g. for each other or for time of day).

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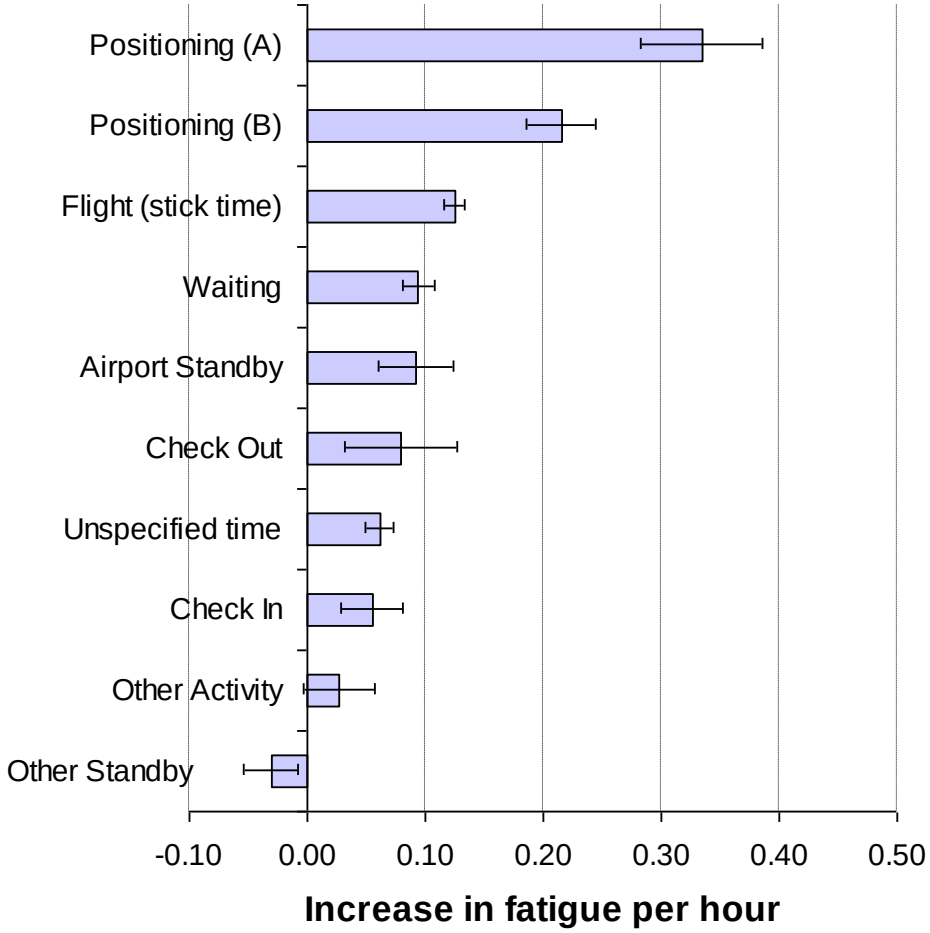
Derivation of a model for fatigue at the end of a duty period

- Statistical modelling of the data was carried out in order to:
  - determine the effect of individual factors, corrected for the effects of all other significant factors,
  - enable comparisons to be made with models for other types of operation.
- The models used were mixed model analysis of variance / regression, with pilot as the single random factor.
- Other factors investigated included length of duty, number of flights, duration of other activities (standby, waiting, etc.), duties on consecutive days, and type of operation (EMS / Air Taxi / Air Taxi nc).

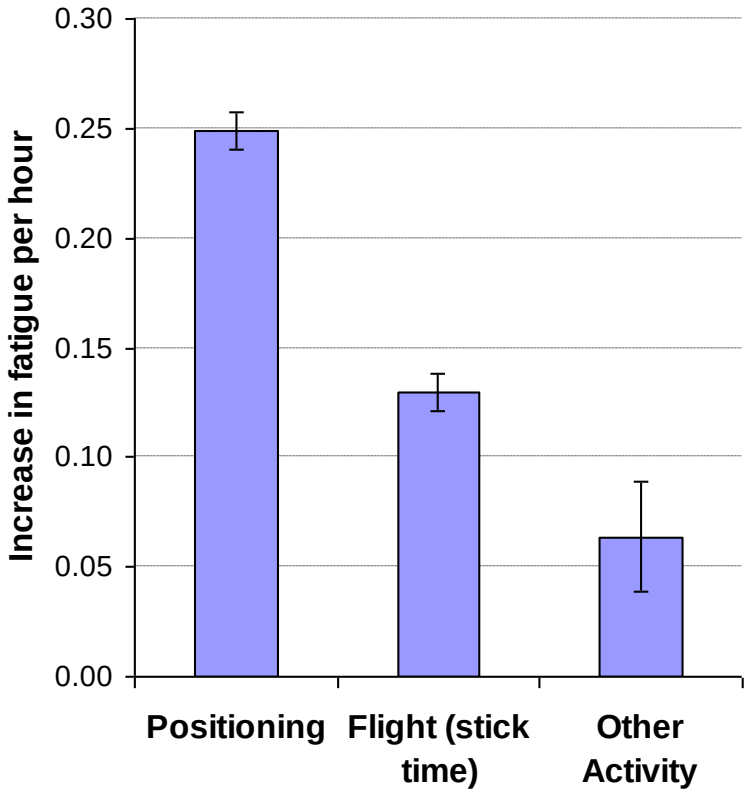
Effects of different types of activity on fatigue

- Fatigue at the end of an FDP depended on the amount of different types of activity that had been carried out.
- The most rapid increases were associated with positioning (but standard errors were large due to the small amounts of these types of activity).
- The activity with the most significant effect was flying.



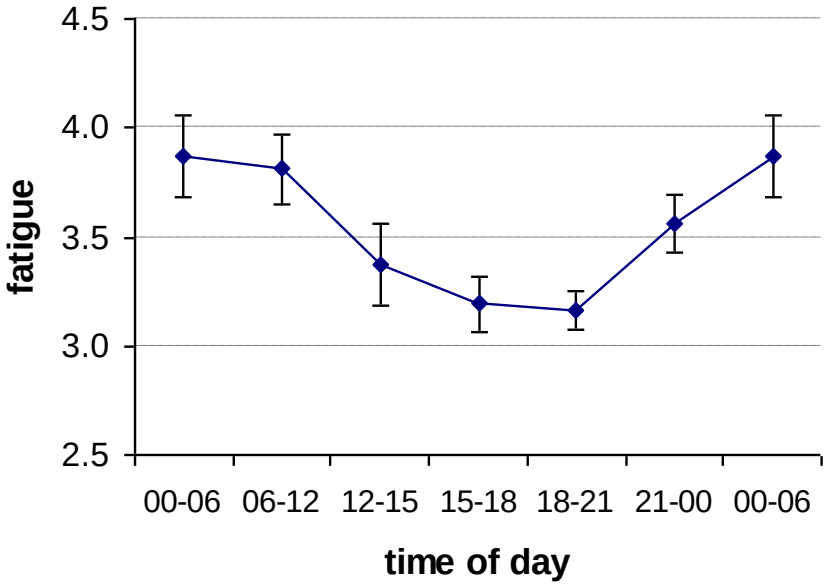
Simplified model based on activity

- Based on the initial calculations, a simplified model for the effect of activity was constructed.
- Activities were classed as ‘Positioning (types A and B), ‘Flight (stick time)’ and ‘Other Activity (everything else).
- On average, every hour of positioning contributed 0.25 to the fatigue score, every hour of flying 0.13, and every hour of other activity approximately 0.06.
- There were no significant differences with type of operation.



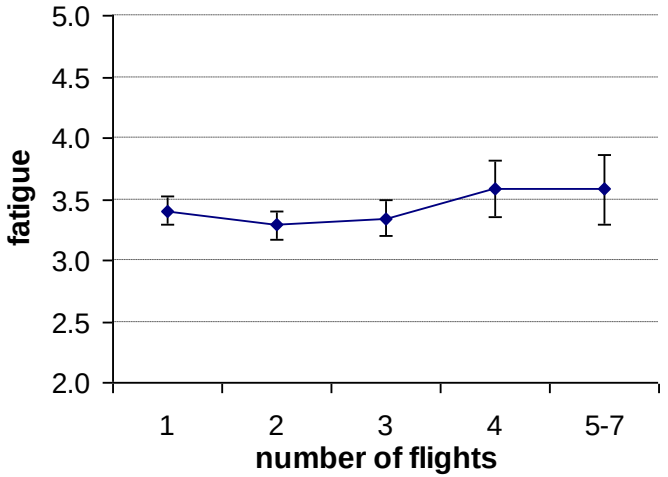
Time of day

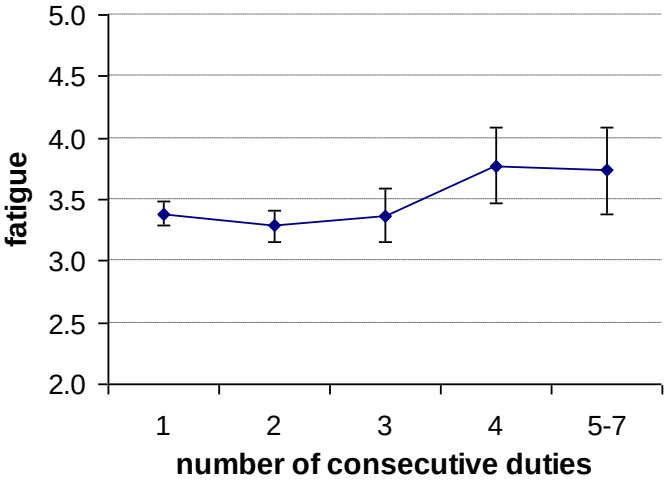
- The variation in fatigue with time of day was similar to that in many other aircrew studies.
- After correcting for the amount of activity, mean levels of fatigue at the end of an FDP are shown alongside.
- A sinusoidal fit has an amplitude of 0.54 (1.07 from peak to trough), and an acrophase of 05:45.



Number of flights and number of consecutive duties

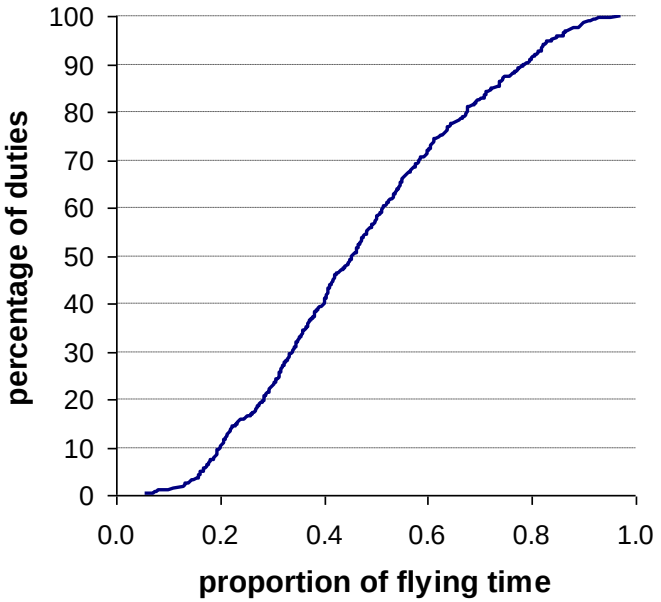
- Number of flights:
  - the no. of flights had no significant effect on fatigue after correcting for the amount of activity
  - this is despite a slight increase after more than three sectors
- Number of consecutive duties:
  - the no. of consecutive duties had no significant effect on fatigue
  - mean levels were somewhat higher after four or more consecutive duties





Summary

- Fatigue at the end of an FDP contains three main components:
  1. a time of day effect, with peak fatigue in the middle of the night,
  2. the total duration of the FDP,
  3. the proportion of the duty taken up by flying or travelling / positioning.
- Typically, time during a duty period was roughly equally divided between flying and non-flying.
- Fewer than 8% of duties had a ratio of more than 4:1 flying to non-flying.



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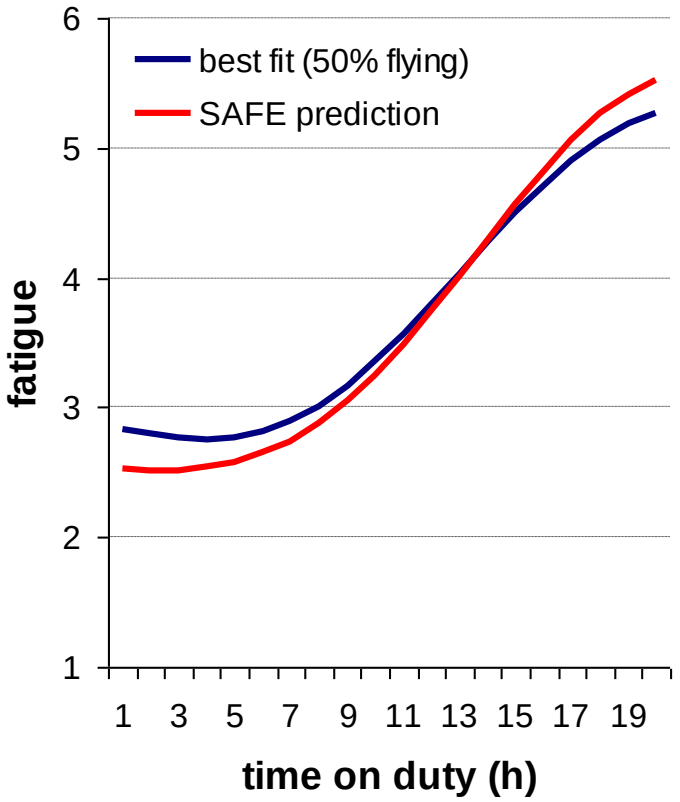
Differences between the types of operation

- The EMS crews tended to have a higher work-rate
  - they did more flying
  - they had longer FDPs
  - they worked more in the late evening and overnight than the Air Taxi crews
- However, there was no significant difference between roles in the number or strength of the factors contributing to fatigue
  - i.e. the same model applied across all operations

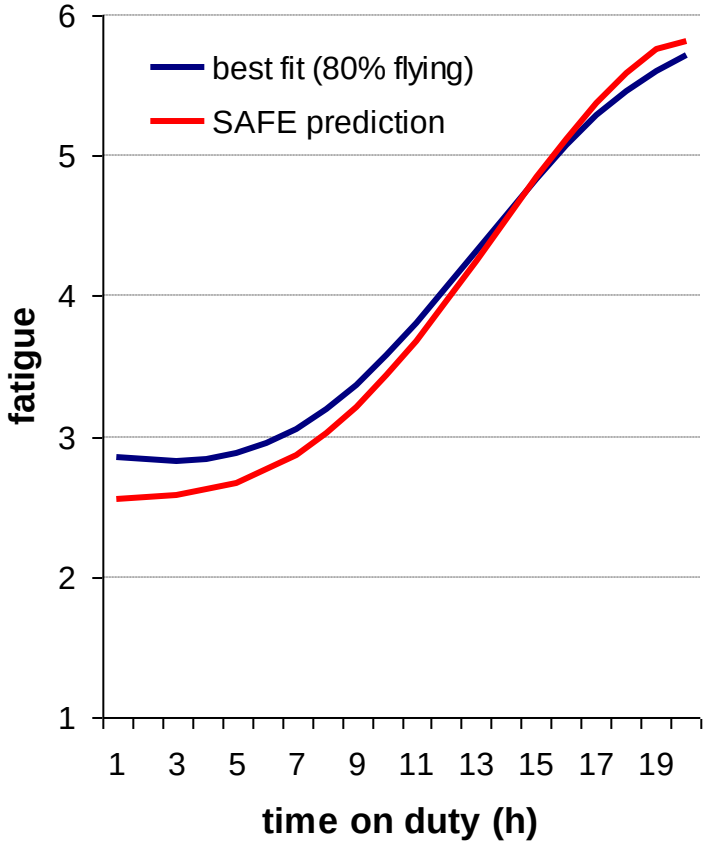
Comparison with the SAFE model

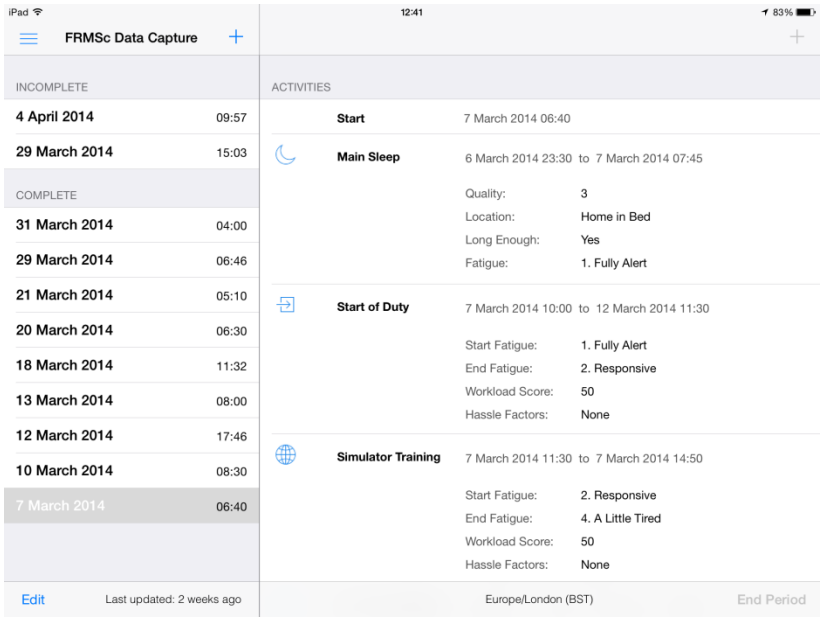
- This figure shows a comparison between the fit derived from this data set and the prediction of the SAFE model:
  - based on a duty period starting at FDP,
  - the fit assumes 50% flying,
  - the SAFE prediction, is based on a single-sector two-crew operation.
- There is good agreement, allowing for a normal margin of error.
- SAFE predicts higher fatigue on very long duties, but these are beyond the range of most of the data.



Comparison of a high workload with the SAFE model

- This comparison is based on the same duty times, with a higher level of workload:
  - the fit assumes an 80% workload,
  - the SAFE model is based on a four-sector duty.
- The two predictions are very close between 14 and 16 hours.





5.0 CONCLUSIONS

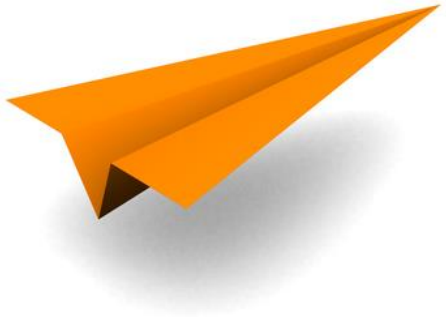
Conclusions (1)

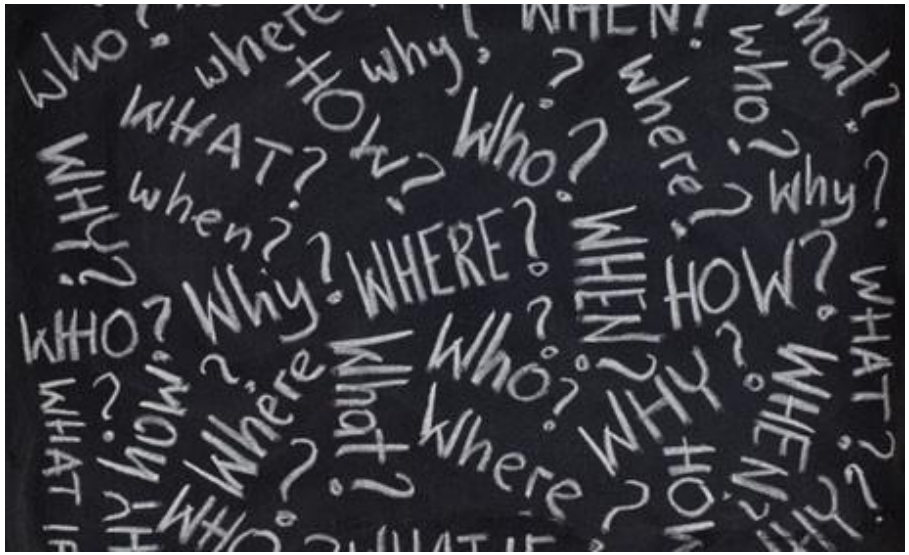
- As in normal commercial operations, the build-up in fatigue during an FDP is determined mainly by the time of day and the duration of duty.
- However, the amount of flying is also an important influence, rather than the number of sectors.
- Although EMS pilots have longer duty hours, the factors contributing to fatigue are the same as for Air Taxi operations.
- There are insufficient data to determine the effects on fatigue of trans-meridian flights in these operations
- Positioning / commuting during an FDP is especially fatiguing

Conclusions (2)

- The work in EMS/AT operations is relatively low in terms of
  - cumulative flying hours
  - total days free of duty
  - consecutive days of duty
- Little significant increase in fatigue with number of sectors (when controlling for flying time).
- Based on these considerations, and after controlling for workload and flying time, it is possible to envisage a modified approach to controlling fatigue in these operations, for example:
  - by relaxing the link between max FDP and number of sectors,
  - by permitting 1h extensions outside the WOCL as standard,
  - by relaxing the link between minimum rest and the duration of the previous duty (but only when the rest is overnight).

Questions





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