

Noise respite at Frankfurt Airport

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ABSTRACT

Frankfurt Airport is the largest airport in Germany, and has been the subject of considerable debate about aircraft noise issues for many years. A six hour ban on scheduled night flights was imposed in November 2015, almost at the same time as the opening of the new fourth runway. In April 2015, as a one year trial, the night cut-off time was brought forward by one hour in the late evening period in certain areas around the airport, and extended by one hour in the early morning period in other areas to provide a seven hours night curfew in those areas by re-distributing the shoulder hours approaching traffic between three of the four runways - the so-called '*Lärmpausen*' project (noise respite). This extended the night curfew in affected areas but also contributed to an increase in shoulder hours traffic in other areas. The trial was monitored operationally, acoustically and perceptually. The perceptual monitoring included focus groups and a cross-sectional telephone survey with 1533 residents from areas that experience decreases in shoulder hours traffic, increases in shoulder hours traffic, or are not at all affected by the re-distributed operation of the runways. The main results of the survey on residents' perceptions of the project are presented in this paper.

Keywords: Aircraft noise, noise abatement, noise respite, annoyance
I-INCE Classification of Subjects Number(s): 63.2, 63.4, 66.2, 68.5

1. INTRODUCTION

Transportation noise in the Rhine Main Area around Frankfurt Airport and its impact on noise annoyance and health on/for the population has been the subject of considerable debate for many years. In the recently conducted NORAH study it was shown that reported noise annoyance can be quite high in certain areas in the vicinity of Frankfurt Airport, and that at least some of this annoyance can be associated with the bringing into use of the new fourth runway, 'runway Northwest (NW)', in October 2011 (1).

Since 2008, noise relief for the exposed population has been a central assignment of the Regional dialogue forum (RDF) of the Forum Airport and Region (FFR). With the opening of the new NW runway in November 2011, a complete ban was imposed on scheduled night flights from 11 pm to 5 am. This provides six hours noise respite in all areas around the airport. From April 2015 till March 2016 a new concept for the use of runways was applied as a pilot for one year – the so-called '*Lärmpausen*' (noise respite). The plan for westerly operations was to concentrate arrivals alternately onto selected runways during the shoulder hours from 10-11 pm and 5 – 6 am in order to grant different residential areas an extra hour of respite at night in the early morning or late evening in addition to the existing core respite period from 11 pm to 5 am. The implemented noise respite is the realization of one of five calculated noise respite models that were developed by the Hessian Ministry for Economy, Power, Transport and State Development (HMWVEL) and the FFR. It stipulates that from 10 to 11 pm there are no scheduled landings on the northwest runway (25R) and the center runway (25C). In the mornings from 5 to 6 am no scheduled landings occur on the south runway (25L), see Figure 1.

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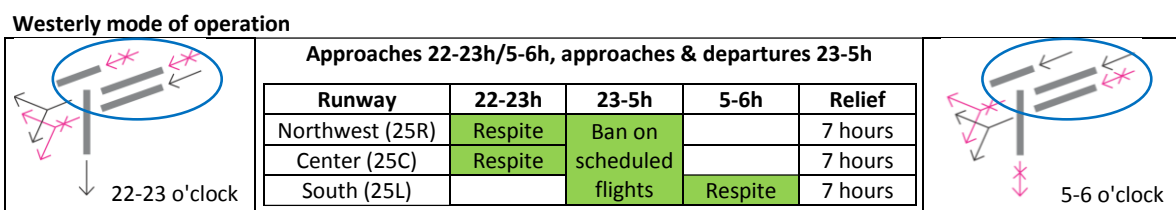


Figure 1 - Noise respite model 'Lärmpausen'.

This concept of noise respite seeks to distribute the noise, i.e. it results in local decreases in aircraft noise exposure in certain areas in the evening and in other areas in the morning but there are associated increases in aircraft noise in certain other areas. The criterion of 'noise respite' underlying this concept was defined as the 6*NA₅₈-aircraft noise contour (six or more aircraft noise events with $L_{pAmax} \geq 58$ dB, NA₅₈ ≥ 6 within the defined time period). Extensive modelling showed that, according to this criterion, the number of residents likely to benefit from an extra hour of noise respite either in the late evening or the early morning periods would exceed the number of residents likely to experience an increase in aircraft noise events during those periods.

According to the categorization of environmental noise interventions by Brown and van Kamp (3) the implementation of the *Lärmpausen* operation mode from 10 to 11 pm and from 5 to 6 am as well as the night curfew from 11 pm to 5 am belongs to the intervention Type A (source intervention, time restrictions on source operations).

The one-year pilot of the *Lärmpausen* operation from April 2015 to March 2016 was accompanied by three different monitorings, (i) monitoring operations, (ii) monitoring the acoustical impact and (iii) 'perception monitoring', i.e. monitoring the perception and acceptance of the noise respite operation among the exposed residents. This paper refers to the latter, perception monitoring. The authors were commissioned by the Environment & Community Center that is an organizational unit of the dialogue forum FFR in the summer of 2015, after the start of the noise respite pilot. This means that the study presented here was not able to compare the before and after situations directly. Instead, the study aims at reflecting how residents perceive air traffic in the shoulder hours of the night, whether they have recognized any change in flight movements and how annoyed and disturbed they are due to aircraft noise within the previous six months (since the start of the *Lärmpausen* operation). There is a particular interest in whether there are differences in perception between groups of residents from areas that were expected to be affected differently by the *Lärmpausen* operation mode.

2. METHODS

2.1. Procedure and sample

The perception monitoring consisted of two parts: qualitative research based on focus groups and a quantitative telephone survey using a standardized questionnaire.

In the qualitative part of the study eight focus groups with a combined total of 85 residents from four communities around Frankfurt Airport, Frankfurt, Hanau, Neu-Isenburg, and Offenbach, were carried out. Two of the focus groups were conducted with residents engaged in action groups, one in favor of the airport and one against aircraft noise. Each of seven focus groups was conducted with 11 to 12 participants, one focus group was conducted with six participants. The participants from Frankfurt (2 focus groups) were expected to experience some noise relief when the *Lärmpausen* operation mode would be running, the focus group members from Offenbach (2 groups) and Neu-Isenburg (1 group) were expected to experience either relief or additional burden due to the *Lärmpausen* operation. The participants from Hanau (1 focus group) were expected to experience additional burden due to the *Lärmpausen* operation. The adult participants of the focus group were sampled following a quota method which allows for a wide range in the distribution of age, education, occupation, household with/without children and house ownership. The duration of each focus group discussion was 2 hours.

The telephone survey was carried out in the region around Frankfurt Airport. Within the study area the sampling of participants was done by clustering noise respite groups due to the effects of the *Lärmpausen* operation mode in the shoulder hours 10-11 pm and 5 – 6 am. Five noise respite groups were defined (Figure 2): One group for whom the evening burden was lessened during *Lärmpausen* operation mode (1: 'Evening relief'), one group for whom the morning burden was lessened (2: 'Morn-

ing relief'), one group that experienced an additional burden in the evening (4: 'Evening burden'), one that experienced an additional burden in the morning (5: 'Morning burden') and finally one control group that experienced no change during the peripheral hours as a result of the *Lärmpausen* operation mode (3: 'No change (control group)').

Noise maps depicting NA_{58} -contours were linked to official geo-coordinates of all dwellings in the overall study area to define the sampling areas. Within each noise respite group households were sampled by random on the basis of phone registers. Within each sampled household the person to be interviewed was selected by random by means of the last-birthday method. The telephone interviews were carried out during four weeks from October to November 2015.

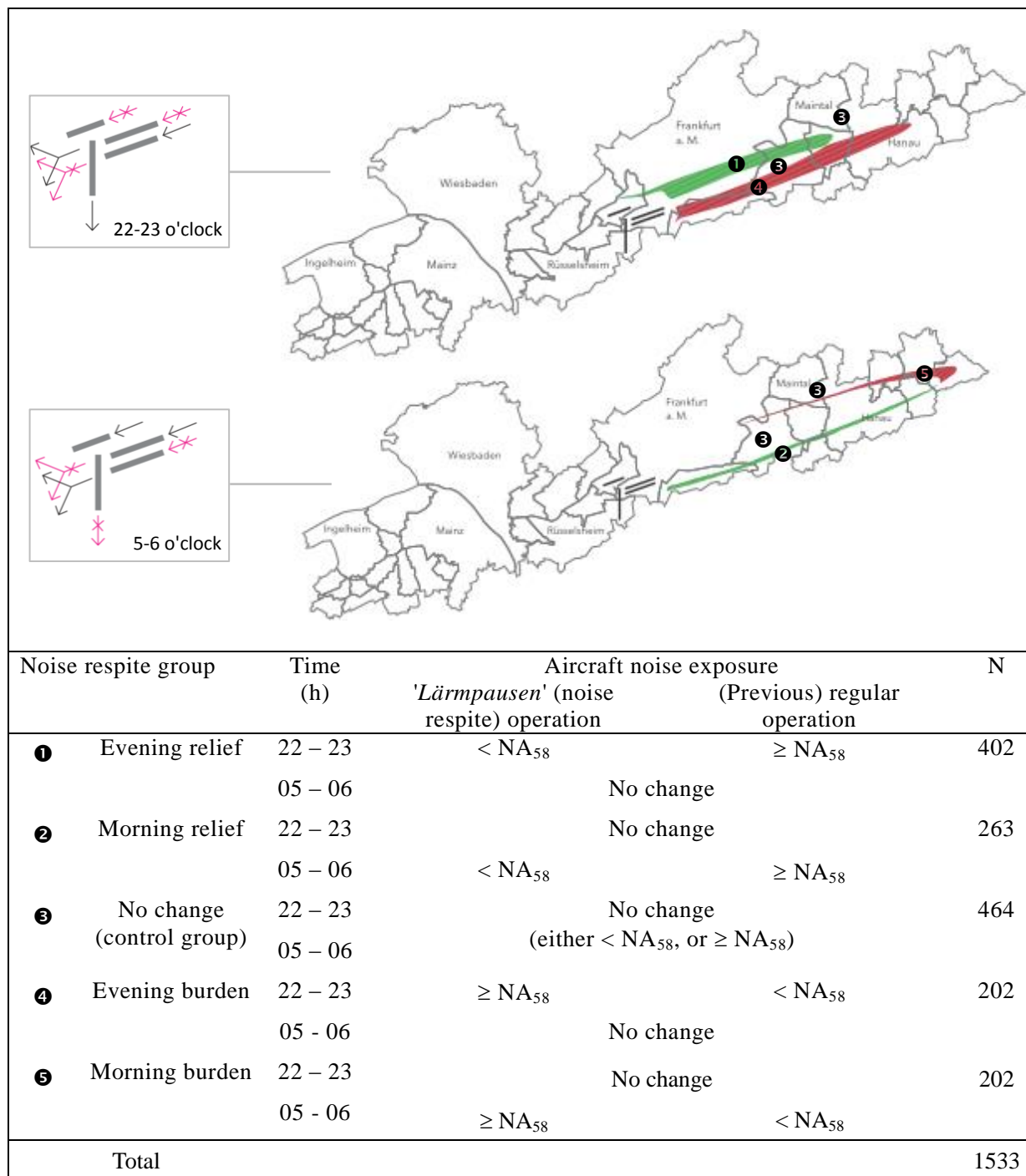


Figure 2 – Noise respite groups in telephone survey

A total of 1604 persons were interviewed, 71 persons were not eligible as their home address did not belong to one of the five pre-defined area groups. Thus, data from 1533 participants were used for the data analysis. This paper focuses on results of the telephone survey with some references to main results of the focus groups. The main assumption underlying the data analysis is that, if the *Lärmpausen* operation mode leads to noticeable noise respite, mean responses of the five noise respite groups would reflect group differences in opinion in terms of the different distributions of aircraft noise events in the late evening and early morning shoulder hours.

2.2. Questionnaire of the telephone survey

The telephone survey was introduced as an interview survey on the perception of aircraft noise in the region. The questionnaire used included questions to noise annoyance and sleep disturbances due to aircraft noise (when falling asleep, during the night, in the early morning), general residential conditions, self-reported noise sensitivity (1-item self-assessment), and trust in willingness of authorities to reduce aircraft noise in residential areas (4 items, Cronbach's α for aggregated mean score = .892). Annoyance and items of sleep disturbances were assessed with the standard 5-point response scale as recommended by ISO/TS 15666 (4). Noise sensitivity and items of trust in authorities were also assessed using a 5-point response scale (1 = low; 5 = high degree of intensity of the respective disposition or attitude).

New questions on the perception of air traffic and aircraft noise in the shoulder hours from 10 – 11 pm and 5 – 6 am were developed for this survey. Four items were aggregated to a mean score of perception of relief in the late evening, 10 – 11 pm (Cronbach's α = .755). Four respective items were aggregated to a mean score of perception of relief in the early morning, 5 – 6 pm (Cronbach's α = .798).

Additional questions were included on awareness and evaluation of the *Lärmpausen* operations, among them eight items aggregated to a mean score of positive evaluation of *Lärmpausen* (Cronbach's α = .819). Questions on information about the noise respite concept and the possibility to mention own suggestions for noise abatement measures were also included. Finally, standard questions on socio-demographic variables such as age, gender, education, occupation, and income came at the end. Education, occupation, and income were aggregated in a combined index of socio-economic status (SES, 5, 6).

2.3. Aircraft noise exposure

For the home address of each participant of the telephone survey the continuous sound level for aircraft noise at daytime ($L_{pAeq,06-22h}$) and night-time $L_{pAeq,22-06}$ of the six busiest months of the year 2014 (before the start of noise respite intervention) was available. The sound levels were estimated by the customer, the Hessian Environment and Community Center using the German calculation method for aircraft noise AzB 2008 (7). Address-related acoustical parameters for the period of the *Lärmpausen* operation pilot were not available. However, results of the operational and acoustical monitoring regarding the use of runways in the hours 10 to 11pm and 5 to 6am and the comparison of hourly average sound levels $L_{pAeq,1h}$ in these shoulder hours for westerly operation mode over the six busiest months of 2013 and 2015 was used to estimate changes in noise exposure. The assessment of the hourly average sound levels was based on data obtained from noise measurement stations in the vicinity of the study areas before (2013) and during (2015) the implementation of the *Lärmpausen* trial.

3. RESULTS

3.1. Sample characteristics

The statistical analysis is based on the data from the 1533 participants included in the defined study areas. The noise respite groups did not differ in the distribution of the variables age, sex, nationality and occupation associated with the airport, while there were of course, significant differences in the continuous sound level L_{pAeq} for daytime and night-time (referred to 2014, before implementation of the *Lärmpausen* operation mode), socio-economic status (SES) and differences in self-reported noise sensitivity (see Table 1). Because average sound levels, SES, and noise sensitivity also correlate with the core variables of interest (noise annoyance, sleep disturbances, perception of air traffic in the shoulder hours, perception of the noise respite) further analyses were adjusted for continuous sound level $L_{pAeq,06-22h}$, SES and noise sensitivity. The L_{pAeq} for daytime (6 am to 10 pm) was chosen for this adjustment because it has a higher correlation with most of the core variables than the L_{pAeq} for night-time (10 pm to 6 am). However, both acoustic metrics levels correlate rather weakly with noise

responses, e.g. $L_{pAeq,06-22h}$ with aircraft noise annoyance in total $r = .122$, $L_{pAeq,22-06}$ with sleep disturbances when falling asleep $r = .115$. For comparison: In the NORAH Study carried out between 2011 and 2013 at the same airport correlation coefficients were considerable higher, e.g. between $L_{pAeq,06-22h}$ and aircraft noise annoyance $r = .47$ (1).

Table 1 – Characteristics of noise respite groups

Variables		Noise respite groups					<i>p</i>
		Evening relief	Morning relief	No change	Evening burden	Morning burden	
	<i>N</i> =	402	263	464	202	202	
Gender = female	%	55,2%	54,0%	51,5%	57,9%	51,5%	
Nationality = German	%	93,3%	95,4%	95,9%	94,6%	95,0%	
Occupation associated with airport	%	7,7%	8,0%	6,0%	6,4%	7,9%	
Age	<i>M</i> (<i>SE</i>)	62.6 (0.8)	62.3 (0.9)	63.6 (0.7)	63.4 (1.1)	60.0 (1.1)	
SES (scores from low to high: 3 – 21)	<i>M</i> (<i>SE</i>)	14.2 (0.2)	13.3 (0.2)	13.4 (0.2)	12.6 (0.3)	12.5 (0.3)	***
$L_{pAeq,06-22h}$ (46 - 61 dB)	<i>M</i> (<i>SE</i>)	53.5 (0.11)	52.0 (0.21)	51.8 (0.14)	53.8 (0.20)	48.6 (0.27)	***
$L_{pAeq,22-06h}$ (38 - 55 dB)	<i>M</i> (<i>SE</i>)	45.2 (0.10)	46.2 (0.27)	44.3 (0.16)	47.1 (0.20)	40.6 (0.26)	***
Noise sensitivity [#]	<i>M</i> (<i>SE</i>)	2.9 (0.1)	2.8 (0.1)	2.8 (0.1)	2.8 (0.1)	2.5 (0.1)	*

= 5-point response scale: 1 = not to 5 = very; * $p < .05$, *** $p < .001$

3.2. Responses regarding air traffic, aircraft noise and noise respite in shoulder hours

Table 2 gives an overview of reported perceptions of air traffic and aircraft noise in the shoulder hours from 10 to 11pm and from 5 to 6am, opinions of the *Lärmpausen* operation as a measure to provide noise respite and reported trust in authorities willingness to reduce aircraft noise in residential areas. The results are grouped according to sampling area and, for each dependent variable, the significance of group differences according to ANOVA analysis is shown.

The mean responses for aircraft noise annoyance and sleep disturbances differ between the noise respite groups. It could be argued that the group differences reflect the estimated differences in aircraft noise exposure. However, the group means were adjusted for difference in $L_{pAeq,06-22h}$. In addition, differences in means between the groups hardly correspond to the differences in group means of average sound levels for daytime and night-time depicted in Table 1. Thus, it does not seem that group differences in annoyance and disturbance as well as in items describing the perception of air traffic and noise respite in shoulder hours can be fully explained by differences in overall average aircraft sound levels. The group 'Evening relief' shows similar or marginally higher reported annoyance and sleep disturbances to the group 'Evening burden'. On the other hand, the group 'Morning relief' reports lower aircraft noise annoyance and sleep disturbances than the group 'Morning burden', particularly with reference to the early morning. The group 'Morning relief' evaluates the *Lärmpausen* operation somewhat more positively, is more satisfied with the concept and their responses to the air traffic in the morning shoulder hour reflect a somewhat higher perception of noise relief in the morning than the responses of other groups, in particular the group 'Morning burden'. In line with this, noise respite in the early morning is spontaneously or in response to closed questions more often preferred than noise respite in the evening. The flight management's compliance to or the temporal expansion of noise respite in the early morning is more often requested as compared to noise respite in the evening.

However, beside group differences, all in all, the perception of noise relief in the shoulder hours is weak on an absolute level in all groups. Participants with higher scores of perception of noise relief in the shoulder hours often reported a higher agreement to prescribed items stating that the air traffic has changed in terms of becoming less frequent, more quiet, or more bearable. This did not apply to the

general case. Instead, higher overall average scores of agreement were given to statements specifying that nothing has changed since the past year and that overflights change in frequency and loudness day by day, and statements that refer to the (lack of) predictability of the aircraft noise events.

Table 2 – Means (standard error) of response scores concerning responses to aircraft noise, perception of air traffic in the hours 10 – 11 pm and 5 – 6 am and judgments of the *Lärmpausen* approach – headlines corrected⁵.

Variables - Responses on 5-point scales from 1 = low degree to 5 = high degree of attitude, perception, judgment	Noise respite groups					p	
	Evening	Morning	Evening	Morning	No change		
	relief	relief	burden	burden	(control)		
	N=	402	263	202	202	464	
Aircraft noise annoyance in total		3.6 (0.07)	3.0 (0.08)	3.3 (0.09)	3.5 (0.1)	3.5 (0.06)	***
Aircraft noise annoyance 10 – 11 pm		2.7 (0.07)	2.4 (0.08)	2.3 (0.09)	2.7 (0.1)	2.5 (0.06)	**
Aircraft noise annoyance 5 – 6 am		3.1 (0.08)	2.4 (0.09)	2.9 (0.10)	3.1 (0.11)	3.1 (0.07)	***
Disturbances when falling asleep		1.9 (0.07)	1.8 (0.07)	1.9 (0.08)	2.0 (0.08)	1.8 (0.05)	n.s.
Disturbances during night		1.5 (0.06)	1.3 (0.05)	1.4 (0.07)	1.5 (0.08)	1.5 (0.05)	*
Disturbances in the early morning		2.9 (0.08)	2.3 (0.08)	2.7 (0.10)	3.0 (0.11)	2.9 (0.07)	***
(Positive) evaluation of <i>Lärmpausen</i>		3.4 (0.05)	3.5 (0.06)	3.5 (0.07)	3.3 (0.07)	3.3 (0.04)	*
Satisfaction with concept of <i>Lärmpausen</i>		2.7 (0.07)	3.0 (0.08)	3.0 (0.09)	2.7 (0.09)	2.7 (0.06)	**
Perception of relief in the evening, 10 – 11 pm		2.1 (0.06)	2.1 (0.07)	2.3 (0.08)	2.1 (0.08)	2.1 (0.05)	n.s.
Perception of relief in the morning, 5 – 6 am		1.8 (0.05)	2.0 (0.08)	1.9 (0.08)	1.6 (0.07)	1.7 (0.05)	***
Trust in authorities		2.4 (0.05)	2.6 (0.06)	2.7 (0.07)	2.4 (0.07)	2.5 (0.05)	**

* $p < .05$, ** $p < .01$, *** $p < .001$, n.s. = group differences not significant.

All values adjusted for $L_{pAeq,06-22h}$, SES, noise sensitivity

3.3. Perception of change in flight movements in the shoulder hours

When directly asked for perceived changes in air traffic at home since 2014, 51% of the participants reported to have noticed changes in aircraft traffic. Noise respite groups did not differ in their re-

⁵ Table 2 of the paper on the Inter-Noise 2016's USB stick has wrong headlines. This is corrected here.

sponses to this question. 29% of the interviewees (n = 449) were able to state since when they have noticed the change. Noticed changes were predominantly dated to the year 2014 (81% of the 449 persons) and refer to re-routing of flight paths, number of overflights, flight altitude and angle of approaching and departing planes. Actually, all of these changes occurred and belong to the active noise abatement program at Frankfurt Airport developed since 2010 (8), and were nothing to do with the *Lärmpausen* trial from April 2015 onwards. The 19% of participants referring to changes since the beginning of 2015 actually mentioned mostly elements of the *Lärmpausen* operation but in vague and incomplete terms. Elements of the noise respite concept often mentioned among the participants were changes in the distribution of flight movements and in the number of flights, in particular in the evening or morning hours, and in many cases may have had more to do with information provided by the airport and in different media than actually observed changes.

Table 3 – Means (standard error) of response scores concerning perception of air traffic and aircraft noise in the hours 10 – 11 pm and 5 – 6 am and judgments with regard to the noise respite.

Variables <i>Responses on 5-point scales from 1 = low to 5 = high agreement to prescribed items</i>	Noise respite groups					<i>p</i>
	Evening relief	Morning relief	No change	Evening burden	Morning burden	
<i>N=</i>	402	263	464	202	202	
It is good that authorities try to relieve residential areas from aircraft noise	4.5 (0.1)	4.5 (0.1)	4.4 (0.1)	4.4 (0.1)	4.5 (0.1)	n.s.
If more people are relieved, the measure will be a good thing	4.2 (0.1)	4.3 (0.1)	4.2 (0.1)	4.2 (0.1)	4.1 (0.1)	n.s.
I believe that the <i>Lärmpausen</i> operation makes sense for the resident population in this region	3.3 (0.1)	3.5 (0.1)	3.3 (0.1)	3.3 (0.1)	3.2 (0.1)	n.s.
The effort for the <i>Lärmpausen</i> operation is not justified because the positive impact is low	3.2 (0.1)	3.1 (0.1)	3.3 (0.1)	3 (0.1)	3.2 (0.1)	n.s.
I do not agree to the <i>Lärmpausen</i> approach as it does not reduce but just distributes aircraft noise	3.1 (0.1)	2.9 (0.1)	3.2 (0.1)	2.8 (0.1)	3.2 (0.1)	*
<i>Lärmpausen</i> lead to tensions between residents of different residential areas	3.1 (0.1)	3 (0.1)	3 (0.1)	2.8 (0.1)	3.1 (0.1)	n.s.
I do not agree to the <i>Lärmpausen</i> approach because some residential areas suffer from additional burden	2.6 (0.1)	2.5 (0.1)	2.7 (0.1)	2.3 (0.1)	2.7 (0.1)	*
I think, the <i>Lärmpausen</i> approach leads to a fair distribution of aircraft noise	2.4 (0.1)	2.6 (0.1)	2.4 (0.1)	3 (0.1)	2.4 (0.1)	**
Evaluation of the <i>Lärmpausen</i> (noise respite) approach (summarizing mean score)	3.4 (0.1)	3.5 (0.1)	3.3 (0.1)	3.5 (0.1)	3.3 (0.1)	*
All in all, how satisfied are you with the <i>Lärmpausen</i> approach? (1: not – 5: very)	2.7 (0.1)	3 (0.1)	2.7 (0.1)	3 (0.1)	2.7 (0.1)	**

* $p < .05$, ** $p < .01$, *** $p < .001$, n.s. = group differences not significant.

All values adjusted for $L_{pAeq,06-22h}$, SES, noise sensitivity

3.4. Knowledge and understanding of 'Lärmpausen' (noise respite)

68 % of the respondents reported to have heard of the term '*Lärmpausen*' (noise respite), in particular from newspapers, TV, and radio. 35 % claimed to know something about the concept. There were no systematic differences between noise respite groups with regard to the knowledge and understanding of the *Lärmpausen* operation. The responses to open-ended questions of participants claiming to have understood the concept reveal vague subjective concepts of the *Lärmpausen* approach. Most answers refer to the aspect of times of day, that, for example, the *Lärmpausen* approach includes "sometimes", "at different times of day", or "for six hours" a decrease in aircraft noise exposure. The specific shoulder hours 10-11pm and 5-6am were seldom mentioned, more often the *Lärmpausen* operation was confused with the night curfew from 11pm to 5am. The changes included in the concept of *Lärmpausen* as mentioned by the respondents were the alternating use of runways, and in consequence constraints for air traffic and the relief as well as additional burden in different residential areas around the airport.

3.5. Opinions about the noise respite intervention 'Lärmpausen'

The answers of respondents to the agreement to prescribed items concerning the evaluation of the *Lärmpausen* operation reveal that the willingness to relieve the resident population from aircraft noise is judged positively (Table 3). The fairness of the distribution of aircraft noise and the cost-benefit relationship is more critically judged. The criticism is milder in the groups 'Morning relief' and 'Burden evening'. However, the criticism does not lead to the refusal of the concept of *Lärmpausen* in general: Respondents show higher agreement to the statement that the *Lärmpausen* approach makes sense to the resident population and lower agreement to the statement that the *Lärmpausen* operation should be refused because some residential areas suffer from additional burden. In line with this, the majority (71%) of those respondents commenting on the continuation of the *Lärmpausen* operation after the trial project ($n_{\text{adjusted}} = 1183$) agreed to the continuation.

3.6. Information about the *Lärmpausen* approach

20% (206 persons) of those that reported to have heard about '*Lärmpausen*' claimed to know how to find out further information about the *Lärmpausen* operations. These are 13% of all respondents. Half of those respondents (10%) (or 6.5% of all respondents) claim to actually use available information offerings, in particular newspapers, information offered by the airport, Fraport AG, internet and information offered by the state government of Hesse and the Hessian Ministries. Respondents over 50 years of age were less interested in using the internet to obtain information about the *Lärmpausen* operation. This is significant because the website <http://webanwendung.umwelthaus.org/laermpausen> offers a tool to monitor and predict the *Lärmpausen* operation. However, according to the findings of this survey this offer of information does not reach all age groups.

3.7. Trust in authorities related to aircraft noise annoyance and the perception of noise respite

As Table 2 shows, the noise respite groups differ in their trust in authorities and this corresponds to the average group responses to aircraft noise and to the perception of air traffic in the shoulder hours and the evaluation of the *Lärmpausen* approach. Thus, it was analyzed to what extent respondents with different degrees of trust in willingness of authorities to reduce aircraft noise in residential areas differ in their perception of the aircraft noise and the noise respite in the evening and morning shoulder hours. Table 4 indicates that those respondents with a higher degree of trust in authorities report less annoyance and sleep disturbance by aircraft noise. They report higher positive evaluation of and satisfaction with the *Lärmpausen* operations and perceive the noise respite in the shoulder hours somewhat more positively than respondents with a lower degree of trust in authorities.

Table 4 – Means (standard error) of responses to aircraft noise, perception of air traffic in the hours 10 – 11 pm and 5 – 6 am and judgments of the *Lärmpausen* approach, grouped by levels of trust in authorities.

Variables - Responses on 5-point scales from 1 = low degree to 5 = high degree of attitude, perception, judgment	Trust in authorities (5-point scale: 1 = low; 5 = high)						<i>p</i>
	Low (response scores ≤ 3)		Middle (response scores = 3)		High (response scores > 3)		
	<i>N</i> =						
Aircraft noise annoyance in total	3.9	(0.05)	3.4	(0.05)	2.8	(0.07)	***
Aircraft noise annoyance 10 – 11 pm	2.9	(0.06)	2.5	(0.05)	2.0	(0.06)	***
Aircraft noise annoyance 5 – 6 am	3.5	(0.06)	2.9	(0.06)	2.3	(0.07)	***
Disturbances when falling asleep	2.2	(0.06)	1.8	(0.05)	1.5	(0.05)	***
Disturbances during night	1.6	(0.05)	1.4	(0.04)	1.2	(0.03)	***
Disturbances in the early morning	3.3	(0.06)	2.8	(0.06)	2.1	(0.07)	***
(Positive) evaluation of <i>Lärmpausen</i>	3.1	(0.04)	3.4	(0.04)	3.8	(0.04)	***
Satisfaction with <i>Lärmpausen</i>	2.3	(0.05)	2.9	(0.05)	3.4	(0.06)	***
Perception of relief, evening, 10–11 pm	1.9	(0.04)	2.2	(0.04)	2.5	(0.06)	***
Perception of relief, morning, 5–6 am	1.5	(0.04)	1.9	(0.05)	2.1	(0.07)	***

*** $p < .001$. All values adjusted for $L_{pAeq,06-22h}$, SES, noise sensitivity.

3.8. Main results of the focus groups

The focus groups were addressed to investigate interpretative methods intended to promote understanding (9), in this case, in-depth understanding of perceptions of the *Lärmpausen* operations among residents. With this in mind, the following conclusions can be drawn from the focus group findings (see 10 for more details): As for the respondents in the telephone survey the participants of the focus groups reported low awareness of the *Lärmpausen* operations and they rarely mentioned this noise respite intervention spontaneously. This suggests that, on average, citizens are either not well informed and take little or no interest in, or cognizance of, information that is provided to them and/or did not perceive the noise respite derived from the *Lärmpausen* operations.

However, it remains unclear whether this low level of penetration has to do with poor communication and ineffectual public relations, disinterest, or even active suppression of information surrounding the issue of aircraft noise. This suppression mechanism, also known in other fields of stress research (11), suggests that some of the residents affected by aircraft noise might not wish to hear, read or see anything on the subject, as they are concerned that this could jeopardise their well-being. Other residents are indeed interested in the topic and are prepared to acknowledge corresponding bulletins and information.

Focus group participants associated the concept of noise respite (*Lärmpausen*) with terms such as peace (night-time, siesta), period of time allowing restoration, period of time without any noise, the night flight ban, period of time with a break of flight movements, although the temporal rhythm was unclear. It is important to note that the '*Lärmpausen*' was often associated with a break, indicating that in a specific period of time there are *no* flight movements. Similar comments were made in responses to open-ended questions in the telephone survey where respondents complained about a lack in compliance to the *Lärmpausen* operation, because in periods of *Lärmpausen* operation mode flight movements were still observed (and heard).

When informed about the concept of the *Lärmpausen* operations by means of an educational video published by HMWVEL the comments in the focus groups about the *Lärmpausen* operations initially were skeptical and dismissive. However, this stance completely changed when the participants were asked to envisage themselves in a responsible decision-making role. If they really had the last word on whether or not to continue with the noise respite intervention '*Lärmpausen*' and if they had to take responsibility for the potential removal of this noise abatement intervention, then one often sees a

basic change in attitude. Participants of the focus groups evidently assumed that by getting rid of the noise abatement periods, a benefit could be lost that the majority of participants are in fact keen to retain. This new stance can now be interpreted in terms of a rational choice. The stance change was commented in terms of 'There must be no way back', 'Better than nothing, the less aircraft noise, the better.', 'It is a beginning', 'In any case, don't stop', but 'keep on improving'.

This finding is in line with the results of the telephone survey where the majority of respondents, although critical with regard to the implementation of the concept of noise respite, reported to be in favor of the continuation of the *Lärmpausen* operations after the pilot period.

3.9. Main results of the operational and acoustical monitorings

The operational and acoustical monitoring studies themselves are not part of the study presented here. The main results of both monitoring studies are published by HMWVEL (2). In the trial period from 1 April 2015 to 31 March 2016 the *Lärmpausen* operation applied only under westerly operation mode (BR25). During the trial period westerly operation mode occurred in the shoulder hours between 5 – 6 am 77.1% of the time and between 10 – 11 pm, 75.9% of the time. From 23 April to 31 December 2015 the *Lärmpausen* operation ran in the evening between 10 – 11am on average in 89% of all operations in westerly operation mode in this evening shoulder hour, that is, on average to 68% of all operations between 10 – 11 pm. Within the same period, the *Lärmpausen* operation ran in the morning between 5 – 6 am on average in 96% of all operations in westerly operation mode within this shoulder hour. This corresponds to *Lärmpausen* operations running on average to 74% of all operations between 5 – 6 am within the monitoring period from 23 April to 31 December 2015.

That means, that during the trial period the *Lärmpausen* operation mode did not run on every day, in particular less in the evening than in the morning. This seems to correspond with the opinion of many respondents that air traffic in the shoulder hours changed in frequency and loudness day by day. The results of the operational monitoring might also explain that an evening noise respite due to *Lärmpausen* operation mode was less noticed by respondents than the morning noise respite.

For the acoustical monitoring of the *Lärmpausen* operation acoustical data from selected measurement stations were analyzed (Figure 3). Acoustical data from 2013 (in part from 2014) were compared with those from 2015. It turns out that at those measurement stations near to areas that belong to the noise respite area group 'Evening relief' there were remarkable reductions up to 10 dB in hourly continuous sound level of aircraft, $L_{pAeq,1h}$ in the evening hour 10 – 11 pm ('abends' in Figure 3) in 2015 as compared to measurements of the year 2013 or 2014, respectively. At those measurement stations that are near to the areas of the noise respite area group 'Respite morning' $L_{pAeq,1h}$ reductions between 4 to 6 dB were obtained. At measurement stations near to areas of those noise respite area groups that were expected to experience additional burden in aircraft noise exposure when *Lärmpausen* operation mode runs the $L_{pAeq,1h}$ increased between 1.5 to 4.5 dB.

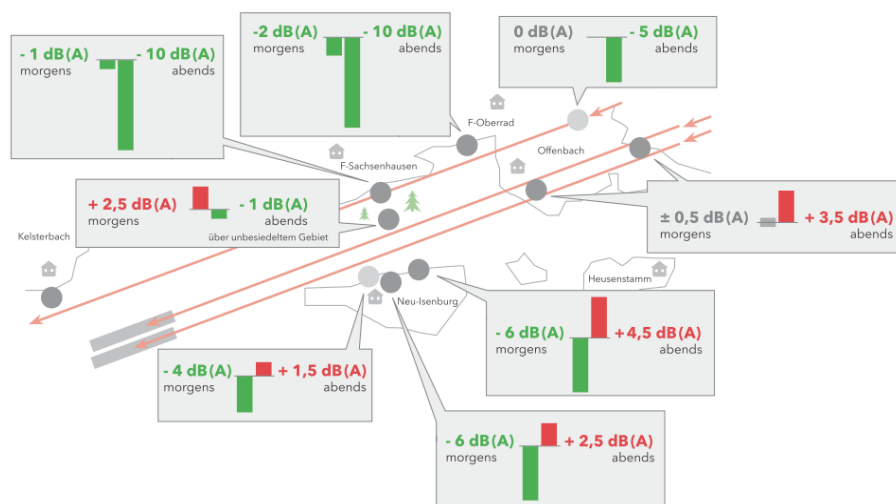
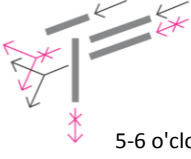
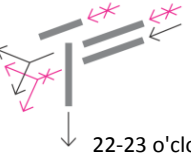


Figure 3 – Differences in $L_{pAeq,1h}$ at measurement stations as measured in 2015 (during the *Lärmpausen* trial) and in 2013/2014, before implementation of *Lärmpausen* operations. The differences in $L_{pAeq,1h}$ refer to evening hour 10 – 11 pm ('abends') and to the morning hour 5 – 6 am ('morgens'). Source: HMWVEL, 2.

The changes in average sound levels are not only due to the *Lärmpausen* operation mode. Because the acoustical measurement stations were not at the same addresses as all participants of the perception monitoring study, the measured acoustical data only approximates the actual changes in sound levels at the home address of the respondents owing to the implementation of the *Lärmpausen* operation mode. Notwithstanding this uncertainty, it is nevertheless very interesting that very few, if any, of the field study respondents seem to have been aware of the apparently quite significant changes in sound levels as measured by $L_{pAeq,1h}$ that actually occurred, particularly with respect to the changes that occurred in the evening shoulder hours. On the other hand, these changes did not occur every night, and the sound levels were measured outdoors at times when the majority of respondents would have been indoors even if not actually asleep.

Looking at changes in the mean number of approaches on the runways 25R, 25C and 25L in the hours 5 – 6 am and 10 – 11 pm in 2015 as compared to 2013 and 2014 (Table 5), it can be seen that in 2015 the numbers of approaches are reduced in particular on those runways and in that shoulder hour where the *Lärmpausen* operation mode should have been run. In particular on the runway South (25L) the reduction in approaches is higher in the morning shoulder hour than the reduction of approaches on the runways Northwest (25R) and Center (25C) in the evening shoulder hour. This could be a contributory factor in explaining why noise respite in the morning hour is somewhat better perceived by respondents than the noise respite in the evening. In addition there are known weaknesses in the ability of L_{Aeq} type equivalent continuous sound level metrics to describe noise exposures characterised by occasional loud events.

Table 5 – Mean numbers of approaches in the shoulder hours 5 – 6 am and 10 – 11 pm in 2013, 2014, 2015

Time of day	Year	Runways		
		Northwest (25R)	Center (25C)	South (25L)
 5-6 o'clock	2013	10.8	3.0	16.6
	2014	8.4	5.6	12.5
	2015	7.5	18.0	0.7
 22-23 o'clock	2013	9.8	0.7	2.8
	2014	6.6	0.5	7.7
	2015	1.3	0.8	12.1

Accentuation in yellow: No landings on runway in *Lärmpausen* (noise respite) operation mode (pilot period of noise respite project: April 2015 to March 2016). Source: 13.

4. CONCLUSION

A total of 1533 residents in the area of Frankfurt Airport were interviewed by telephone with regard to their perception of a newly implemented noise abatement procedure, the noise respite trial project *Lärmpausen*. In addition, focus group discussions were carried out in order to get a deeper understanding in the perception of the noise respite in the exposed resident population. The existing night cut-off time was brought forward by one hour in the late evening period in certain areas around the airport, and extended by one hour in the early morning period in other areas to provide a seven hours night curfew in those areas by re-distributing the shoulder hours traffic between the four runways. The trial not only extended the night curfew in affected areas to seven hours but also contributed to an increase in shoulder hours traffic in other areas.

The results of the telephone survey and the focus groups showed the *Lärmpausen* operations to exert only marginal effects on the perception and assessment of residents affected by them. Relief was

more noticeable in the morning shoulder hour, if at all. Otherwise, people hardly notice any difference in the air traffic/aircraft noise during the morning and evening shoulder hours since the implementation of the *Lärmpausen* operation mode. Only a minority of the participants reported to be informed about the *Lärmpausen* operations and was able to name detailed elements of the *Lärmpausen* approach, although in vague and partly incorrect terms. Nevertheless, in both parts of the perception monitoring study, in the focus groups and the telephone survey, the majority of participants were in favor of a continuation of the *Lärmpausen* operations at Frankfurt Airport after the one-year trial period. This finding is entirely consistent with the preliminary results of similar research being carried out around airports in the UK (14).

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