PILOTS' BUNK SLEEP VARIES SIGNIFICANTLY DURING LONG REST PERIODS

An extract from - **"**Consensus Emerges from International Focus on Crew Alertness in Ultra-long range Operations"

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The amount and quality of in-flight sleep that flight crews are able to obtain during scheduled rest periods is a critical issue for designing safe long-range operations (flight-sector lengths between 12 and 16 hours) and ultra-long range (ULR) operations (flight-sector lengths greater than 16 hours).[1] This in-flight sleep will be influenced by both physiological factors (prior sleep history and the body's biological clock) and operational factors (flight-sector length, crew complement, the number and type of crew-rest facilities available, in-flight disturbances and the method of allocating rest periods, etc.). Currently, very few scientific data are available on the in-flight sleep that pilots are able to obtain – particularly during the long rest opportunities that might be available during ULR operations.

The main aim of this study[2] was to document the amount of sleep and the quality of sleep that individual pilots were able to obtain in the crew-rest facility of the Boeing 777-200ER when they were provided a single seven-hour sleep opportunity during a flight sector with an average length of approximately 15 hours. A total of six non-revenue airplane-delivery flights were conducted. A comparison also was made between the amount and quality of sleep obtained during the first half of the flight compared with the amount and quality of sleep obtained during the second half of the flight, and the researchers assessed the effect of this sleep on the alertness of crewmembers during the final 50 minutes that they were on duty.

This study extends previous research on in-flight sleep in that the flight times and the rest periods were the longest yet monitored. The findings of the study are strengthened by the methods that were used for recording in-flight sleep data and for measuring alertness during the last 50 minutes of duty. One method – called polysomnography – involves recording brain activity, eye movement and muscle tone using small electrodes that are attached to the head and the face of the pilot.

Twenty-one pilots – 11 captains and 10 first officers who had experience in long-range flights for a commercial airline – were monitored before, during and after a round-trip operation between Singapore and Seattle, Washington, U.S., or between Kuala Lumpur, Malaysia, with most spending at least 72 hours there before conducting the return leg for delivery of a Boeing 777-200ER aircraft.

To enable researchers to estimate the sleep obtained across the study period, the crewmembers wore an Actiwatch for approximately nine days – three nights prior to departing from their home base for Seattle, during their time in the United States and for a further three nights after returning to their home base. (The Actiwatch – a small, lightweight device approximately the size of a wrist watch – measures and records the motion of the body; this research method is called actigraphy. Actigraphy devices have proven to be highly sensitive to sleep, and they are a useful means of objectively monitoring sleep over extended periods of time.)

During one night in Seattle, the sleep of each pilot was monitored using polysomnography. This was done to allow pilots to adapt to the equipment and to provide data for the sleep study that could be compared to data from in-flight sleep. During each airplane delivery flight, polysomnography was used to monitor and to record the crewmembers' in-flight sleep and their alertness at the end of the flight.

The study found that in the 72 hours leading up to the aircraft-delivery flight, crewmembers obtained less sleep than they believed was necessary to be fully rested (called sleep debt). Prior to the flight,

crewmembers accumulated an average sleep debt of 4.3 hours. Nevertheless, there was considerable individual variability, with some having zero sleep debt or very little sleep debt and others having a sleep debt of nearly 10 hours. In the 24 hours before the flight, crewmembers averaged seven hours of sleep, which was on average 1.9 hours less sleep than they believed was necessary to be fully rested.

During the flight, crewmembers were asked to spend as much as possible of their seven-hour rest opportunity trying to sleep but, on average, they spent 4.7 hours in the bunk and obtained 3.3 hours of sleep. The quality of the in-flight sleep was poorer compared to sleep obtained in the hotel during the layover. Sleep efficiency (percentage of time asleep compared with the time elapsed while trying to sleep) dropped from 90percent in the layover hotel to 70 percent in the bunk. In-flight sleep also was more disrupted (indicated by more awakenings and sleep disturbances called arousals, which are short-duration changes in sleep). Less than 1 percent of in-flight sleep was deep sleep, with no stage-4 sleep observed.[3]

Pilots who were provided the sleep opportunity during the first half of the flight spent less time trying to sleep than those who had the later sleep opportunity (average 4.0 hours versus 5.4 hours), and pilots who had their sleep opportunity during the first half of the flight also obtained less sleep (average 2.7 hours versus 3.9 hours) than the others. The quality of sleep was comparable in both sleep opportunities, however.

The data showed that the amount of bunk sleep and quality of bunk sleep were not related to the amount of sleep obtained in the 24 hours preceding the flight (as estimated by data from the Actiwatch). This suggests that the strategy of purposely restricting layover sleep to improve the pilot's in-flight sleep may not always be advisable.

The most consistent factor affecting the amount and quality of bunk sleep was the crewmembers age. Older crewmembers took longer for sleep onset, obtained less total sleep – with lower proportions of certain stages of sleep (light stage-2 sleep and dreaming, also called rapid eye movement sleep[4]) – and experienced sleep that was more disrupted than the sleep of younger crewmembers. These statistical differences persisted after accounting for the amount of prior sleep that crewmembers had obtained and for whether they had slept during the first half of the flight or the second half of the flight.

Pilots who slept during the second half of the flight were more alert during their final 50 minutes of duty than those who slept during the first half of the flight. The amount of bunk sleep, but not the quality of bunk sleep, also had a significant effect on alertness in the last 50 minutes of duty; more sleep was associated with greater alertness. The study supports the general principle that more sleep results in higher alertness at the end of the flight, regardless of the age of the crewmember.

In summary, as this study and others show, in-flight sleep obtained in an airplane crew-rest facility is generally of poorer quality than sleep obtained in a layover hotel. In this study, in-flight sleep in the crew-rest facility occurred under relatively ideal conditions because the possibility of sleep disturbances caused by passengers was absent on these non-revenue flights. The pilots who slept during the second half of the flight obtained more sleep than the pilots who slept during the first half of the flight. This finding has been replicated in several other studies and is consistent with the well-established principle that the pressure for sleep (particularly for deep sleep) increases as the length of time awake increases.

Older crewmembers obtained less sleep regardless of when their sleep opportunity was provided. Other studies have suggested that older crewmembers also lose more sleep across trip patterns. These changes are consistent with well-established age-related changes in sleep, which begin about the age of 50 years.

Taken together, these findings suggest that – on this type of flight – each crewmember should be provided with one long sleep opportunity per flight, and that, to maximize the alertness of the landing crew, the landing-crew pilots should be provided their sleep opportunity during the second half of the ULR flight sector. Given that very little deep sleep was observed in the crew-rest facilities, the feeling of grogginess and disorientation on waking (called sleep inertia) is probably not a serious concern. Nevertheless, adequate time must be allowed for the landing crew to become fully alert and to be suitably briefed to take control of the flight.

Moreover, the best pattern of in-flight rest for any given flight will depend on departure times, whether or not crewmembers are adapted to the departure time zone, and the amount and quality of sleep obtained during prior layovers.

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Notes

1. These definitions were used by the Ultra-long-range Crew Alertness Steering Committee, a safety initiative cosponsored by Airbus, Boeing Commercial Airplanes and the Flight Safety Foundation.

2. This article is based on the technical report titled "Sleep During Ultra-Long Range Flights: A Study of Sleep on Board the [Boeing] 777-200 ER During Rest Opportunities of 7 Hours" by Leigh Signal, Ph.D., Philippa Gander, Ph.D., and Margo van den Berg. The authors are researchers at the Sleep/Wake Research Centre, Massey University, Wellington, New Zealand. This study was funded by Boeing.

3. A typical night's sleep normally involves four cycles or five cycles of brain activity (electrical waves) that include non-rapid-eye-movement (NREM) sleep followed by rapid-eye-movement (REM) sleep. Within NREM sleep, sleep stages can be identified by specific patterns in an electroencephalogram (a visual representation of brain-activity wave forms). Stage-1 sleep lasts for a few seconds to 10 minutes and a person awakened during this stage may not realize that the onset of sleep has occurred. Stage-2 sleep is slightly deeper than stage-1 sleep and lasts between 10 minutes and 45 minutes. Stage-3 sleep and stage-4 sleep comprise the deepest sleep (also called slow wave sleep), which has important restorative properties and growth-inducing properties involved in maintaining general health.

4. Almost all dreaming occurs during REM sleep, which is similar in depth to NREM srtage-2 sleep. Although the body is nearly motionless during REM sleep (except for twitches), the brain is as active or more active than when the person is awake. REM sleep completes each sleep cycle and plays a major role in memory, learning, task performance and mental health.