EFFECTS OF NOCTURNAL AIRCRAFT NOISE
OVERVIEW OF THE DLR HUMAN SPECIFIC INVESTIGATIONS

A. Samel, M. Basner, H. Buess, N. Luks, H. Maaß, L. Mawet, E.W. Müller, U. Müller, C. Piehler, G. Plath, J. Quehl, E. Rey, M. Schulze, M. Vejvoda, J. Wenzel
DLR-Institute of Aerospace Medicine, Germany

Introduction The steady increments of air traffic volume in the past are very likely to continue in the future. The noise sensitivity of residents living close to airports has increased simultaneously. Studies on human specific influences of aircraft noise with large numbers of subjects as well as a high methodological expense are lacking, and hence statistically reliable recommendations for the protection against aircraft noise cannot be made in the present. However, scientific investigations are necessary in order to provide proper guidelines for authorities and users, and technical advances for noise abatement procedures. Therefore, the DLR-Institute of Aerospace Medicine has been investigating the influence of nocturnal aircraft noise on sleep, subjective well-being and performance since 1999. These investigations are performed within the frame of the DLR project "Quiet Air Traffic" in which a catalogue of different measures is developed to reduce aircraft noise.

Methods The human specific reactions to nocturnal aircraft noise are studied in laboratory and field experiments (i.e. at the subjects´ homes). In total, 192 healthy volunteers undergo about 2300 study nights during these studies. The first group of 32 subjects was studied in 1999, the second in 2000 and the third in 2001, followed the last group of 32 volunteers in 2003. The age of the subjects (males and females) was between 18 and 65 years. In the isolation facility of the institute, 128 subjects were examined for 13 consecutive nights. 16 subjects served as control, i.e., they did not receive any aircraft noise. For the other 112 subjects, aircraft noise events have been played back between 4 and 128 times per night with maximum sound pressure levels between 50 and 80 dB(A). This corresponds to an equivalent sound pressure level between 30 and 53 dB(A) within the interval of eight hours of sleep. Occurrences of sleep disturbances (primary effects of aircraft noise) are assessed by electrophysiological parameters containing the electro-encephalogram (EEG), electro-oculogram (EOG), electro-myogram (EMG) and electro-cardiogram (ECG), respiration, finger pulse amplitude and position in bed. These signals have been recorded together simultaneously with the acoustic data in order to calculate event-correlated reactions. As possible secondary effects of aircraft noise on sleep, the concentration of stress hormones (cortisol, epinephrine and norepinephrine) were determined from all night urine samples. Furthermore, 24-h recordings of subjects´ activity, several computerized performance tests in the evening and in the morning were conducted, as well as questionnaires were applied with respect to fatigue, well-being, mood and annoyance.

Results This and the following reports represent a partial analysis of the first two (or three) laboratory studies derived from 64 (96) volunteers and 832 (1248) study nights (including the 16 subjects who served as control group). Results from the different disciplines will be presented in separate presentations. Whether data of 64 or 96 subjects are presented, depends on the status of the analysis of the different parameters investigated. The data and results acquired in the laboratory will be validated in two field studies consisting of 64 volunteers who are being observed during 9 consecutive nights at their homes near Cologne airport. This airport is ranked second in Germany with respect to nocturnal air traffic. The field studies

commenced in September 2001 and finished in November 2002. The fourth laboratory investigation (with another 32 subjects) takes place between March and June 2003. In this final laboratory study, results from the field studies will be considered. It is planned that the main results of all laboratory experiments and field studies will be available by the end of 2003.
The results of the two laboratory studies (64 subjects, 832 study nights) in summary show that primary effects of nocturnal aircraft noise on sleep are as follows (all nights combined) [1]: Significant differences between control and noise nights were detected with respect to a reduction of slow-wave-sleep and an increase of stage-1 sleep during noisy nights. Total sleep time, wake time after sleep onset, REM sleep and stage-2 sleep did not change significantly.
The results of the investigation of secondary effects, analyzed from data of three laboratory studies (96 subjects, 1248 investigated nights) in summary indicate that some, but not all functions were affected by aircraft noise during sleep (all nights combined): With respect to the computerized performance tests applied in the morning, one (out of four) test showed a small, significant increase of response times. The other tests (and all tests applied in the evening) did not alter between the two conditions. Concerning the data of stress hormones, the findings of the three laboratory studies suggest that catecholamine excretion rates did not alter during noisy nights; cortisol excretion rates showed weak changes the clinical relevance of which has to be discussed. Annoyance data analysis support the conclusion that the number of aircraft events as well as the maximum noise levels influence the annoyance occurring from aircraft noise exposure during sleep.
Both, the detected (and also the not observed) primary and the secondary effects found in the two (or three) laboratory studies have to be validated by the field investigations. Therefore, final conclusions will not be drawn at this time.
In addition, a comparison between the laboratory and field studies indicate that with respect to the acoustical environment – as expected – considerable differences were observed between the two acoustical conditions. With respect to the $L_{AS,eq(3)}$, the in-door noise level applied in some laboratory nights was higher than observed in the field.
Detailed analysis of the different parameters will be presented in additional presentations during this congress.

Discussion These series of investigations, which are using identical methods concerning the standard electrophysiological recordings of sleep, additional measurements of stress hormones, of performance and of subjective ratings, are very ambitious and unique, even compared to a world wide standard. By an exceptional database and with conclusive results, DLR wants to contribute by profound experimental knowledge to the very controversial disputes about the degree of impairing effects on human specific reactions to nocturnal aircraft noise. The entire project will be completed at the end of the year 2003, therefore, final conclusions can earliest be presented at that time.

Keywords: aircraft, noise, acoustic, sleep, stress hormones, performance, annoyance, fatigue

References

[1] Basner, M. el al. (2001) Nachtfluglärmwirkungen – eine Teilauswertung von 64 Versuchspersonen in 832 Schlaflabornächten [Effects of nocturnal aircraft noise – preliminary results based on 64 subjects and 832 laboratory nights]. DLR-Forschungsbericht 2001-26, Institut für Luft- und Raumfahrtmedizin, Köln.