Common Protocol for Minimum Data Collection Variables in Aviation Operations

Introduction

FRMS processes provide tools to manage and mitigate organizational fatigue. Operational data collection is necessary to identify operational practices requiring additional attention and for monitoring the effectiveness of various fatigue management approaches. These data collection points or metrics can be used as safety performance indicators (SPIs) to help identify fatigue hazards in the operation for risk assessment, mitigation and monitoring. They also play a role in the monitoring of mitigations and unintended consequences. It is important to look at multiple metrics, not just a single measure, to gain a comprehensive overview of the impact of fatigue within your operations. Please see "*Fatigue Safety Performance Indicators (SPIs): A Key Component of Proactive Fatigue Hazard Identification*" (March 2014). Available from: www.iata.org

It is challenging to collect data during aviation operations because there is little flexibility in terms of experimental control and measurement strategies. Due to the cost and complexity of collecting data in operational environments, very few studies have been published to date. Thus, it is very difficult to establish the degree to which flight operations may exacerbate the fatigue-related challenges that already have been identified in both laboratory and other 24/7 operational environments. Therefore, it is necessary to develop scientifically-based data collection protocols that measure a common set of SPIs. Data can be collected in many ways. These include subjective surveys, such as daily diaries; including sleep logs and work schedules, as well as objective data collection tools such as actigraphy and objective performance tests.

Collating and comparing data collected through a combination of techniques provides the most meaningful information. Establishing a common protocol for use throughout industry allows for comparison of data across industry and analyzing larger data sets help to strengthen the findings. This document presents an overview of a common protocol and identifies a minimum set of fatigue related variables that would allow for the comparison of data across operational studies. Both subjective and objective measures are required to assess individuals on non-duty and duty days. These data are critical to form a baseline to establish the safety associated with current operations.

Carriers can use the information for planning and conducting Proactive Fatigue Hazard Identification within a carrier's operations. The information collected will help them:

1. Assess whether specific fatigue and sleepiness challenges exist in the operation of interest;
2. Learn whether the magnitude of any observed problems is significantly more pronounced than what would be expected;
3. Evaluate the degree to which flight duration and departure time interact to affect crews' abilities to perform; and
4. Ascertain whether the scheduling of flights (i.e., daytime versus nighttime departures) would be expected to exert substantial effects on crew alertness and behavior.

Participants

Interested crew must be invited to volunteer to participate in the data collection protocol and not be coerced into participation. They should be representative of the group of interest and flight crew should hold current Class I physicals. Examples of other variables of interest that should be collected include age, gender, years in profession, currency, etc. Some variables might be sensitive within the culture and can be adjusted accordingly to characterize the population of interest. All volunteers must be treated in accordance with "Ethical Principles of Psychologists and Code of Conduct" (American Psychological Association, 2002) or the Declaration of Helsinki (Declaration of Geneva, 1948). All participants should be given unique identification numbers and their data be stripped of identifying information prior to analyses.

Data Collection Measures

Data collection from the crew is a valuable, proactive approach that helps with the assessment of fatigue levels within aviation operations. Analyses of data can help to identify specific aspects of work schedules or other factors that may contribute to fatigue. Both subjective and/or objective data can be collected in many ways ranging from retrospective surveys to objective performance assessments. Carriers are encouraged to conduct rigorous real-time protocols that assess both subjective and objective measures known to be sensitive to sleep loss and circadian variation. However, rigorous data collection procedures can be cost prohibitive for carriers. This section breaks down the minimum set of data collection measures to assess potential fatigue risk associated with challenging operations.

These have been broken down into "levels" of data collection. There are 5 levels of data collection where Level 1 is the minimum set of measures and Level 5 combines subjective data capture techniques, such as surveys or daily logs, with objective assessments to provide meaningful data. Each level builds on the measures used in the previous approach. A summary table that describes Level 1 – Level 5 data collection measures, platforms for data collection, and examples of tools used in multiple aviation data collection protocols is provided after the *"Level 5 Data Collection"* section.

Level 1 Data Collection

Level 1 data collection includes a *background questionnaire*, which is necessary to characterize the population of interest and establish baseline measures. It is used in combination with a *survey assessment about operations.* Both are completed by the volunteer crew. These are the minimum set of measures to begin the process of Fatigue Hazard Identification. For more detailed information, please see the document developed by the IATA FRMS Task Force "*Fatigue Safety Performance Indicators (SPIs): A Key Component of Proactive Fatigue Hazard Identification*" (March 2014). Available from: tp://www.iata.org

Background questionnaire. The background questionnaire collects demographic information, professional experience, average sleep at home on non-duty days, average sleep on duty days, average sleep duration during flight and a duty history 1 – 2 weeks prior to both the subjective and objective data collection periods. Collecting previous sleep data helps to establish a baseline level for sleep that is then used for comparison purposes on duty days. The questions included in the questionnaire should be developed based on the specific questions of interest to the carrier. Appendix A provides an example of a comprehensive, validated background questionnaire developed by the NASA Ames Fatigue Countermeasures Group that has been used in various operational data collection protocols (Rosekind, Gregory, Co, Miller and Dinges, 2000). The background questionnaire can be administered as a paper and pencil questionnaire, a web-based survey, or electronically on a hand-held device.

Survey assessment about operations. Survey assessments are a very effective method for quickly collecting a large quantity of information about operations from a large population. For example, it can be used to identify the duties that they personally find the most fatiguing, identify specific city pairs or schedules associated with increased fatigue, or identify other operational variables that may be contributing to fatigue. The data can be analyzed through a variety of sophisticated statistical techniques to identify patterns of fatigue among survey respondents and to identify other challenges within operations that might be appropriate for further objective evaluation or immediate mitigation. Survey questions should be developed to target specific areas of concern or to gather general information concerning fatigue within the specific aviation organization or population. Information should be collected across a wide-range of fatigue-related topics. Similar to the background questionnaire, it can be administered as a paper and pencil questionnaire, a web-based survey, or electronically on a hand-held device.

Level 2 Data Collection

Level 2 data collection includes Level 1 measures (i.e., background questionnaire and subjective survey assessment about operations) plus the addition of sleepiness and alertness ratings. The sleepiness and alertness ratings are only collected if a particular

operation is identified, based on the analyses of subjective survey assessment about operations, to be associated with increased fatigue risk.

Sleepiness and alertness ratings. Sleepiness and alertness ratings are subjective tools with which crew assess their sleepiness and alertness levels. It is important that these assessment tools be sensitive to sleep loss and circadian rhythmicity. Ratings can be administered as a paper and pencil survey or electronically on a hand-held device. The *Karolinska Sleepiness Scale (KSS)* and the *Samn-Perelli Fatigue Scale* are two assessment tools that have been used extensively in aviation data collection protocols.

The Karolinska Sleepiness Scale (see Appendix B) is a nine-point Likert-type scale of subjective sleepiness ranging from 1 = "very alert" to 9 = "very sleepy, fighting sleep." Crews are asked to indicate on the KSS their sleepiness level in the previous five minutes prior to completing the scale. This scale has been shown to be sensitive to sleep loss and circadian rhythmicity (Gillberg, Kecklund and Åkerstedt, 1994; Åkerstedt and Gillberg, 1990).

The Samn-Perelli Fatigue Scale (see Appendix C) is a seven-point Likert-type scale of subjective fatigue ranging from 1 = "fully alert, wide awake" to 7 = "completely exhausted, unable to function effectively." Unlike the KSS, the Samn-Perelli scale was developed for use in aviation operations to assess flightcrew fatigue based on work/rest profiles (Samn and Perelli, 1982). The data are used to show quantitatively if flight and duty hours are contributing to crew fatigue.

Level 3 Data Collection

Level 3 data collection includes the addition of Sleep/Activity and Duty Logs. Daily sleep/wake diary data can provide insights into the actual work habits and sleep/wake schedules of individuals.

Sleep/activity and duty logs. Sleep/activity and duty logs consist of questions about sleep and wakeup times, sleep quality, daytime activities, beverage consumption, medication (optional), and daytime naps. If there are sensitivity issues with specific variables, the questions should be modified. They also include Likert Scales which use fixed-choice response formats to measure opinions and assign a quantitative value to qualitative data (Rattray and Jones, 2007). A numerical value is assigned to each potential choice and a mean figure for all the responses is computed at the end of the evaluation or survey. Likert scales usually have five potential choices (strongly agree, agree, neutral, disagree, strongly disagree), but may go up to ten or more. One of the Likert-type scales asks individuals to rate their sleep quality and quantity after each rest period, on a scale from 1 = "extremely good" to 7 = "extremely poor." Sleepiness and alertness ratings described in Level 2 data collection are often included in the sleep/activity and duty logs. Sleep/activity and duty logs can be administered as hardcopy logs or programmed onto a hand-held electronic device. An example is provided in Appendix D.

Level 4 Data Collection

Levels 1 – 3 data collection included the use of subjective measures in which the volunteers give their opinions, interpretations, and perceptions about the subject of interest (e.g. total sleep time, levels of alertness and sleepiness, performance levels, etc.). Subjective approaches, although useful as the first step in managing and mitigating fatigue risk, can sometimes be biased. If any of the subjective measures collected during Levels 1 – 3 data collection suggest a potential safety issue associated with operations, the carrier may elect to collect objective measures. Objective measures are collected using standalone testing devices and are not influenced by personal feelings or opinions and represent the facts. These measurements provide objective data that can be used to supplement the subjective data collected in the subjective surveys and assessments. If data collection is tightly controlled and adheres to a protocol, the data may be suitable to make decisions concerning the operations. Level 4 data collection builds on the subjective measures previously described and includes actigraphy, an objective measure of sleep. Actigraphy data correlate well with standard polysomnographic assessments, the gold standard for measuring sleep (Ancoli-Israel, 2003).

Actigraphy. Actigraphy data are collected using an activity monitor, the accelerometer, to estimate the sleep/activity rhythms of individuals based on physical movement (see Appendix E). The monitors are worn according to the manufacturer's instructions (usually on the non-dominant wrist), 24 hours a day on both duty and non-duty days. The monitors have straps so they can be taken off when the volunteer is engaged in activities likely to cause equipment damage (i.e. swimming, showering, and extreme sports). The accelerometer generates and stores physical movement data. Typically, the sampling frequency is 32 Hz, segmented into no more than one-minute epochs, allowing data to be collected at a high enough resolution for detailed analyses of estimated sleep/activity cycles. Once the data are collected, they are visually inspected along with activity logs to determine the amount of sleep on both duty and non-duty days.

Actigraphy should be used with Sleep/Activity and Duty logs to fully interpret the data. It yields a number of objective variables collected during both duty and non-duty days: mean total sleep (minimum), mean sleep latency (minimum time to fall asleep), mean number of awakenings and mean sleep efficiency (% of time spent sleeping) per sleep episode.

Level 5 Data Collection

Level 5 data collection includes all of the measures previously described with the addition of an objective measure of performance. The data are collected through the process of performance testing that is known to be sensitive to sleepiness and circadian rhythm changes.

Objective performance testing. Performance is usually specified in terms of response times, throughput (transactions per second), and any other measure that represents basic levels of cognitive functioning. The challenge with administering such tests is that they are often long tests and require frequent testing (e.g., every 1 – 2 hours). One assessment tool that has been used extensively in aviation data collection protocols is the Psychomotor Vigilance Task (PVT).

The PVT task is a “simple” (as opposed to multiple choice) reaction time (RT) test designed to evaluate the ability to sustain attention and respond in a timely manner to salient signals (Dinges & Powell, 1985). The task was designed to be simple to perform, free of a learning curve or influence from acquired skills (aptitude, education), and highly sensitive to an attentional process that is fundamental to normal alert functioning. The PVT and its resulting metrics are based on a model of changes in the interaction between sleep and circadian systems regulated by the brain (Dinges, 1989).

For operational assessments, a 5-minute touchscreen-based PVT, such as that developed at the Walter Reed Army Institute for Research (Balkin, Bliese, Belenky, Sing, Thorne, Thomas, Redmond, Russo and Wesensten, 2004; Thorne, Johnson, Redmond, Sing, Belenky, & Shapiro, 2005) has been shown to be effectively utilized for various field studies in 24-hour operations. The 5-min PVT is a hand-held test that delivers a three-mm visual stimulus (a reaction-time counter) that requires the volunteer to make a pushbutton response within 1.5 seconds with interstimulus interval varying from one to ten seconds (see Appendix F). Volunteers are instructed to press the response button as rapidly as possible once the visual stimulus appears; however, volunteers are cautioned against pressing the button too soon to avoid a "false start." Each 5-minute PVT session yields a number of output variables: mean reaction time per trial (RT, msec), mean speed per trial (1/RT), total lapses (RTs > 500 msec), and total false starts (FS, responses prior to stimulus onset). Many different versions of Psychomotor Vigilance Tasks have been developed so it is important to consider the validation research demonstrating its sensitivity to fatigue and alertness.

Summary Table of Data Collection Levels 1 – 5

	Measures	Platform for Data Collection	Example Tools
Level 1	Background questionnaire	• Paper and pencil • Web-based • Electronically on a hand-held device	NASA Fatigue Countermeasures Background Questionnaire
	Subjective survey assessment about operations	• Paper and pencil • Web-based • Electronically on a hand-held device	Must be customized for specific carrier, operations and topic of interest
Level 2	Sleepiness and Alertness Ratings	• Paper and pencil • Electronically on a hand-held device	Karolinska Sleepiness Scale Samn-Perelli Fatigue Scale
Level 3	Sleep/activity and duty logs	• Paper and pencil • Electronically on a hand-held device	Sleep/activity and duty logs
Level 4	Actigraphy	• Wrist-worn accelerometer	Actiwatch, Actigraph
Level 5	Objective Performance Testing	• Vigilance tests programmed on electronic device	3, 5 or 10 min PVTs

Important The example tools mentioned above are just for example purposes. This is not an exhaustive list of all the tools available in the market and it is not an indication that these tools are necessarily better than other existing ones that have not been mentioned above.

DATA COLLECTION TIMELINES

Offline Measures

Background questionnaire. The background questionnaire is administered offline and prior to either subjective or/and objective data collection. Once the background questionnaire data are collected from a volunteer, it is not necessary to have them complete it again for future studies. Their demographic information can be stored in a confidential database only identified by a unique identification number.

Survey assessment about operations. Survey assessments about operations take a retrospective approach that requires crew to recall previous experiences with specific operations and routes after they occur. It is completed offline.

Real Time Measures: Duty and Non-Duty Days

Sleep/activity and duty logs. Volunteers complete the logs at discrete time points during the data collection period. Ideally, volunteers would be asked to complete the logs during the following periods:

- Baseline – for 3 days prior to data collection period
- Throughout data collection period
- Recovery – for 3 days post data collection period

Actigraphy. Volunteers wear an actigraph device on their wrist continuously 24 hours/day. Data should be collected throughout the following periods:

- Baseline – for three 3 days prior to data collection period
- Throughout data collection period
- Recovery – for 3 days post data collection period

In some operational contexts, it may not be feasible to collect baseline and recovery data for 3 days using sleep/activity and duty logs and actigraphy. Keep in mind that data collection across multiple days will help to increase the power of the findings. The minimum requirement is 1 day prior and post data collection period.

Real Time Measures: Duty Days

Sleepiness and alertness ratings. Volunteers complete the sleepiness and alertness ratings at various times throughout duty.

- Pre-duty
- TOC
- Before and after sleep periods; inflight sleep periods only
- TOD
- Post-duty

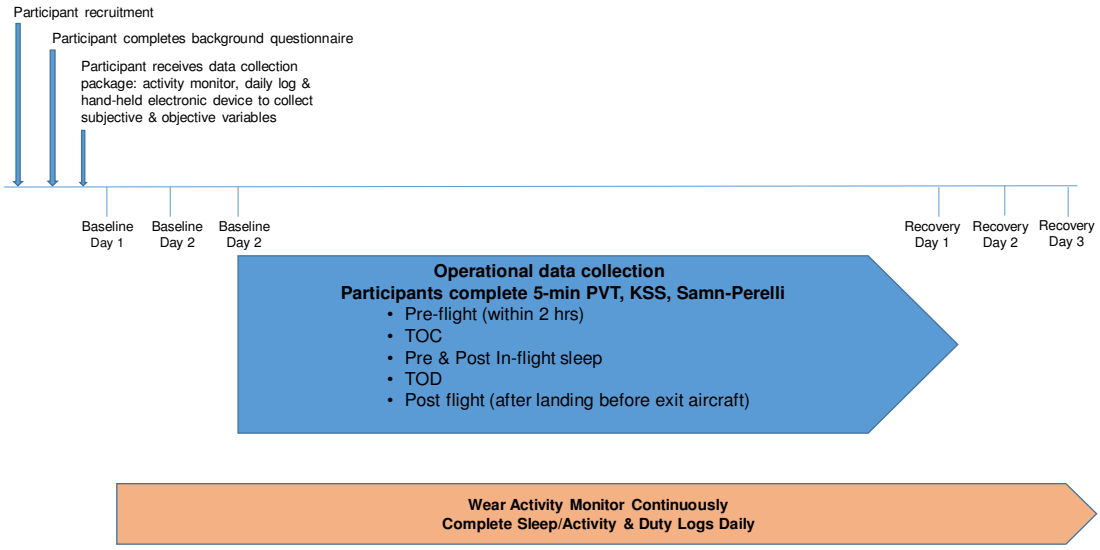
Ideally, sleepiness and alertness ratings would be collected at each of the time points listed above, although operational demands will not always allow for such intensive data collection. Data collection focused on how fatiguing a particular operation is should be collected, at a minimum, at TOC and TOD. Studies focused on the quality of in-flight sleep periods should be collected pre-sleep and post-sleep, at a minimum.

Psychomotor Vigilance Task (PVT). Volunteers complete objective performance testing at critical time points throughout the data collection period. Critical time points include:

- Pre-duty
- TOC
- Before and after sleep periods; inflight sleep periods only
- TOD
- Post-duty

Similar to the sleepiness and alertness ratings, objective performance testing would also be collected at each of the time points listed above. However, operational demands and data collection costs often make this prohibitive. Data collection focused on how objective performance is affected should be collected, at a minimum, at TOC and TOD. Studies focused on how restorative in-flight sleep periods are should be collected pre-sleep and post-sleep, at a minimum.

Level 5 Data Collection Scenario



Appendix A: Background Questionnaire

A. GENERAL

1. What is your flightdeck position? — Capt. ☐ F/O ☐ S/O or F/E ☐
2. What aircraft are you currently operating? — B747 series ☐ B747-400 ☐ B767 series ☐ A300 series ☐ MD-11 ☐ other (please specify) ☐
3. How many total flight hours have you logged? ☐
4. How much experience do you have flying long-haul? — years ☐ months ☐
5. Gender — male ☐ female ☐
6. Age? ☐
7. What is your weight? ☐ lbs. **OR** ☐ kg.
8. What is your height? ☐ ft. ☐ ins. **OR** ☐ cm.
9. In what time-zone do you live? ☐
10. In what time-zone relative to GMT do you live? ☐ hrs. (specify + or -)
11. Do you have a regular bed partner? ☐ yes ☐ no
12. Number of children at home under 18 years of age? ☐
13. Number of others living with you? (e.g., older children, in-laws, relatives) ☐
14. Specify: _____

B. SLEEPING AT HOME

Please give one best answer to each of the following questions based on **an average night of sleep at home**. (About 3-4 days after your return home following a long-haul trip.)

15. On your days off, at what time do you usually go to sleep? (Use 24 hour clock) — hours ☐☐ minutes ☐☐
16. On your days off, at what time do you usually get up? (Use 24 hour clock) — hours ☐☐ minutes ☐☐
17. On your days off, how long after going to bed do you usually fall asleep? — hours ☐☐ minutes ☐☐
18. When sleeping at home, how many times <u>on average</u> do you wake up? ☐ times
19. If you wake during the night, what is it that usually causes you to wake up? _____
20. If you wake during the night, on average, how long does it take you to go back to sleep? — hours ☐☐ minutes ☐☐
21. When sleeping at home, what is the usual total amount of sleep you get? — hours ☐☐ minutes ☐☐
22. How often do you take a daytime nap at home? — never ☐ seldom 1-4 times/yr ☐ sometimes 1-3 times/mo ☐ often 1-4 times/wk ☐ majority of time 5-7 times/wk ☐
23. When sleeping at home, do you have problems getting to sleep? — never ☐ seldom 1-4 times/yr ☐ sometimes 1-3 times/mo ☐ often 1-4 times/wk ☐ majority of time 5-7 times/wk ☐

REMEMBER: Give one best answer based on average night of sleep at home (about 3-4 days after you return from a long-haul trip).

24. Please rate the following factors and indicate how much they **interfere with or promote** our sleep at home?

	interferes 1	2	no effect 3	4	promotes 5
1) quality of sleep surface	☐	☐	☐	☐	☐
2) heat	☐	☐	☐	☐	☐
3) cold	☐	☐	☐	☐	☐
4) thoughts running through your head	☐	☐	☐	☐	☐
5) random noise events	☐	☐	☐	☐	☐
6) constant background noise	☐	☐	☐	☐	☐
7) background lighting	☐	☐	☐	☐	☐
8) readiness for sleep	☐	☐	☐	☐	☐
9) comfort of clothing	☐	☐	☐	☐	☐
10) low humidity/dry air	☐	☐	☐	☐	☐
11) high humidity	☐	☐	☐	☐	☐
12) trips to bathroom	☐	☐	☐	☐	☐
13) bed partner	☐	☐	☐	☐	☐
14) privacy	☐	☐	☐	☐	☐
15) ventilation	☐	☐	☐	☐	☐
16) sheets	☐	☐	☐	☐	☐
17) blankets	☐	☐	☐	☐	☐
18) pillows	☐	☐	☐	☐	☐
19) other (specify) _____	☐	☐	☐	☐	☐

25. Please rate the following on the extent to which they **interfere** with your sleep at home.

	strongly interfere 1	2	3	4	no effect 5
1) hunger	☐	☐	☐	☐	☐
2) thirst	☐	☐	☐	☐	☐
3) personal worries	☐	☐	☐	☐	☐
4) respiratory factors (i.e., asthma, allergies, etc.)	☐	☐	☐	☐	☐
5) other (specify) _____	☐	☐	☐	☐	☐

26. Please list any other factors that **promote** your sleep at home.

1. _____
2. _____
3. _____
4. _____
5. _____

REMEMBER: Give one best answer based on an average night of sleep at home (about 3-4 days after you return from a long-haul trip).

	never	seldom 1-4 times/yr	sometimes 1-3 times/mo	often 1-4 times/wk	majority of time 5-7 times/wk
27. Do you take medication to help you sleep?					

28. If yes, please specify. _____

	never	seldom 1-4 times/yr	sometimes 1-3 times/mo	often 1-4 times/wk	majority of time 5-7 times/wk
29. Do you ever use alcohol to help you sleep?					

	very poor	poor	good	very good
30. Overall, what kind of sleeper are you?				

	yes	no
31. Do you have a sleep problem?		

32. If yes, what is your sleep problem. _____

	yes	no
33. If yes, has it been diagnosed by a physician?		

	yes	no
34. Has it ever prevented you from flying a scheduled trip?		

Fill out this section **ONLY** if you are currently flying an aircraft equipped with a bunk

C. SLEEPING IN AIRCRAFT BUNKS

Please give one best answer to each of the following questions based on experiences in your aircraft.

35. How often have you used a bunk in the past 12 months?
    1) current aircraft ____ times
    2) other types of aircraft ____ times

	upper	lower	either
36. Based on your current aircraft, which bunk do you usually sleep in?			

	yes	no
37. Are you able to undress for a comfortable sleep?		

	yes	no
38. Is it important for you to undress for a comfortable sleep?		

	hours	minutes
39. How long after getting into the bunk does it take you to fall asleep?		
a) What is the typical amount of sleep you get in the bunk?		
b) What is the longest sleep period you have experienced in the bunk?		
c) What is the shortest period of time that you would use the bunk for sleep?		

	never	seldom	sometimes	often	majority of time
40. When you have an opportunity to use the bunk, how often do you experience difficulty sleeping?					
a) How often do you use the bunk only for rest and not sleep?					

	yes	no
41. Are you required to spend some time in the bunk when not flying?		

	Co. Policy	Sr. Capt.	flight length	others (specify)
42. If yes, who or what mandates its use?				

43. What other factors determine bunk use and rostering?
    1. _____
    2. _____
    3. _____
    4. _____

44. In general, what percentage of cruise time is made available to you for using the bunk? _____%

	very neg	negative	neutral	positive	very positive
45. Rate your overall attitude about the bunk.					

	very decreased alertness	decreased alertness	no change	improved alertness	very improved alertness
46. How does bunk sleep affect your overall alertness?					

	very decreased performance	decreased performance	no change	improved performance	very improved performance
47. How does bunk sleep affect your performance?					

48. How often can you sleep when you use any of the following:	never	seldom	sometimes	often	almost always
1) cockpit seat					
2) 1st class seat					
3) passenger seat					
4) bunk					
5) at home in bed					

This is **one of the most important questions in this survey.** Please take your time and answer thoroughly.

	interferes		**no effect**		**promotes**
49. Please rate the following factors and indicate how much they **interfere with or promote** your sleep in the bunk?	**1**	**2**	**3**	**4**	**5**
1) quality of sleep surface					
2) heat					
3) cold					
4) thoughts running through your head					
5) random noise events					
6) constant background noise					
7) background lighting					
8) readiness for sleep					
9) comfort of clothing					
10) low humidity/dry air					
11) trips to bathroom					
12) someone in the other bunk					
13) seat belt sign					
14) turbulence					
15) privacy					
16) bunk size					
17) facility size					
18) headspace					
19) lighting					
20) ventilation					
21) storage space					
22) curtains					
23) sheets					
24) blankets					
25) pillows					
26) other (specify) _____					

	strongly interferes				**no effect**
50. Please rate the following on the extent to which they interfere with your sleep in the bunk.	1	2	3	4	5
1) hunger					
2) thirst					
3) claustrophobia					
4) personal worries					
5) respiratory factors (i.e., asthma, allergies, etc.)					
6) other (specify) _____					

51. Please list any other factors that **promote** good sleep in the bunk.

1. _____
2. _____
3. _____
4. _____
5. _____

52. When using the bunk, do you do anything to help you get to sleep or to minimize disturbance of your sleep, such as:

	yes	no
1) Wear earplugs?	☐	☐
2) Wear eyeshades	☐	☐
3) Listen to music?	☐	☐
4) Relaxation techniques?	☐	☐

5) Other (specify) _____

53. Describe any **pre-trip** strategies you use to help you sleep in the bunk. (Things you do before you are on the aircraft.)

1. _____
2. _____
3. _____
4. _____

54. Please suggest how the crew rest facility can be improved to be more conducive to sleep?

1. _____

Appendix B: Karolinska Sleepiness Scale (KSS)

This scale asks people to rate how sleepy they feel right now. Any of the values from 1-9 can be ticked, not only those with a verbal description.

1 = extremely alert
2
3 = alert
4
5 = neither sleepy nor alert
6
7 = sleepy, but no difficulty remaining awake
8
9 = extremely sleepy, fighting sleep

Extracted from ICAO (2012): ICAO Doc 9966: "*Fatigue Risk Management Systems - Manual for Regulators*"

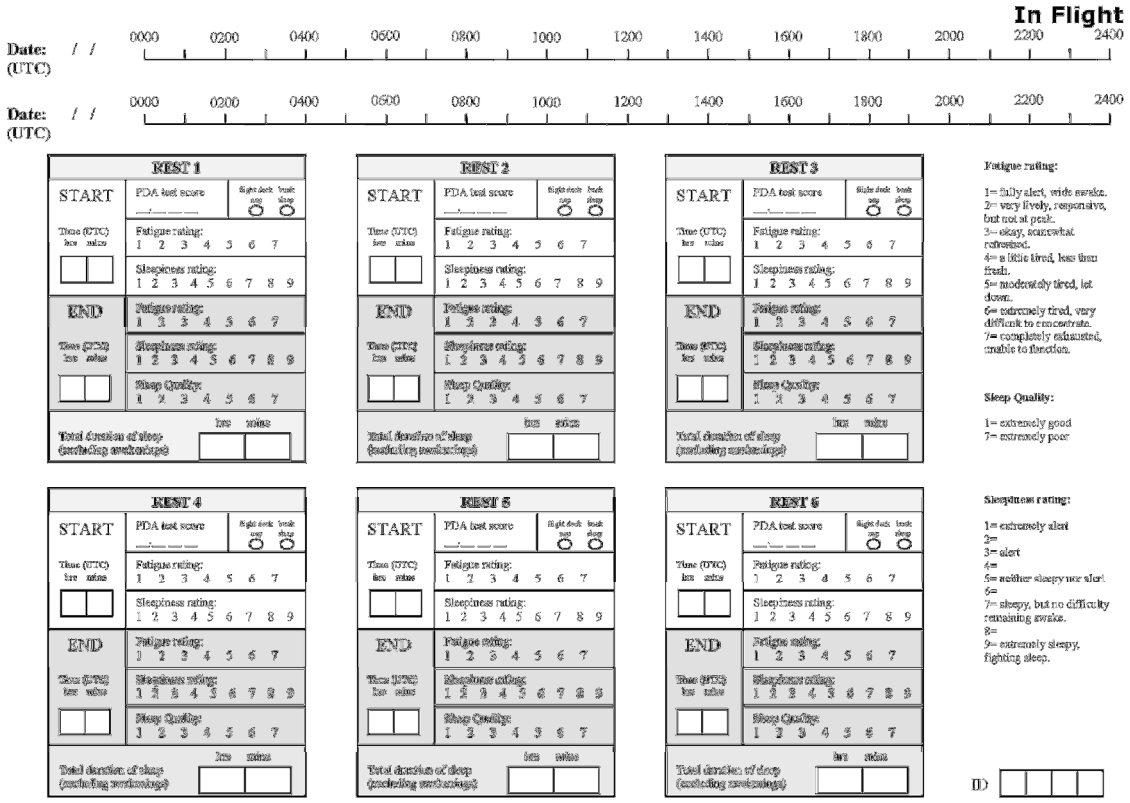
Appendix C: The Samn-Perelli Crew Status Check

This scale asks people to rate their level of fatigue right now, and is a simplified version of the Samn-Perelli Checklist.

1 = fully alert, wide awake
2 = very lively, responsive, but not at 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

Extracted from ICAO (2012): ICAO Doc 9966: "*Fatigue Risk Management Systems - Manual for Regulators*"

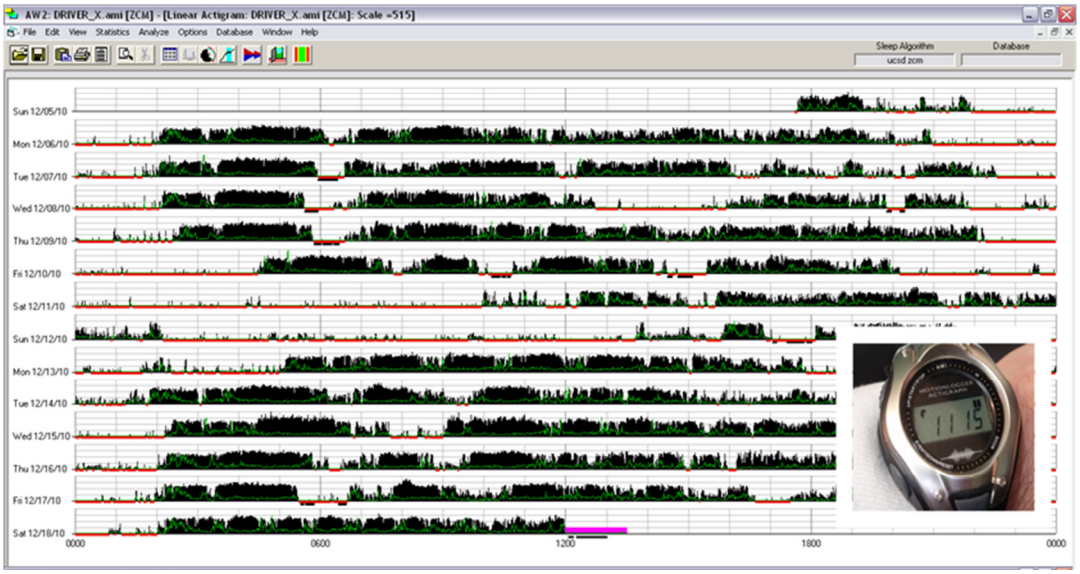
Appendix D: Example of Sleep and Duty Log on Flight Days



Extracted from ICAO (2012): ICAO Doc 9966: "*Fatigue Risk Management Systems - Manual for Regulators*"

Appendix E: Actigraphy

Actigraphs are worn on the non-dominant wrist (with most manufacturers) and continuously monitors an individual's sleep/wake behavior for days or weeks. A sample of an actigraphy profile for an individual who has worn the actigraphic device for a 2-week period. The solid red bar below activity data shows times scored as "asleep."



Appendix F: Objective Performance Testing

The original Model PVT-192 is shown in the top panel. In the bottom panel, the Walter Reed Army Institute of Research personal digital assistant version of the PVT is shown

References

Åkerstedt T, Gillberg M. (1990). Subjective and objective sleepiness in the active individual. International Journal of Neuroscience, 52: 29-37, 1990.

American Psychological Association. (2002). American Psychological Association ethical principles of psychologists and code of conduct. Available from: http://www.apa.org/ethics/code2002.html. Accessed May, 2015.

Ancoli-Israel, S., Cole, R., Alessi, C., Chambers, M., Moorcroft, W., and Pollak, C. (2003). The role of Actigraphy in the Study of Sleep and Circadian Rhythms. Sleep, 26(3): 342 – 392.

Balkin, T. J., Bliese, P. D., Belenky, G., Sing, H., Thorne, D. R., Thomas, M., Redmond, D. P., Russo, M. and Wesensten, N. J. (2004). Comparative utility of instruments for monitoring sleepiness-related performance decrements in the operational environment. Journal of Sleep Research, **13**: 219-227.

Declaration of Geneva. (1948) physician's oath: adopted by the General Assembly of World Medical Association at Geneva Switzerland. Available from: http://www.cirp.org/library/ethics/geneva/ Accessed: May 2015.

Dinges, D. I, & Powell, J. W. (1985). Microcomputer analysis of performance on a portable, simple visual RT task sustained operations. Behavioral Research Methods, Instrumentation, and Computers, 17, 652–655.

Dinges, D. F. (1989). The influence of the human circadian timekeeping system on sleep. In M. Kryger, W. Dement, & T. Roth (Eds.), *Principles and practice of sleep medicine*. (pp. 53-162). Philadelphia, PA: Saunders.

Fatigue SPIs: A Key Component of Proactive Fatigue Hazard Identification (March 2014). Available at: www.iata.org

Gillberg M, Kecklund G, Åkerstedt T. (1994): Relations between performance and subjective ratings of sleepiness during a night awake. Sleep 17(3): 236-241.

Rattray, J., and Jones, M.C. (2007): Essential elements of questionnaire design and development. Journal of Clinical Nursing 16: 234 – 243.

Rosekind, M., Gregory, K., Co E., Miller, L. and Dinges, D. (2000): Crew Factors in Flight Operations XII: S Survey of Sleep Quantity and Quality in On-Board Rest Facilities. NASA Ames Research Center. Moffett Field, CA. NASA/TM – 2000-209611.

Samn S.W, Perelli LP. (1982): Estimating aircrew fatigue: A technique with implications to airlift operations. Brooks AFB, TX: USAF School of Aerospace Medicine. Technical Report No. SAM-TR-82-21, 1982.

Thorne, D.R., Johnson, D.E., Redmond, D. DP, Sing, H., Belenky, G., and Shapiro, J.M. (2005): The Walter Reed palm-held psychomotor vigilance test. Behavioral Research Methods Feb; 37(1):111-118