ARG/US

ASOS Research Brief

Research Request:

Ultra-Long Flight Fatigue Applied to Business Jets

Research Response:

Introduction

Ultra-long range (ULR) flights are defined as those non-stop flights of 16 flight hours duration or more covering 8,000 nautical miles (NM) or more. This flight profile is only available to a few long-haul aircraft that have extreme range capability. Although today's business jets cannot fly an ultra-long single-leg profile, they are capable of approaching this ultra-long range profile with one stop. A two-leg Gulfstream V flight in excess of 16 hours flight hours possess the same pilot fatigue challenges faced by a Boeing 777 crew flying from New York to Singapore. However, ultra-long range airline flights carry four pilots to allow for extended crew rest. The aircraft also contain a built-in crew module rest environment designed to maximize rest period effectiveness. No such extensive features exist in a business jet.

Fatigue - 'Use what we already know'

Observations on the ULR sleep study by Dr. Mark Rosekind :

It is critical that we use what we already know scientifically about fatigue. For example, it represents a significant safety risk, all types of flight operations create fatigue (i.e., short haul, long haul, overnight cargo, on-demand), and there are alertness strategies that have been scientifically validated. Regarding this study, it is important to consider the context that the National Aeronautics and Space Administration (NASA) nap study showed even a brief in-flight rest of only 40 minutes resulted in a 34 percent performance boost and increased alertness 54 percent. In another NASA study of bunk sleep, it was found that sleep obtained in the bunk was not as efficient as home sleep but did result in pilots maintaining their performance throughout long flights.
It is equally critical as technology and operations evolve that we continually increase our knowledge about what is actually happening to alertness, performance, and safety. Hence, the importance of this study. It builds on scientific knowledge that exists, and expands to new challenges associated with ULR operations. The findings and mes-

sages are important: inflight sleep periods improve alertness and performance, they should be planned/scheduled, the landing pilots receive more benefit from a later rest period that boosts alertness and performance closer to the time when a critical phase of operation is undertaken.

Current Guidelines For Duty Time in Business Aviation

The Flight Safety Foundation's (FSF) 1997 report published the results of the Fatigue Countermeasures Task Force's effort to set a standard for the business aviation industry. Their recommendations have been accepted and widely implemented throughout the industry. Additionally, the FSF's Flight Safety Digest (Vol. 24 No. 8-9, August-September 2005) published several studies related to ultra-long range flights in the airline industry. Although not a direct corollary to a business jet flight profile, some similarities allow for comparison.

Extended Flight Time Guidelines (augmented flight crew) [1997 FSF Report]

With additional flight crew and an opportunity to sleep, fatigue would be expected to accumulate more slowly. In such circumstances, flight time can be increased beyond the recommended limit of 10 hours within each 24-hour period. (There are additional guidelines on page 8 of the report.)

Six hour extension: A 16-hour flight time requires a reclining seat for sleep that is separated from the flight deck and passengers.

Eight hour extension: An 18-hour flight time requires adequate sleep facility (permitting a supine position) that is separated and screened from the flight deck and passengers.

No specific empirical data is referenced as the derivation for these standards.

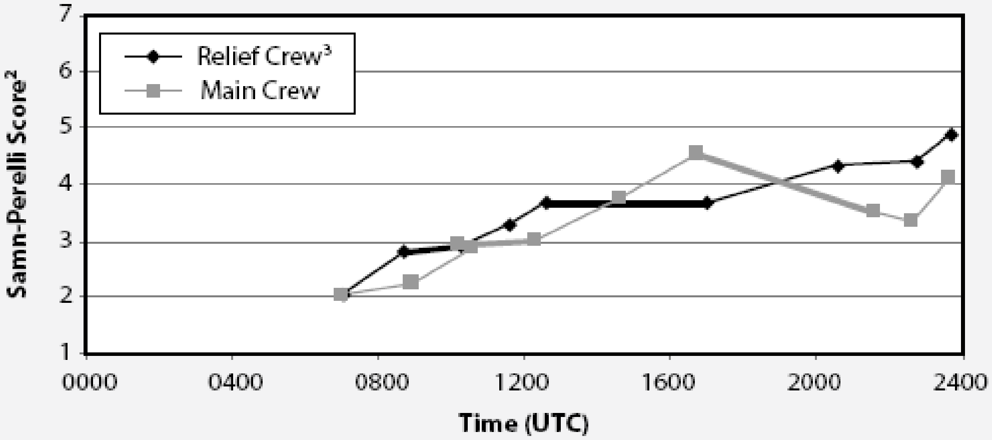
Additional recommendations for Ultra-Long Flights (Singapore Airlines Study)

Each crewmember should be provided with one long sleep opportunity per flight, and to maximize the alertness of the landing crew, the landing-crew pilot should be provided sleep opportunity during 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.
See graphs following.

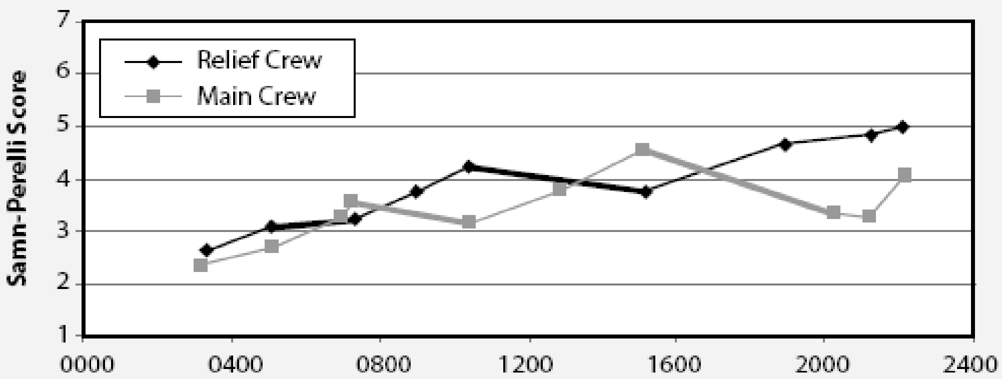
Figure 4

Average Levels of Fatigue Reported by Singapore Airlines Pilots During ULR Flights, 2004[1]

Singapore to Los Angeles, California, U.S.



Los Angeles to Singapore



ULR = Ultra-long range   UTC = Coordinated universal time

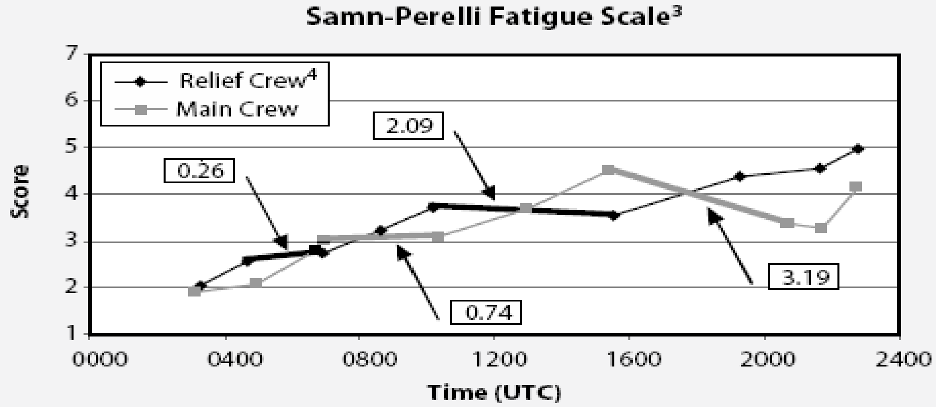
Notes:

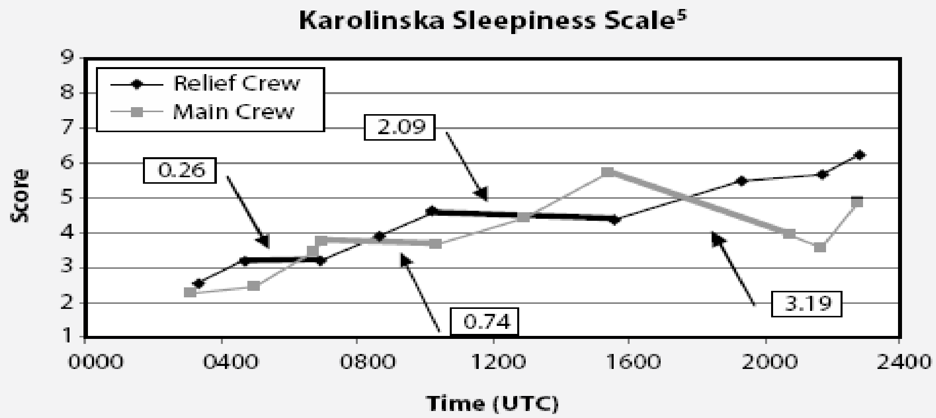
1. ULR flights have planned flight-sector lengths (block times) greater than 16 hours and flight-duty periods from 18 hours to 22 hours in scenarios defined by the ULR Crew Alertness Steering Committee, an initiative cosponsored by Airbus, Boeing Commercial Airplanes and Flight Safety Foundation.
2. Using the Samn-Perelli fatigue scale, study participants rate themselves as 1 (fully alert, wide awake); 2 (very lively, responsive, but not at peak); 3 (OK, somewhat fresh); 4 (a little tired, less than fresh); 5 (moderately tired, let down); 6 (extremely tired, very difficult to concentrate); or 7 (completely exhausted, unable to function effectively).
3. During each sector, one captain (the pilot-in-command of the flight) and one first officer comprise the main crew. Another captain and another first officer, comprising the relief crew, alternate with the main crew in flight deck duty and in obtaining sleep during the precoordinated in-flight rest periods.

Source: Capt. Paul Ho K.C.; Senior First Officer Shane Landsberger; Leigh Signal, Ph.D.; Dr. Jarnail Singh; and Barbara Stone, Ph.D.

Figure 6

Average Levels of Pilot Fatigue and Sleepiness on Singapore Airlines ULR Flights,[1] Singapore to New York, New York, U.S.[2] 2004





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1. ULR flights have planned flight-sector lengths (block times) greater than 16 hours and flight-duty periods from 18 hours to 22 hours in scenarios defined by the ULR Crew Alertness Steering Committee, an initiative cosponsored by Airbus, Boeing Commercial Airplanes and Flight Safety Foundation.
2. Flights to the New York area arrive at Newark (New Jersey) Liberty International Airport. Changi Airport is the home base of Singapore Airlines.
3. Using the Samn-Perelli fatigue scale, study participants rate themselves as 1 (fully alert, wide awake); 2 (very lively, responsive, but not at peak); 3 (OK, somewhat fresh); 4 (a little tired, less than fresh); 5 (moderately tired, let down); 6 (extremely tired, very difficult to concentrate); or 7 (completely exhausted, unable to function effectively).
4. During each sector, one captain (the pilot-in-command of the flight) and one first officer comprise the main crew. Another captain and another first officer, comprising the relief crew, alternate with the main crew in flight deck duty and in obtaining sleep during the precoordinated in-flight rest periods.
5. Based on subjective responses to a questionnaire, the Karolinska Sleepiness Scale rates each study participant from 1 (very alert) to 9 (extremely sleepy); this standardized tool is used by sleep researchers worldwide and can be correlated with objective measures of sleepiness.

Source: Capt. Paul Ho K.C.; Senior First Officer Shane Landsberger; Leigh Signal, Ph.D.; Dr. Jarnail Singh; and Barbara Stone, Ph.D.

Sleep/Wake Research Center Report (2003, Massey University, New Zealand)

Results in brief:

Crewmembers who slept later in the flight were more alert during their final 50 minutes of duty. The policy implication is evident: *the landing crew should have the second sleep opportunity.* Since the amount and quality of sleep pilots are able to obtain on board is an important aspect of safe ULR flights, the study's ancillary findings are important:

* Sleep in a bunk during flight was not as efficient as layover sleep. The efficiency of the pre-departure sleep was judged some 89 percent, as measured by the time actually asleep in comparison to the time spent trying to sleep. Bunk sleep during flight was judged about 70 percent efficient. Volunteer crewmembers averaged seven hours of layover sleep. Although crewmembers were asked to spend as much of their in-flight rest period as possible trying to sleep, no-one spent seven hours trying to sleep. On average, the test pilots spent 4.69 hours trying to sleep, in which an average of 3.27 hours was scored as sleep.
* Sleep later in the flight was longer and of higher quality than early in the flight. Even after controlling for age and the individual's "sleep deficit" before the flight, those scheduled for rest later in the flight got more sleep. As measured by awakenings longer than 60 seconds, the pilots from the second rest period also slept more soundly (although variations in rapid eye movement, or REM, and other measures of sleep "quality" were not statistically significant).
* Pilots who slept later in the flight were more alert than those who slept earlier.
* The amount and quality of sleep in the bunk was unrelated to the amount of layover sleep before the flight. This finding suggests that purposely restricting pre-departure sleep to improve sleep on board is not advisable.
* Older crewmembers got less sleep than younger crewmembers, which is consistent with changes in human sleep patterns that start to appear at about 50 years of age. In fact, the subject's age was the most dominant factor affecting bunk sleep.

The sleep trials were conducted during delivery flights, not on regular revenue flights, which would be part of a more complex sequence of back-to-back flights, and where varying noises associated with meal service and passenger activity could impair the resting crewmember's ability to sleep.

Leigh added, "The findings [in the report] apply to flights with similar departure times. As explained in the [report] introduction, our body clock is important in determining when we can sleep most easily. The flights [we studied] departed Seattle around midday local time, and this will have an impact on sleep quantity and quality in flight."

Synopsis

Ultra-long flights demand fatigue management. Although business jets are incapable of flying a single leg ultra-long flight, their performance allows for an ultra-long profile with one fuel stop. Lessons can be drawn from the studies and standards associated with long range airline flights, and reasonable conclusions derived. These studies indicate even in the most optimum rest conditions, fatigue accumulates and accelerates approaching the 18th hour of flight time, in spite of previous available rest periods. Proximal rest for the landing crew was also identified as an important tactic to increase alertness during the critical landing phase.

Because of the complex nature of the factors that contribute to fatigue, no one solution for fatigue prevention in the aviation industry exists. Therefore, fatigue management systems cannot simply replace flight and duty time limits.

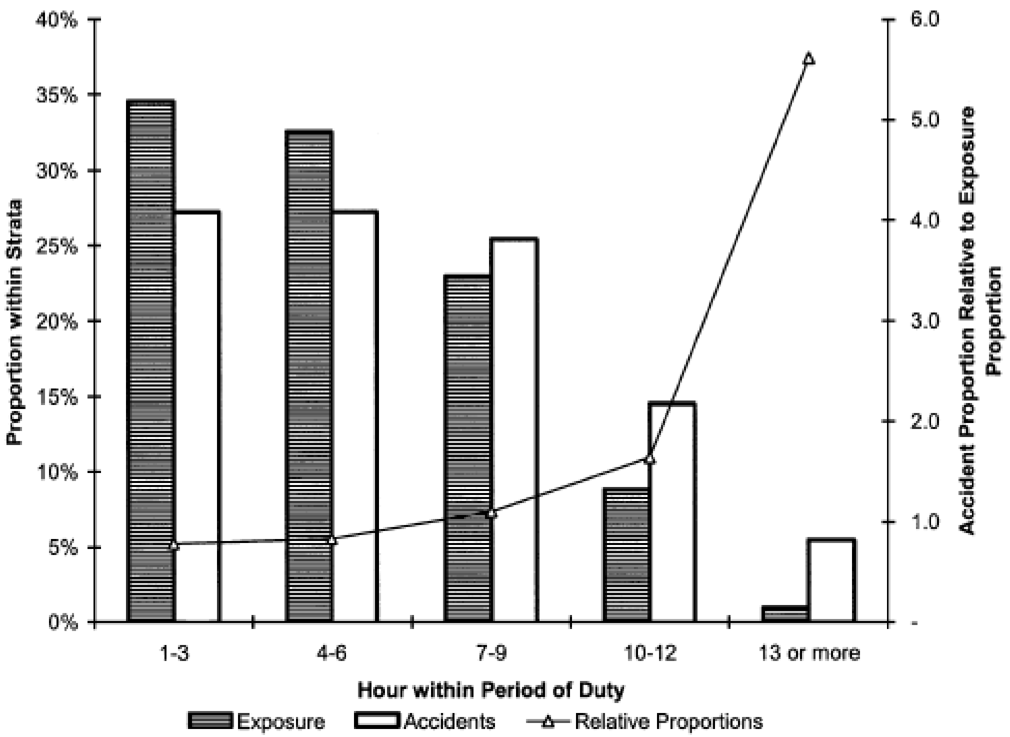

Fig. 1. Captains' duty hours and accidents by length of duty.

Source: J.H. Goode, National Safety Council, 2003