The potential of mostly non-acoustic factors to reduce and better predict long-term aircraft noise annoyance - examples from three European airports assessed in telephone interviews and field studies – Results of the COSMA Study

U. Müller, S. Bartels

German Aerospace Center (DLR), Linder Höhe, 51147 Köln, GERMANY, uwe.mueller@dlr.de

ABSTRACT

Studies on aircraft noise around airports in the last 20 years in general show a higher percentage of highly annoyed residents for a given day-night average sound level DNL than can be derived from the current EU dose response relationship which is mainly based on numerous studies from the 1970s and 80s. In particular, these newer studies imply that there is not one curve which is valid for all kind of airports as well as that the percentage of DNL explaining variance in the annoyance ratings is decreasing and mostly non-acoustical factors become more and more important.
One aim of the EU-project COSMA (Community Oriented Solutions to Minimize aircraft noise Annoyance) was to identify commonalities of the most important non-acoustic factors contributing to aircraft noise annoyance around three different important European airports (London Heathrow, Cologne/Bonn, Stockholm Arlanda) and therewith prepare further studies aiming at updating and more differentiating the current EU dose response relationship. Therefore around 1.200 residents were interviewed by telephone as well as 50 residents at each airport were supervised four consecutive days including continuous sound pressure level recordings and hourly annoyance ratings. The results show that working on other, mostly non-acoustic, influential factors possibly carry a higher potential to reduce aircraft noise annoyance in the medium term than acoustic factors are able to do due to long-term technical implementation times.

INTRODUCTION

Forecasts about future air traffic development expect a yearly increase of aircraft movements from roughly 2 – 7 % until 2030 whereas the highest growth rates are expected for Asia and the Middle East, the lowest for North America and Europe (ICAO, 2013). Due to considerable cutbacks in jet and airframe noise within the last decades (Neise & Enghardt, 2003; Dobrzynski, 2010) but also by means of improved noise abatement procedures, the aircraft noise of a single overflight has distinctly decreased. However, the number of aircraft movements increased to such an extent that day-night average sound levels DNL around airports in general did not vary too much in the last 20 years.

The current officially used exposure-response curves for calculating the percentage of highly annoyed residents around airports e.g. for the EU and the US are primarily based on meta-analyses of studies that were mainly performed in the 1970's and 80's (Miedema & Vos, 1999), (Miedema & Oudshoorn, 2001), (Schultz, 1978), (Fidell, Barber & Schultz, 1991). Newer e.g. European studies from the 1990's and early 2000's (van Kempen & van Kamp, 2005; Brink et al., 2008), however, show that in general there are considerably more people highly annoyed at the same DNL around European airports than predicted by the so-called EU-curve based on the Miedema meta-analysis.

This general tendency suggests that other possible acoustical features of airport noise scenarios as e.g. the number of aircraft movements or the repose period among noise events, that are not taken into account by the DNL, could be annoyance-relevant. Moreover, the variance among the exposure-response curves of these newer studies could also lead to the conclusion that in addition to the pure physical noise load also other influential, mostly non-acoustic, factors contribute to the annoyance judgment. Although e.g. Guski already stated in 1999 (Guski, 1999) that at best just one third of the variance of annoyance reactions can be explained by the variance of acoustical features, official exposure-response curves still merely depend on the DNL. Recently attempts were made to consider these non-DNL related effects in exposure-response curves, which are airport dependent, by introducing a so-called Community Tolerance Level (CTL) which provides a value in decibel units that characterizes community level differences in reactions to transportation noise exposure (Fidell et. al., 2011). The CTL alone, however, without further analysis of data that reveal the reasons for these distinctions in annoyance ratings at different airports is not sufficient in order to minimize effects of non-DNL related factors on the prevalence of annoyance.

Especially in the usually dense-populated areas of industrialized countries the number of highly annoyed airport residents due to aircraft noise is increasing, often coming along with massive protests. A further airport development with the construction of new runways becomes extremely difficult as current examples of planning a possible third and/or fourth runway in Heathrow (UK), the new already operated runway in Frankfurt (GER) or a potential expansion of Munich airport (GER), protests at Newark airport (US) or opposition against planned airports in Nantes (F) and Sydney (AUS) prove. For the balance of interests between airport residents and the aviation industry and their stakeholders, policy-makers more and more need up-to-date and airport-specific information about all factors that constitute aircraft noise annoyance in the situation considered. Reducing the aircraft noise load has definitely still to be the first measure to take. With aircraft life cycles of 20-25 years, however, normally it takes a substantial amount of time until noise reducing technologies at the source are established. In addition, steeper departure and approach procedures can lead to a reduction and a reallocation of the noise load as well as to changes in the perceived aircraft sound quality in certain areas. More research is needed on that issue.

Other influential factors contributing to aircraft noise annoyance can be roughly subsumed in the following categories (Guski, 1999): Personal and social factors as sensitivity to noise, fear of harm connected with the source, evaluation of the source or capacity to cope with noise; Trust or misfeasance with source authorities,

expectations of residents, history of noise exposure. Certainly some of these factors as e.g. the personal noise sensitivity cannot be altered in a program aiming at reducing the annoyance around airports by balancing interests. It seems though that there are still a number of measures that potentially could help but are not systematically studied yet.

METHODS AND RESULTS OVERVIEW

One main aim of the EC-funded project COSMA (Community Oriented Solutions to Minimize aircraft noise Annoyance, 2009-2013) (Bauer et al., 2010) was to identify and better understand the main today's effective influential factors at three different European airports that determine aircraft noise annoyance. Selected airports were London Heathrow LHR as one of Europe's biggest hubs with around 480,000 movements per year, Stockholm Arlanda ARL as the most important Nordic International airport but with just half of the movements of LHR and Cologne/Bonn airport CGN with heavy nocturnal traffic up to 120 movements /night but in total just a fourth of LHR's movements. COSMA aimed amongst others at preparing further studies to update and differentiate exposure – response relationships for aircraft noise annoyance and sound the potential effect of non-acoustic factors to better predict long-term aircraft noise annoyance.

Around 1.200 telephone interviews each were performed at the three airports. The whole interview consisted of in maximum 43 questions. Interviewees were selected from six different noise areas around the airports by means of public telephone directories (for more detailed information see (Bartels et al., 2013), more publications in preparation). These telephone studies were followed by field surveys in those areas with the highest aircraft noise load at the three airports. Main focus of these surveys was the contribution of the hourly annoyance to the long-term annoyance. 50 subjects each hourly rated the annoyance for the previous hour during 4 days in daytime and documented the then performed activities. The sound pressure level was continuously measured day and night outside the house. Damping characteristics determined for different rooms and window positions were considered. An even more extended questionnaire than in the telephone studies was used at the beginning and the end of the study period to gain more information about the effective (mostly non-acoustical) factors further than the DNL contributing to long-term annoyance at the three study airports (for more detailed information see (Griefahn et al., 2013), more publications in preparation).

The applied questionnaires in the telephone and field studies covered most currently known influences that determine the annoyance judgment. They can be divided in the following groups:

- demographic variables (age, gender, education, employment, house ownership, occupancy)
- personal noise sensitivity
- attitude towards residential area (satisfaction, advantages and disadvantages)
- presence of additional noise sources
- satisfaction with noise insulation
- most annoying hours due to aircraft noise per day (weekdays/weekends)

- disturbed activities indoors, outdoors, during sleep because of aircraft noise
- applied coping measures
- attitude towards the airport
- estimation of environmental/economic aspects of air traffic
- link to airport/air traffic (employment, number of private and business air trips)
- perceived predictability of aircraft noise
- expectations of future air traffic at the local airport
- expectations of getting used to aircraft noise
- attitude towards communication policy of airport authorities concerning aircraft noise/perceived fairness of noise authorities
- estimation of possible health effects of aircraft noise (only in field study)

Due to the continuous sound pressure level recordings outdoors in the field studies during the four examination days, it was possible to calculate a real bulk of 40 acoustic variables and consider them for a correlation model to predict aircraft noise annoyance at all three airports that was assessed by means of the ICBEN question (Fields et al., 2001). In the end just the number of aircraft AC, the number above threshold NAT55, NAT60, the total AC exposition time and the mean time distance among AC significantly contributed to the statistical model for all three airports. For CGN and ARL with distinctly lower noise background levels than LHR also the NAT65 and NAT70 as well as the total equivalent continuous sound pressure level L_{AEQ} were significant. These results are in line with many previous studies and emphasize that there are presumably no additional, more sophisticated acoustic parameters that could improve the analysis of variance in annoyance judgments. Both the results of the field as well as of the telephone studies ($L_{AEQ\ Day\ and\ Night}$ – Levels in 5 dB-steps were available) show for CGN that just less than 20 % of the variations in the ratings for long-term aircraft noise annoyance are explained by these acoustic variables.

The air traffic scenarios at the three study airports as well as the background noise were considerably different. So it is not astonishing that differences between the airports can also be seen in other factors influencing annoyance judgments. E.g. the results in the categories ‘very negative’ and ‘rather negative attitude towards the airport’ vary from 4% (ARL) to 17% (LHR), ‘very and rather positive attitudes’ from 45 % (LHR) to 81% (ARL). However, in a first approach how to consider these other influential factors in predicting the number of highly annoyed residents around airports, it is reasonable to summarize the commonalities that could have been found in the COSMA telephone and field studies (Bartels et al., 2013), (Griefahn et al., 2013), (more publications are in preparation). Although odd ratios and rank orders of these factors varied in the analysis for the different study airports, it can be concluded that:

<u>the following influences **enhanced** long-term annoyance around the study airports:</u>

- annoyance at night or in early/ late hours of the day
- disturbed mental work or relaxation
- noise felt as a health hazard
- coping measures necessary
- personal noise sensitivity

the following influences **reduced** long-term annoyance around the study airports:

- feeling fairly treated by airport authorities
- believe in getting used to aircraft noise in the future
- believe that the airport is economically important
- satisfaction with noise insulation
- satisfaction with residential area

Including these other influential factors in the prediction model, 55% of the variance in the annoyance ratings could be explained for CGN. This shows the importance of these other than acoustical factors. The annoyance situation around airports cannot sufficiently be described without taking them into account.

CONCLUSIONS AND OUTLOOK

In many dense-populated areas around existing or planned airports in industrialized countries protests of residents against aircraft noise increase. A fair and transparent balance of interests is needed between profiteers of air traffic and disadvantaged airport residents in order to ensure that an increase of aircraft movements will also be feasible in the future.

Those policy-makers that organize such a balancing process must be independent and their procedure has to be transparent. For their activities they need as detailed information as possible about the current and planned future aircraft noise situation at the airport considered. Present exposure-response curves representing the number of highly annoyed airport residents as they are in use in the EU and the US are definitely not satisfactory for such a process. There is not one curve that represents the annoyance situation around all airports. It should be reviewed in future studies if a clustering of different kinds of airports (e.g. international hubs, regional airports, airports with significant night traffic, steady-state airports, airports in change situations etc.) and the establishment of exposure-response curves for those cluster airports could be a feasible solution in order to avoid to assess every single airport.

Future exposure-response curves also have to consider other annoyance-influencing factors than just the physical aircraft noise load. Reducing aircraft noise emissions as best as possible definitely has still to be the first measure to take and is effective at every airport. But with at least the same power these other mostly non-acoustic factors in addition bear the possibility to reduce aircraft noise annoyance in shorter time periods than this could be achieved with developing new noise reducing breakthrough technologies and implementing them in typical aircraft life cycles of 20-25 years.

The ranking of importance of these factors, however, may differ from airport to airport. But the COSMA studies indicate that there are some that presumably matter at every airport. Based on these results, future studies at selected cluster airports should start concentrating on understanding the underlying effects of annoyance reactions at night or in early/late hours of the day, residents' attitude towards possible health

hazards and examinations about their satisfaction with the installed noise insulation. Is it e.g. important to guarantee for day and night in at least one room each of the airport residents' homes that they always can retire from aircraft noise if they wish to? For a further discussion see (Bartels et al., 2013).

Although most scientific findings about possible noise health hazards show moderate positive correlations, an improved data basis is needed in order to have clearer evidences for informing the airport residents as well as to get better conceptions about how to effectively prevent possible aircraft noise health hazards.

A highly striking influential factor that contributes to the annoyance ratings is the trust of the residents in airport and public authorities. To minimize annoyance due to this factor it is inevitable that there is an always comprehensive, transparent and understandable communication policy about all aircraft noise activities that concern the airport residents. Due to possibly poor experiences in the previous times and resulting hardened positions on both sides, at many airports it might not be feasible to start such a communication process by its own. Independent agencies specialized in mediation processes and with a necessary broad background knowledge about all aspects of aircraft noise could assist. As part of this process, also the establishment of focus groups could help to get an improved understanding especially for the very local aspects of the aircraft noise problem. Focus groups might be a good completion to conventional forms of surveys.

The perception of airport residents of being fairly treated by the authorities might comprise at least two important aspects of the aircraft noise problem, a financial and a participation one. Do airport residents feel that they have to suffer the noise burden whereas others make money with it? At some airports singular compensation payments are possible for potential property value losses. In future studies it would be interesting to understand if yearly paid reasonable compensations for the noise burden of airport residents, financed e.g. by moderate increases of passenger ticket prices, could improve residents' acceptance of aircraft noise. Another interesting question of this aspect is also the problem if or in how far airport residents can be involved in very complex decision making processes like the fixing of flight paths or the time schedule for alternating runway use.

Especially at airports with already conceivable changing future air traffic, residents normally cannot assess how the aircraft noise load will change in the future in their house or garden. That alienates them and therewith they are considerably more annoyed. Meanwhile techniques establish (e.g. 3D-glasses with headphones) that can visually and acoustically simulate todays and future air traffic for a certain airport in different home contexts. Could such a tool help residents in the future to better assess and compare their todays and future noise load by reason of air traffic and therefore reduce annoyance effects due to uncertainty?

Some of the results of the above proposed future studies can be culturally biased and might not be straightly transferable to other countries. However, international cooperation in this field is strictly recommended because the assessment of humans' perception in the noise context and the emergence of attitudes is rather complex so

that just the depth of various studies dealing with different aspects of the aircraft noise problem can succeed in getting a better understanding of it.

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