ANIMA

Aviation Noise Impact Management through Novel Approaches

D3.6 - Evaluations of previous interventions in improving quality of life

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[1] Use one of the following codes: R=Document, report (excluding the periodic and final reports)
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OTHER=Software, technical diagram, etc.

[2] Use one of the following codes: PU=Public, fully open, e.g. web
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1 Executive Summary

The growth of the aviation sector worldwide poses new challenges for noise management and calls for new approaches to reduce noise impacts. Aircraft noise exposure can have adverse health effects and a significant negative impact on people's quality of life (e.g. Schreckenberg et al., 2010). This relationship is often mediated by aircraft noise annoyance, which has been linked to the experience of stress (van Kamp, 1990). To address these negative impacts of aircraft noise, a vast number of aircraft noise managing and mitigating interventions are implemented by airports, surrounding communities and other stakeholders. However, little is known about the value of such interventions for the residents as well as their impact on residents' quality of life.

Therefore, the current study aims to examine whether interventions implemented by airports or other stakeholders in airport regions could have an impact on residents' quality of life, and, if so, identify which specific aspects of these interventions play a role. The results provide starting points and guidance for stakeholders while shedding light on relevant aspects for future research.

Within this study, quality of life (QoL) has been defined in line with EUROSTAT's approach, embracing nine dimensions of QoL: health, economic and physical safety, natural and living environment, productive or main activity, education, material living conditions, leisure and social interactions, governance and basic rights, and overall life satisfaction.

Interventions were selected based on the four pillars of ICAO's (International Civil Aviation Organization) Balanced Approach: 1) reduction of noise at the source, 2) land use planning and management, 3) operational procedure, and 4) operational restrictions. Communication plays a key role in each of these pillars. For this study, four European airports with one intervention each were selected:

- Mikroklimaat Leimuiden – Schiphol Airport, The Netherlands
- Consultation procedure - Frankfurt Airport, Germany
- Sound insulation – Marseille Airport, France
- Sound insulation - Heathrow Airport, UK

In the following sections, the selected interventions as well as the study methodologies are described, and an overview of the results, overall conclusions, and recommendations is given.

1.1 Description of four interventions

A change with respect to an operational procedure was made for one departure route at Schiphol Airport (Microklimaat Leimuiden). A **radius-to-fix approach** was implemented aiming at concentrating the flight path while making a turn, thereby preventing spread of flights over a densely populated area. In this way, it was intended that fewer households would be exposed to aircraft noise.

In 2018, a **consultation procedure** was carried out around Frankfurt Airport in preparation for making a decision regarding a potential flight path change. The aim was to engage the public and allow political representatives and residents to share their opinions, concerns, and ideas regarding the potential flight path change. Integrating the results of the consultation procedure, a decision was to be made regarding the shift and testing of the potentially adapted flight path.

A **sound insulation scheme** was chosen for Marseille and Heathrow Airport. A key aim of such schemes is to reduce noise complaints and general community dissatisfaction by reducing noise disturbance attributable to aircraft overflights.

Since 1997, the French state has implemented a specific system for large airports: soundproofing assistance. Residents affected by aircraft noise can receive a grant for sound insulation for their homes. This system was originally managed by the environment and energy management agency in France and financed by the general tax on polluting activities. Now, the grant has been exclusively financed by airlines via a tax on air noise pollution (TNSA), levied by the DGAC (Directorate General of Civil Aviation) according to the "polluter pays" principle. Criteria for eligibility around Marseille Airport are that the accommodation is located inside the annoyance map contours and was built before the noise annoyance plan had been created.

A voluntary daytime noise insulation scheme was introduced by Heathrow Airport in the mid-90s, followed by a voluntary night noise insulation scheme early in the following decade. By 2014, Heathrow started to offer the Quieter Homes Scheme (QHS) for those residents living closest to the airport within the 69dB $L_{Aeq,16hr}$ aircraft noise contour.

1.2 Distilling previous knowledge

To gather relevant literature concerning a consultation procedure's impact on residents' quality of life, a literature search was conducted in August/September 2020 using databases such as Web of Science, Google Scholar and Researchgate. The following search terms were used: aviation AND noise annoyance AND quality of life OR satisfaction AND intervention (adapted for each intervention). International articles, books, grey literature, meta-analyses, etc. were included. Studies had to be conducted in an airport region and had to have assessed the intervention's impact on participants' quality of life (or indicators of it).

1.3 Study results

1.3.1 Microklimaat Leimuiden

A study was conducted with residents living in the vicinity of Schiphol Airport from November 2018 until October 2019. The resultant survey data provides a general overview of residential satisfaction, noise annoyance due to different sources, as well as aspects residents are mainly concerned about.

The study area was divided into three areas according to different levels of aircraft noise exposure:

1. Inner area (Binnengebied, close to the airport; 58dB L_{den}),

2. Outer area (Buitengebied; 48dB – 57dB L_{den}),
3. Area outside noise contour (Buiten contour; less than 48dB L_{den}),

with Leimuiden being located in the outer area with L_{den} ranging from 48dB to 57dB. Statistical analyses were performed comparing the three study areas. Results show that the residential satisfaction across all three study areas is quite high. Comparing the three study areas, some significant differences become apparent. In the inner area, the reported aircraft noise annoyance is significantly higher than in the other two study areas. Moreover, more disturbances due to aircraft noise, a general increase in aircraft noise annoyance and an expected increase in future noise annoyance are significantly more often reported by participants living in the inner area. Participants from the inner area report significantly less sleep disturbance due to noise from neighbours and railway traffic, but significantly more aircraft noise-related sleep disturbances. This indicates not necessarily an absence of noise from neighbours, but could reflect the prominent role aircraft noise takes in areas within the airport's proximity. The results indicate that perceived and expected aircraft noise annoyance is highest for people living in close proximity to the airport, but that overall, there are other more prominent aspects for residents in airport regions.

1.3.2 Consultation Procedure

The consultation procedure that was conducted around Frankfurt Airport in 2018 addressing a potential flight path change (AMTIX kurz) was evaluated by means of 27 in-depth telephone interviews. To identify the potential impact of the consultation procedure on residents' quality of life, three different communities in the Frankfurt Airport region were chosen as study areas: Weiterstadt-Gräfenhausen, Darmstadt-Wixhausen, and Darmstadt-Arheilgen. All of these communities were involved in the consultation procedure; however, the impact of the potential flight path change on these communities differs.

Participants mentioned quite a few negative aspects with respect to their perception of the consultation procedure's premise and execution. The consultation procedure was mainly perceived as not being open-ended and participants expressed a degree of lack of trust to some extent. Despite these negative aspects, the majority of participants are in favour of the general concept and the idea of conducting a consultation procedure engaging the public. These results stress the importance of open and transparent communication and execution of a consultation procedure. According to the participants, the consultation procedure itself does not have an effect on their quality of life. However, directly questioning people about the link between an intervention and quality of life may not reveal any apparent relationship as participants may not be consciously aware of the way in which a consultation procedure affects them.

1.3.3 Sound insulation Marseille

To assess the effect of the sound insulation scheme at Marseille Airport, four focus groups were carried out. The four groups were categorized by their eligibility for sound insulation and by the presence of sound insulation in their homes:

- Eligible for the grant / non-insulated yet
- Eligible for the grant/ insulated
- Non-eligible / non-insulated

The fourth focus group included only residents who are members of action groups regarding aviation noise.

The insulation scheme was mainly familiar to and known by participants who already received the grant and were insulated. Thus, awareness and knowledge of the scheme were not high. Participants rated the insulation scheme as useful during winter, when the windows are usually closed, and were in favour of the improvement of thermal comfort and the reduction of the household's energy bill. However, especially during the summer, the insulation scheme alone is not sufficient. As people in the Marseille Airport region tend to spent most of the summer outside their homes, participants are still annoyed and disturbed by aircraft noise. Participants reported feeling annoyed and discomfited, when they have guests invited to their homes as conversations are regularly interrupted by the noise.

Overall, despite the lack of improvement in the noise situation during the summer, the insulation scheme is still well perceived and shall continue to be pursued according to respondents.

1.3.4 Sound insulation Heathrow

In total, ten interviews were conducted with residents of the Heathrow Airport region. All ten participants were recruited through a local civic group, HACAN (Heathrow Association for the Control of Aircraft Noise).

Generally, there was a low level of awareness of what the airport does to minimise noise exposure. Further, participants expressed some cynicism about governance in general and feeling that communications were largely manipulative and tokenistic. In addition, there appeared to be a general lack of transparency/fairness.

There was a low level of awareness of insulation provision. Overall, participants agreed with the principle of addressing the most noise affected areas, although the means for determining this was criticised, as well as the airport's offer to pay 50% of the insulation work, which was viewed as unfair. Participants raised different relevant topics and suggested that aspects such as 1) respite made more of a contribution than insulation, 2) the description of insulation schemes was too technical, and 3) that there was a need to more explicitly describe the performance of the insulation provision.

There was universal agreement that noise disbenefits outweighed any positive contribution from the airport to local communities. Participants expressed the desire to be consulted; but also fears that the airport would control the agenda and, thus, outcomes. There was clearly room for improvement in communication over how operations can be enhanced to allow for influence over factors that currently feel out of control.

1.4 Key learnings and recommendations

This research has sought to gain insights into the relationship between historic sound interventions and quality of life of residents. While there has been little evidence found on the direct link between the interventions and people's quality of life, the work has revealed some of the critical success factors which may contribute to the development of interventions that are more nuanced in meeting residents' expectations and needs, and, thereby, of increased likelihood of influencing their lived experience.

Results of the case studies indicate that the interventions studied have only a minor impact on residents' quality of life. However, there also appears to have been a lack of understanding about quality of life from the airports. To better address and include quality of life, an intervention must take the following criteria into account:

- **Participation/Fairness** (capacity of the intervention to include residents in the decision-making process)
- **Health** (capacity of the intervention to lower the pollution, noise, and stress effects of air traffic and to improve sleep of residents)
- **Social life and leisure** (capacity of the intervention to lower the impact of air traffic on these activities)

- **Living environment** (capacity of the intervention to address the indoor AND the outdoor impact of air traffic)

The involvement of residents needs to be genuine and effective participation, and not more perfunctory consultation as it has been shown that such approaches are less successful, for example, reflecting on the perception of the consultation procedure at Frankfurt. The intervention and associated air traffic changes may be more likely to be acceptable to the public if people feel that they have been able to fairly contribute to the decision-making. Proper community engagement requires early involvement, transparency, having a voice that is listened to and having a real choice. Across the different case studies, participation was always appreciated by the residents.

There are a number of considerations that may assist airports as they move forwards to development of new interventions. We consider the following issues to be central to improved airport thinking about residents and quality of life:

- It is important to know what you are trying to do and to establish from the start what methods you can use to evaluate whether you have achieved your goals.
- There needs to be a consensus between airport operator and residents about what is seen as effective.
- Airports would benefit from efforts to gain a better understanding and awareness of QoL in their communities.
- Use citizen science approaches to engage with communities rather than using what can appear to be random consultation methods.
- Think about new methods of assessment of success (e.g. well-being evaluation techniques).
- Airports may find it helpful to address the apparent lack of understanding in the community of how the operator's contribution could be beneficial to residents.
- Try to work innovatively to share aviation benefits with residents.
- Ask residents what they expect or wish for.

It is only by fostering effective communication and open dialogue between an airport and its surrounding communities that steps can be made towards successful interventions that are fair, of value to residents and reflect authentic joint-working towards mutually agreed solutions.

2 Introduction

It is well established that aircraft noise can have significant negative effects on people's health and quality of life (e.g. Schreckenberg et al., 2010). The link is often noise annoyance, which has been associated with the experience of stress (van Kamp, 1990). To tackle these negative impacts of aircraft noise, a large number of aircraft noise managing and mitigating interventions are implemented by airports, communities and other stakeholders worldwide. Their aim is to reduce noise-related adverse health impacts as well as noise annoyance/number of highly annoyed people.

However, little is known about the value of such interventions for the residents as well as their impact on residents' quality of life. How does a sound insulated window affect people's residential satisfaction? Which aspects of community engagement can enhance residents' quality of life? This report aims at filling some of these gaps and answers some of these questions, providing starting points and guidance for stakeholders while shedding light on relevant aspects for future research.

For this study, four European airports with one intervention each were selected:

- Mikroklimaat Leimuiden – Schiphol Airport
- Consultation procedure - Frankfurt Airport
- Sound insulation – Marseille Airport
- Sound insulation - Heathrow Airport

This study aims at examining whether interventions implemented by airports or other stakeholders in airport regions could have an impact on residents' quality of life, and, if so, identifying which specific aspects of these interventions play a role.

Unfortunately, because of the COVID-19 crisis, the planned work could not be conducted, so some research questions will remain unanswered. Nevertheless, those that could be explored with the data that was collected are discussed in this report.

3 Background information

3.1 Defining quality of life

Quality of life (QoL) has been variously described but, after reviewing a range of definitions (from, for example, WHO, EUROSTAT, the Dutch Social and Cultural Planning Agency and British Office for National Statistics), the following definition was adopted: 'the objective environmental parameters related to, and a person's subjective reflections on, current and future wellbeing' (ANIMA Deliverable 3.1: Roosien et al., 2018). Given the concept's multi-faceted nature, QoL was further segmented into several dimensions to simplify its context and measurability by airports. As this process resulted in segmentation akin to that of EUROSTAT (2017), the latter was adopted as the framework for the various dimensions of QoL included in the study. The derivation of the dimensions of quality of life is described further in the following section.

The review of QoL indicators found that there had been multiple efforts to illustrate a "concept of quality of life" and assess quality of life, either on a national basis from different countries (e.g. 'Measuring National Well-being', ONS; the Dutch 'Leefsituatie index', SCP; the Italian 'Benessere Equo e Sostenibile'; the Austrian 'Wie geht's Österreich?', STATISTIK AUSTRIA) or through initiatives such as the Organisation for Economic Co-operation and Development (Eurofound, 2013; OECD, 2017).

According to The International Wellbeing Group (2006), it was crucial to differentiate between objective and subjective dimensions of QoL as they do not reflect the same factors. The importance of this distinction, as well as the need to assess both aspects, was underlined in a final report about QoL indicators by EUROSTAT (2017). EUROSTAT combined objective indicators of QoL with individuals' subjective (perceived) situation. This resulted in a total of nine different dimensions being considered by EUROSTAT: material living conditions, productive or main activity, health, education, leisure and social interactions, economic and physical safety, governance and basic rights, natural and living environment, and overall life satisfaction.

Garcia Diez (2015) compared the assessment of quality of life from different national initiatives and EUROSTAT's approach, concluding that there was a comparable basic structure within these quality of life assessments, with regard to dimensions, but also that there were differences in methods used. These different approaches to classifying quality of life by dimensions often overlapped in terms of topic but differed in phrasing. Overall, the majority of studies regarded aspects such as health, education, employment, governance, social relationships, environment, security and overall life satisfaction as essential factors in QoL.

The ANIMA review resulted in similar segmentation to EUROSTAT's and a decision was made to adopt the latter framework for this research, embracing nine dimensions of QoL: health, economic and physical safety, natural and living environment, productive or main activity, education, material living conditions, leisure and social interactions, governance and basic rights, and overall life satisfaction (See Figure 1). Indicators were then mapped onto one of the nine QoL dimensions and assessed in terms of data availability, sensitivity to changes in QoL, general advantages, key limitations and relevance to an airport. It was considered vital that indicators were of good quality and could meet the goals of airport management. Thus, a selected indicator needed to be easily monitorable and, ideally, have associated high quality data available. To match airport operator aims, it was also important that the aspect captured by the indicator could be influenced by the airports.

It should be noted that the types of indicators used were diverse. There were absolute qualities, absolute surrogates for qualities (i.e. crime rates for fear of crime) and subjective indicators. Availability varied and this highlights that if an airport wants to understand its impact on QoL, it will most likely be necessary to collect new data, with attendant cost implications unless digital technologies can be used innovatively.

Figure 1: Objective environmental parameters related to a person's subjective reflection on current and future wellbeing. The figure above shows nine indicators of quality of life (QoL) in relation to aviation (© NLR).

3.2 Selection of interventions

The research sought to include a mix of previous interventions for study which are summarised in the table below:

Table 1: Interventions and airports studied.

Airport	**Frankfurt (FRA)**	**Heathrow (LHR)**	**Marseille (MRS)**	**Schiphol (AMS)**
Intervention	Consultation procedure	Sound insulation	Sound insulation	Departure procedure
Pillar of BA	Communication	Land use planning	Land use planning	Operational procedure

Flight movements per year	513.912	476.133	109.894	496.826
Number of passengers	70.560.987	80.000.000	10.151.743	71.700.000
Year founded	1947	1946	1922	1916 as military airbase; 1949 main civil airbase
Recent expansions	Runway Northwest 2011 Terminal 3 (planned for 2021)	Runway 3 (On hold at present)	Extension Terminal 1 (finished in 2022)	Polderbaan opened in 2003 New pier completed 2019 New terminal and pier development operational in 2023
Ranking in country	1	1	5	1
Night time operations	Night-flight ban between 11pm and 5am	No formal ban on night flights but since the 1960s, Government has placed restrictions on them, according to a noise and number calculation which effectively means that more movements are possible, if aircraft are quieter Currently, 5,800 night-time movements/year (23:30 to 06:00)	Night restriction for noisy aircraft "chapter3" flights from 22h45 to 6h15	Restrictions for take-offs and landings between 23:00 and 06:00, single take-off and single-landing runway

In order to provide context to this study, it was important to investigate interventions involved in the scope of the Balanced Approach (ICAO, 2008) procedure. Indeed, as this is a European project, there was perceived to be merit in selecting "standardized" interventions that can also be developed in other countries. Moreover, each of these interventions is well established in the ICAO program and has some clear goals to achieve. Thus, it was considered important to see if the objective of the intervention studied was in line with a more sensitive goal like residents' QoL. The aim was to investigate if some of these interventions were likely to improve residents' QoL and, as a minimum, to formulate some recommendations, in line with our data, if not.

The Balanced Approach entails identifying the various noise problems at an airport and then analysing the measures available to reduce noise. Four main methods are used to enhance the management of noise in the environment. The measures set out in the balanced approach are applied on a case-by-case basis, taking into account the specifics of each airport. This strategy allows airports to pursue their integrated development strategies.

According to ICAO's Balanced Approach, there were initially four pillars each comprising a different set of interventions (See Figure 2). Reduction of noise at the source was mainly designed for aircraft characteristics (e.g. manufacturer's new technology) whereas land use planning and management aims at noise impact reduction by either zoning areas to prevent the exposure of sensitive receptors to aircraft noise and/or by reducing noise inside buildings by providing insulation to dwellings within specified noise exposure limits by defining several legal areas for noise mitigation (e.g. insulation, tax rebates, relocation plan, etc.). Operational measures refer to interventions that aim at reducing aircraft noise by using alternative procedures (e.g. specific procedure for take-off and landing, impose turn to pilot, noise preferential routes, etc.*)*. Finally, operating restrictions refer to the limitation of access of an aircraft at an airport, ICAO considers this as the last option that should be used (e.g. noise quotas, Curfew, etc.).

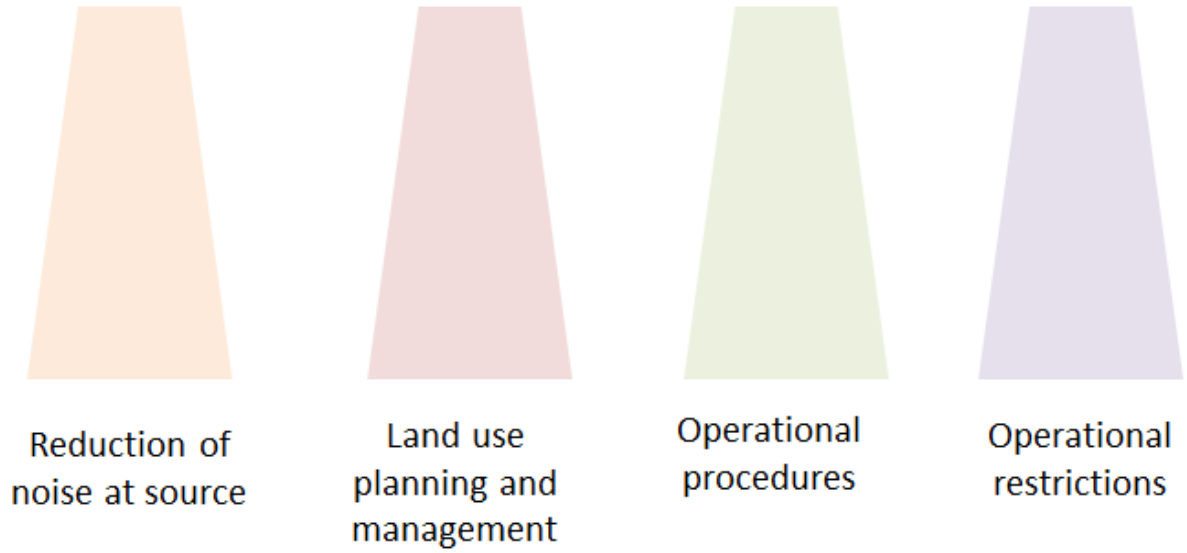

Figure 2: Four pillars of the ICAO Balanced Approach.

One of the key learnings within ANIMA is the understanding of communication strategies with all stakeholders and especially towards residents. Successful implementation of any kind of interventions requires understandable and transparent communication throughout the whole process, starting as early as possible. The importance of community engagement and communication strategies is emphasised by the four previous interventions, assessed within the current study.

4 Microklimaat Leimuiden – Schiphol Airport

In the Netherlands, the Alderstafel is a consultation roundtable about the development of aviation in its environment. The Alderstafel is named after the chairman, former minister and commissioner of the Queen of Groningen, Mr. Hans Alders. The consultation table was set up in December 2006 to advise the cabinet on the development of Schiphol Airport in conjunction with Eindhoven and Lelystad airports. The Alderstafel aims for a balance between aviation development, nuisance-limiting measures, improving the quality of the living environment and the possibilities for using the space around the airport. With regard to Schiphol airport, the Alderstafel aimed for a reduction of aviation noise annoyance by limiting the number of flight movements in 2008, by promoting continuous descent approaches (CDA) and by optimizing departure and arrival routes. At the same time, Schiphol airport was aiming for growth, introduction of a new air traffic management (ATM) concept and new noise legislation. Together with the idea of growth, new traffic distribution rules were discussed related to the opening of Lelystad airport. The basis for the development of Lelystad Airport is Schiphol's market forecast. Until 2020, the market demand for traffic at Schiphol was expected to be 580,000 aircraft movements per year. The Alders Agreement stipulates that of these 580,000 aircraft movements, 510,000 movements will be able to take place at Schiphol. Capacity will be created at Eindhoven Airport and Lelystad Airport for 70,000 non-Mainport-bound aircraft movements. Both airports are part of Schiphol Group.

With the aim to reduce the noise exposure around Schiphol airport, the Mikroklimaat study in the areas of Rijsenhout and Leimuiden was carried out. In 2009, the departure route from the Kaagbaan to the east was, after a period of experimentation, definitively changed due to the reduction of noise exposure on Rijsenhout. However, the introduction of this change of route had a negative effect on the number of people exposed to aircraft noise in Leimuiden. The runway system at Schiphol airport is shown in Figure 3.

Figure 3: Schiphol runway system (www.vlieghinder.nl).

As a result, the municipality of Kaag en Braassem visited the Alderstafel in November 2011 and made a request for a Microklimaat study. On June 14, 2012, the Alderstafel decided on a Mikroklimaat project for Leimuiden. The flight tracks (see purple lines in Figure 4) for departures from the Kaagbaan are illustrated in Figure 4. The departure route passes both areas around Rijsenhout and Leimuiden (see red circles in Figure 4).

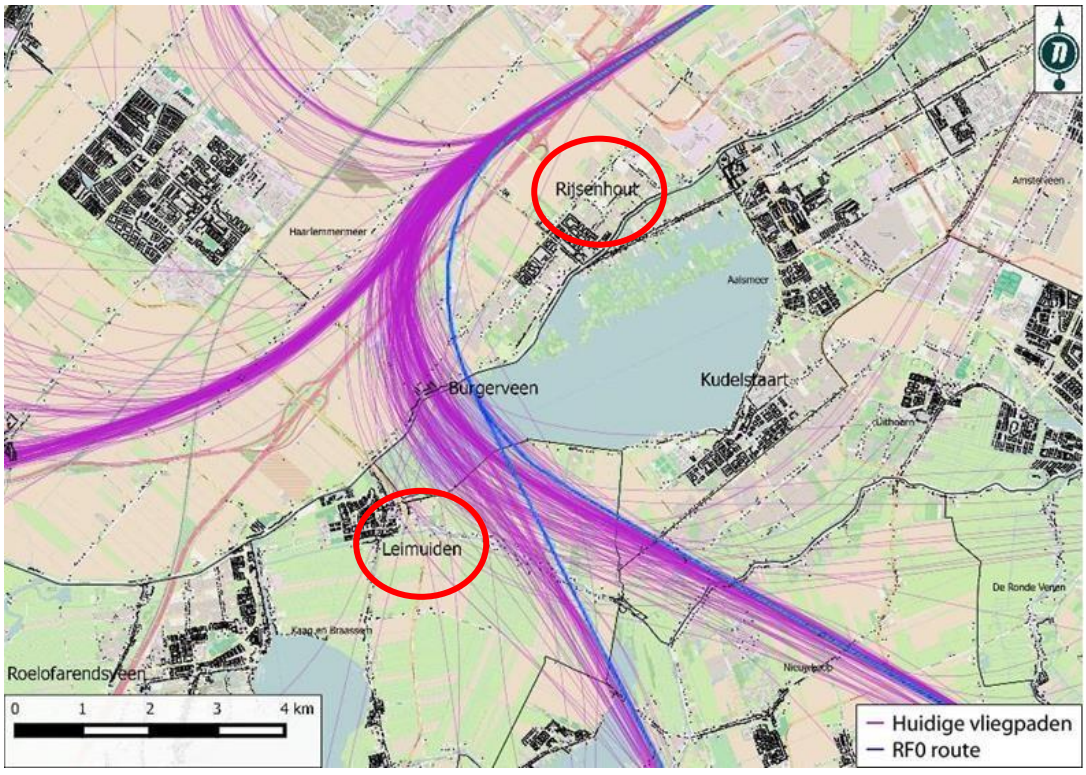

Figure 4: Flight tracks for the departure route from the Kaagbaan (www.rijsenhout.info.nl).

On December 11, 2014, the Alderstafel took a decision on the basis of a quick scan reprioritization of ongoing Mikroklimaat studies. For the Mikroklimaat Leimuiden, a recommendation was made to conduct further research into a combination of a new (optimal) design to fly a fixed curve radius. The original design of the departure procedure implemented during the Mikroklimaat Leimuiden study started in 2015 when a Mikroklimaat study on the area Rijsenhout, together with the implementation of the Noise Abatement Departure Procedure (NADP2) began.

The aim of the Microklimaat Leimuiden study was an optimization of the departure procedure. A radius-to-fix flight procedure was introduced. The purpose of the radius-to-fix was to concentrate flights while making a turn, preventing aircraft from flying spread out over a large inhabited area. In that way, the noise exposure is concentrated and fewer households are exposed to aircraft noise. It was hypothesized that a smaller number of noise exposed households would result in a smaller number of annoyed residents. The flight path was closer to Rijsenhout and further away from Leimuiden (see Figure 4 and Figure 5 for illustrations of the locations).

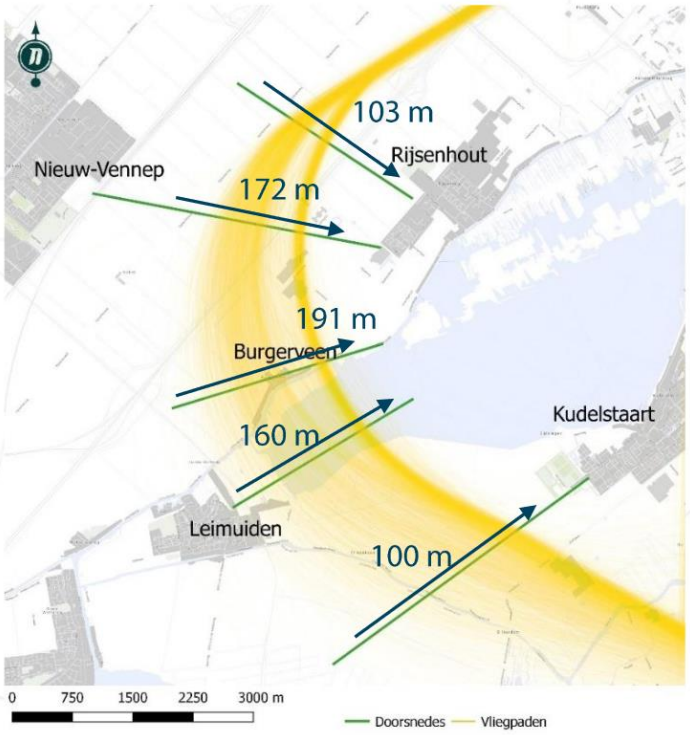

Figure 5: Departure flight paths including an illustration of the radius-to-fix turn (www.omgevingsraadschiphol.nl).

The flight path for the flight turn procedure is shown in yellow in Figure 5. By applying the radius-to-fix procedure, flight paths are less spread towards Leimuiden and more concentrated towards the north, in the direction of

Burgerveen, Kudelstaart and Rijsenhout. The implementation of the Leimuiden Mikroklimaat started in September 2015.

The success criteria for the implementation of the radius-to-fix departure procedure were defined as follows:

- Reduction in the estimated number of highly annoyed residents in surrounding 4 municipalities
- Reduction of the estimated number of highly annoyed residents within the 48 L_{den} contour
- For Rijsenhout, the noise exposure must not exceed the noise levels from before 2007
- For the municipality, Burgerveen, the number of annoyed residents must not increase
- An overall reduction of noise annoyance in Leimuiden

The radius-to-fix departure procedure was proposed, based on the above mentioned preconditions. The effects of this procedure were calculated by the consultant company To70 and assessed by a mixed group of stakeholders, including representatives from local municipalities, the local government, Community Council Schiphol (Omgevingsrad Schiphol – ORS) chairs, residents that were representatives within and outside the ORS and representatives from the Air Navigation Service Provider (ANSP), a hub-airline and the airport. The group of stakeholders was called the "working group".

In December 2015, the working group concluded that the collected research data on the alternative departure procedure provided sufficient information for the execution of an experiment. On January 27, 2016, after consultation of the respective constituencies, the radius-to-fix turn procedure was proposed for implementation.

Monitoring factors for the tested flight procedure were:

- Shift in lateral movements / ground paths of air traffic
- Concentration of flight bundles ("Poortjes Methode")
- Local pivot point ("locale draaipunt")
- Fixed curve radius ("vaste bochtstraal")

Within the current study, the radius-to-fix departure procedure was experimentally tested for approximately 40% of the air traffic during that time in 2017. The expected noise levels were calculated before and after the implementation of the procedure. Noise measurements were additionally carried out during the experimental period.

Within the working group, technical aspects of the departure procedure and the results from the calculations and measurements were presented and explained by external consultants from the consultant company To70. The measured peak noise levels (L_{Amax}) were averaged for the flight movements in 2017 (orange colour, Figure 6) and compared to the averaged peak levels for the flight

movements in 2016 (blue colour, Figure 6). In Figure 6 the normalized flight movements are on the y-axis and the peak noise levels L_{Amax} in dB(A) on the x-axis. The data suggest that the normalized number of flights was higher for peak levels between 65 and 69 dB(A) in 2016 compared to 2017.

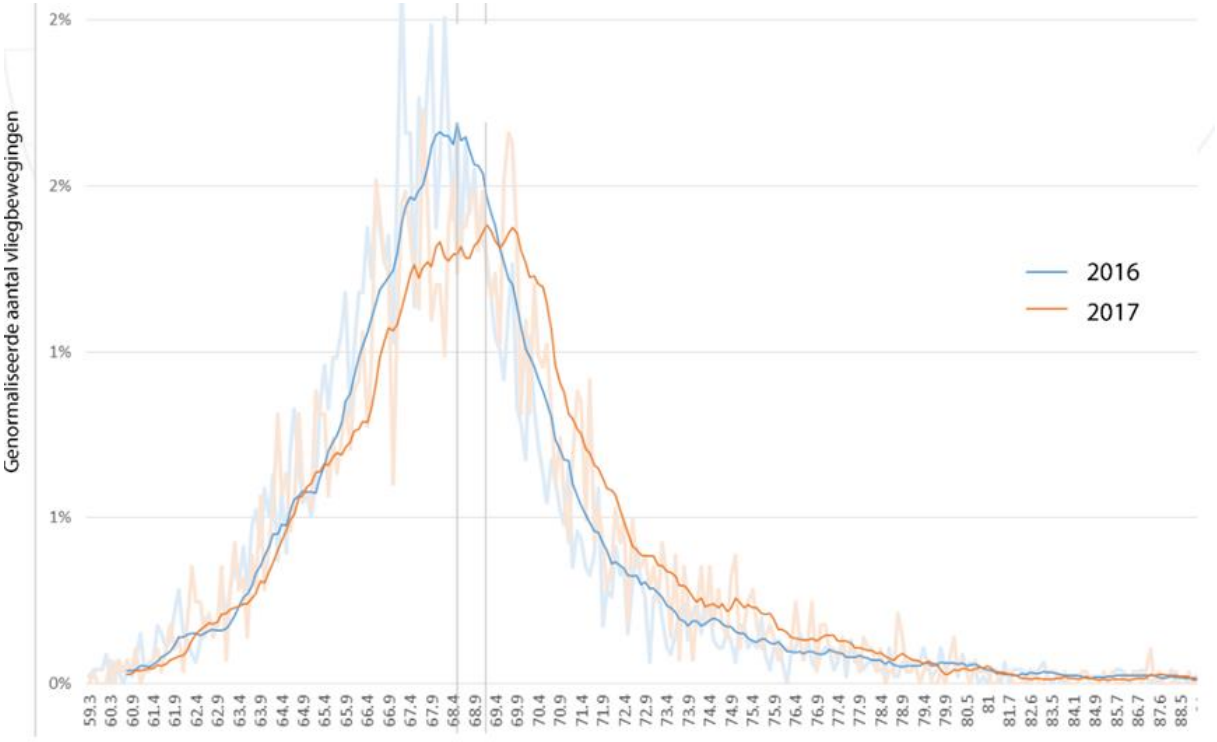

Figure 6: Normalized number of flights over peak noise levels (L_{Amax}) (www.omgevingsraadschiphol.nl).

Additionally, L_{den} levels were calculated for the departures from different runways at Schiphol airport (see Figure 7). The number of take-offs from and landings on the Aalsmeerbaan are higher in the second half of 2017 than in 2016. The second runway was used more intensively due to the increase in the number of movements at Schiphol. Overall, the average noise levels for 2017 seem to be lower compared to the average noise levels in 2016.

Within the ORS Regioforum, the decision for starting and monitoring the experiment was made. The information about the ongoing experiment was shared via local and social media.

In December 2017, the technical status was presented to the stakeholders within the working group. The technical results such as the calculations of noise levels promised a reduction of noise exposure. Most residents were supportive of the new departure procedure. However, there were also signs of doubts amongst the residents of Aalsmeer and Kudelstaart (for information on the location see Figure 4 and Figure 5).

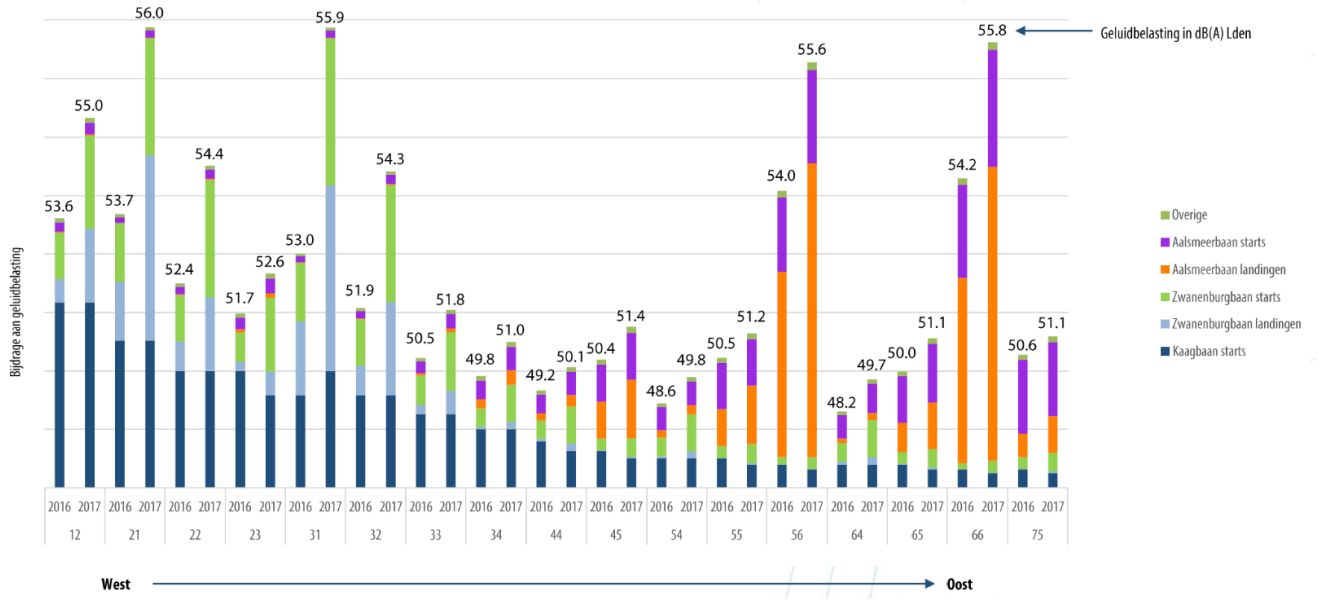

Figure 7: L_{den} noise levels for departures from different runways at Schiphol for 2016 and 2017 (www.omgevingsraadschiphol.nl).

Figure 8 shows the difference of noise exposure in dB for the percentage of residents for Kudelstaart and Leimuiden for 2016 and 2017. The exposure of higher noise levels, caused by air traffic, was higher in 2016 in Leimuiden compared to Kudelstaart. In 2017, the calculated noise exposure in Kudelstaart was higher than in 2016. In Leimuiden, the noise exposure was actually lower in 2016 than in 2017, but still higher than in Kudelstaart.

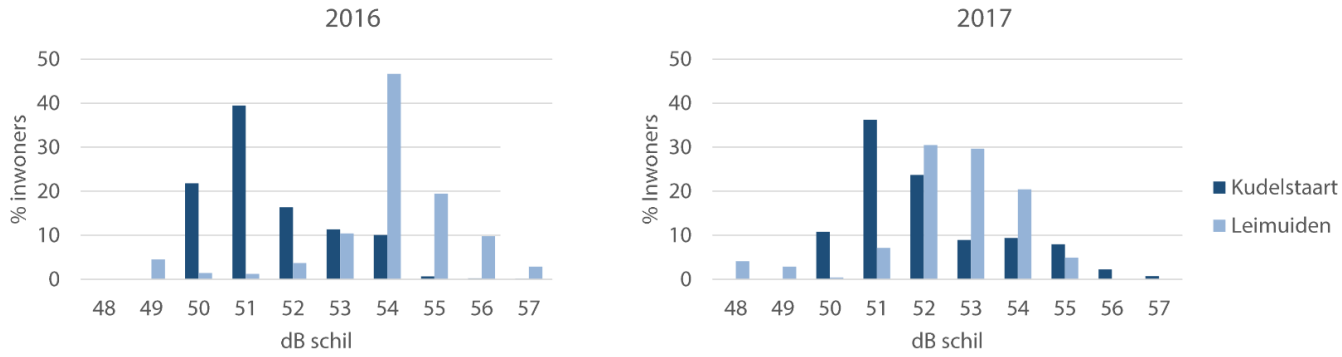

Figure 8: The percentage residents for Kudelstaart and Leimuiden across the difference in aircraft noise exposure between 2016 and 2017 (www.omgevingsraadschiphol.nl).

It was decided that the experiment should be continued to gather more detailed data. In 2018, a decision was made to carry out an annoyance perception study. During this study, input from the residents around Kudelstaart was provided. Reports and complaints around the area Kudelstaart were collected for the time between 2016 and 2018. The data was collected by the Residents Contact Point Schiphol (Bewoners Aanspreekpunt Schiphol - BAS). Notifications are automatically linked to a runway by BAS. Specific and periodic complaints were examined. Specific complaints are, for example, per flight, related to aircraft

taking off from the Kaagbaan at a specific time. Periodic complaints are reports over a period. The specific complaints were analysed in 2018. The effect of the experiment was investigated by examining complaints and reports related to flights that flew the radius-to-fix turn departure procedure and a "control group" for flights that flew the original departure procedure (see Figure 9). The grey curve in Figure 9 indicates the total number of complaints, the light blue curve refers to the number of complaints related to the radius-to-fix turn procedure and the black curve refers to complaints related to the original departure procedure. The willingness to report complaints increased for the test groups exposed to the alternative departure procedure (radius-to-fix turn) and in the control group to a similar extent. There was no direct interaction between the increase in complaints and the Microklimaat study indicated.

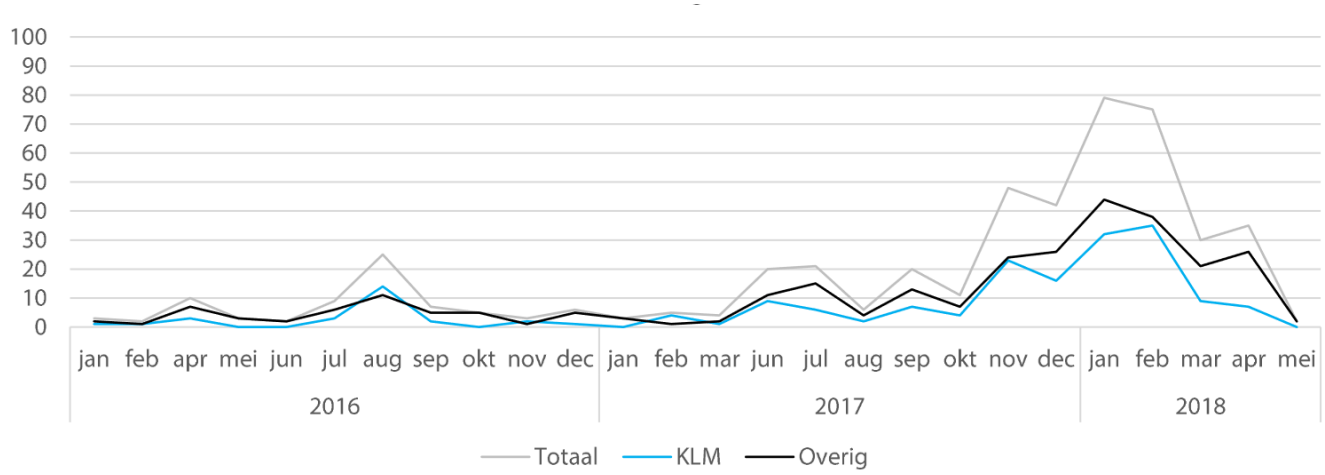

Figure 9: Number of complaints and reports between 2016 and 2018 (www.omgevingsraadschiphol.nl).

The overall number of complaints and the number of reporting persons has increased, which corresponds to the general trend for the Schiphol area (www.bas.nl).

A survey about the living environment, aircraft noise annoyance and residential satisfaction was conducted from November 2018 until October 2019. This survey was commissioned by the Community Council Schiphol. In total, a sample of 1,212 resident responses was collected. During the survey period, approximately 100 telephone interviews were conducted each month for the period of one year. The results of the survey are described further in section 4.2.

4.1 Distilling previous learnings

4.1.1 Methodology

In order to distil previous learnings, we applied the following key words for the literature search:

- Aviation AND noise annoyance AND quality of life AND intervention OR satisfaction OR living environment OR operational procedure

The literature search was applied using Google scholar. The above mentioned combination of keywords provided mainly results on wind turbines, urban development, traffic noise and health related aspects of quality of life. It was especially difficult to identify research related to quality of life and aviation.

4.1.2 Results

It was not possible to identify a large body of literature describing the implementation of comparable operational procedures in aviation. However, the annoyance response to aircraft noise exposure in general has been investigated. The annoyance response to stable and changing aircraft noise exposure has been assessed for changes in flight operations that have been carried out between 2001 and 2003 (Brink et al., 2008). A considerable number of early morning and late evening flight operations have been relocated around Zürich Airport to use another runway. In that way, the effects of a recent step decrease and recent step increase on the exposure-annoyance relationship were investigated. The results from the applied survey showed that residents experiencing a step increase elicited a quite pronounced 'over-reaction' of annoyance which correlated with the magnitude of the change (Brink et al., 2008). The residents' pronounced annoyance reaction was surprising for the authors as the upcoming changes in the flight regime were announced in the media for more than a year in advance. Brink et al. (2008) conclude that residents actually rate their annoyance based on real experienced exposure and not on any imaginary future noise scenario.

Another recent study investigated aircraft noise annoyance and health related quality of life (HQoL) before and after the opening of the 4th runway at Frankfurt Airport (Schreckenberg et al., 2016). The aim of opening the new runway was to increase the capacity of the number of operations from 83 to 120 flight movements per hour. Telephone surveys on the effects of transportation noise on annoyance, disturbances and HQoL, in addition to reported diagnosed health diseases and sleep quality, were carried out. The results suggested an association between HQoL and aircraft noise annoyance, noise sensitivity and aircraft noise exposure. The percentage of highly annoyed people was found to be higher than predicted from general exposure-response curves. It was found that the more residents were annoyed by aircraft noise, the poorer was their HQoL. All in all, the study showed that the impact of aircraft noise on residents living in the vicinity of an airport affects noise-specific stress reactions (annoyance, disturbances) as well as QoL in general (Schreckenberg et al., 2016, 2017).

Aircraft noise annoyance, disturbances, environmental (EQoL) and health-related quality of life (HQoL) were assessed within another survey in which data from 2,312 residents living near Frankfurt Airport was assessed (Schreckenberg et al., 2010). The survey data was compared with data on exposure due to aircraft, road traffic, and railway noise. Results indicate a link between HQoL and aircraft noise annoyance and noise sensitivity. The higher the aircraft noise annoyance, the lower the reported HQoL; especially for higher noise-sensitive participants. There was

also a small effect of aircraft noise exposure on reported EQoL (Schreckenberg et al., 2010). A study by Wirth, Brink, and Schierz (2004) found that a high satisfaction with the acoustical characteristics of one's living environment is related to a decrease in noise annoyance. There was no effect with respect to non-acoustical characteristics and noise annoyance.

An effect of noise annoyance on residential satisfaction has also been identified for other noise sources (road and rail traffic; Urban & Máca, 2013); although, there was no influence of noise annoyance on overall life satisfaction.

The relationship between airports and multiple subjective wellbeing measures has been investigated for seventeen English airports (Lawton et al., 2016). The relationship was assessed by merging national household-level data (APS) with geographical location data on airport proximity (within 5 km) and objective measures of aviation noise contours (dB). The results suggest that the presence of daytime aviation noise has a consistent negative impact on five subjective wellbeing measures. A marginal negative association with every additional decibel of aircraft noise was found. The authors suggest a negatively associated effect of living within a daytime aircraft noise contour (at or above 55 dB) and lower life satisfaction, lower sense of being worthwhile, lower happiness, increased anxiety and lower positive affect balance. Overall, it was concluded that living under air traffic flight paths has a negative effect on peoples' overall and momentary wellbeing, equivalent to around half the effect of being a smoker for some wellbeing measures (Lawton et al., 2016). However, as the study took Leq day contours into account to assess noise exposure, it might be tricky to draw conclusions for noise exposure under air traffic flight paths.

4.1.3 Discussion

Currently decisions about operational changes of flight procedures around airports are typically based on calculations of average noise levels, technical aspects of flight procedures or the calculated number of households within a noise contour. Based on this kind of technical data, assumptions are made about the perception and annoyance of aircraft noise. Aircraft noise might affect the environmental quality of life more than road or railway noise and furthermore people of poor HQoL might suffer most from annoyance. Future research should seek to capture the effects of aviation on effective measures of well-being like happiness and anxiety and quality of life, through use of real-time surveys and real-time scenarios.

4.1.4 Conclusion

When residents around airports were able to listen to actual changes in operational flight procedures, the percentage of highly annoyed people was found to be higher than predicted from general exposure-response curves. The consideration and the decision-making process related to changes in operational flight procedures should not only be based on technical calculations of noise exposure and extrapolating from that to predicting annoyance. Rather airports need to adopt a more holistic approach complementing calculations with nuanced understanding of people's reactions regarding noise exposure. The residents'

actual perception of aircraft noise and aspects of annoyance should also be taken into account in the decision-making process.

4.2 Survey data

A study was conducted with residents living in the vicinity of Schiphol Airport from November 2018 until October 2019. The study was commissioned by the Community Council Schiphol and conducted by the Dutch company Team Vier. The survey started one year after the implementation of the radius-to-fix approach. Leimuiden is located within the study area; however, the change in aircraft noise annoyance due to the radius-to-fix approach was not specifically addressed in the survey. The aim of the survey was to assess residents' experiences and perceptions of living in an airport's vicinity and identify relevant topics for residents and potential concerns regarding their living environment as the general number of complaints increased for the Schiphol area. The ANIMA research team received permission to use this data for further analyses. This survey data provides a general overview of residential satisfaction, noise annoyance due to different sources, certain days or times of day when specifically aircraft noise is annoying and disturbing, as well as aspects residents are mainly concerned about. In the following sections, the analyses are described and the results discussed.

4.2.1 Methodology

The study area was divided into three areas according to different levels of aircraft noise exposure:

4. Inner area (Binnengebied, close to the airport; 58dB L_{den}),
5. Outer area (Buitengebied; 48dB – 57dB L_{den}),
6. Area outside noise contour (Buiten contour; less than 48dB L_{den}),

with Leimuiden being located in the outer area with L_{den} ranging from 48dB to 57dB. Figure 10 depicts the three study areas on a map.

Figure 10: Map of region around Schiphol Airport indicating the three study areas. The red dot indicates the location of Leimuiden.

As less people live in the inner area than in the other two areas, a disproportionate stratified sample was used allowing for statistical comparison between the groups. The sample consists of 1.212 residents, aged 18 and older, which translates into a response rate of ca. 14%.

The following topics were covered in the survey: residential satisfaction (assessed using a 5-point scale ranging from 1= very satisfied to 5= very unsatisfied), duration of residence, noise annoyance and sleep disturbance due to various noise sources (according to ISO norm ISO/TS 15666, 2003; 11-point scale ranging from 0= not at all to 10= extremely), perception of the previous development of aircraft noise annoyance (answered using a 3-point scale where 1= increased, 2= stayed the same, and 3= decreased) as well as future expectations of aircraft noise annoyance (answered using a 3-point scale with 1= have increased, 2= have remained the same, and 3= have decreased), and frequency about being disturbed by aircraft noise in the past month (4-point scale with 1= often to 4= seldom or

never). Item 10 was an open question asking whether participants can indicate days or times of day where they experience most aircraft noise annoyance. Participants, who then indicated certain days or times of day, were presented with questions specifically assessing when they experienced aircraft noise annoyance (n = 779). Moreover, worries about different topics such as the environment (answered on a 3-point scale ranging from 1= a lot of worries to 3= no worries) were assessed.

The data were analysed using SPSS 27.

4.2.2 Results

In the following section, the sample descriptions as well as the different analyses are presented. A description of the sample can be found in Table 2.

Table 2: Sample description.

		inner area	outer area	outside noise contour	Total
N		251	722	239	1212
Age	*m(SD)*	58.7 (13.2)	58.5 (13.9)	56.7 (13.2)	58.2 (13.6)
	min	18	18	19	18
	max	83	87	81	87
Sex	female	140	393	131	664
	male	111	329	108	548
Home office	always	18	20	13	51
	often	12	10	7	29
	regularly	19	49	24	92
	sometimes	32	89	32	153
	seldom/never	59	219	67	345
	missing & n/a	111	335	96	542
Duration of residence	0 - 5 years	20	92	36	148
	5 - 10 years	28	89	21	138

	10 – 20 years	62	206	78	346
	20 – 30 years	57	147	48	252
	> 30 years	84	188	56	328
Highest level of education	no education / basic education / civic integration course / Dutch language course	7	17	2	26
	LBO / VBO / VMBO (framework or profession-oriented learning pathway) / MBO 1 (assistant training)	15	42	8	65
	MAVO / HAVO or VWO (first three years) / ULO / MULO / VMBO (theoretical or mixed course) / secondary special education	37	94	32	163
	MBO 2, 3, 4 (basic vocational, professional, middle management or specialist training) or MBO old (before 1998)	58	178	66	302
	HAVO or VWO (transferred to 4th grade) / HBS / MMS	20	48	17	85
	HBO or WO propaedeutic year/HBO (except HBO master's programme) / WO candidate or WO	70	219	69	358

	bachelor's programme				
	WO-doctoral or WO-master or HBO-master / postdoctoral education	40	115	39	194
	n/a	4	9	6	19
Employment	fulltime	83	205	88	376
	part-time	58	183	55	296
	no	109	333	95	537
	n/a	1	1	1	3
Employment Schiphol	yes	11	23	7	41
	no	130	365	136	631
	missing & n/a	110	334	96	540
Ownership	owner	206	489	168	863
	rent	44	233	70	347
	missing	1	0	1	2
Residential satisfaction	very unsatisfied (5)	8	14	2	24
	unsatisfied (4)	18	23	6	47
	neither satisfied nor unsatisfied (3)	24	45	14	83
	satisfied (2)	125	377	121	623
	very satisfied (1)	75	262	96	433
	missing	1	1	0	2

	m(SD)	2.05 (1.02)	1.83 (.85)	1.73 (.75)	1.85 (.86)

m = means; SD = standard deviation

On a scale from 1 to 5 (1=very satisfied, 5=very unsatisfied), average residential satisfaction is 1.85 (*SD*=.87), showing an overall high residential satisfaction. Only 12.9% of participants were not satisfied with their living environment. Participants stating that they were very unsatisfied mentioned aircraft noise annoyance as the main reason (See Figure 11).

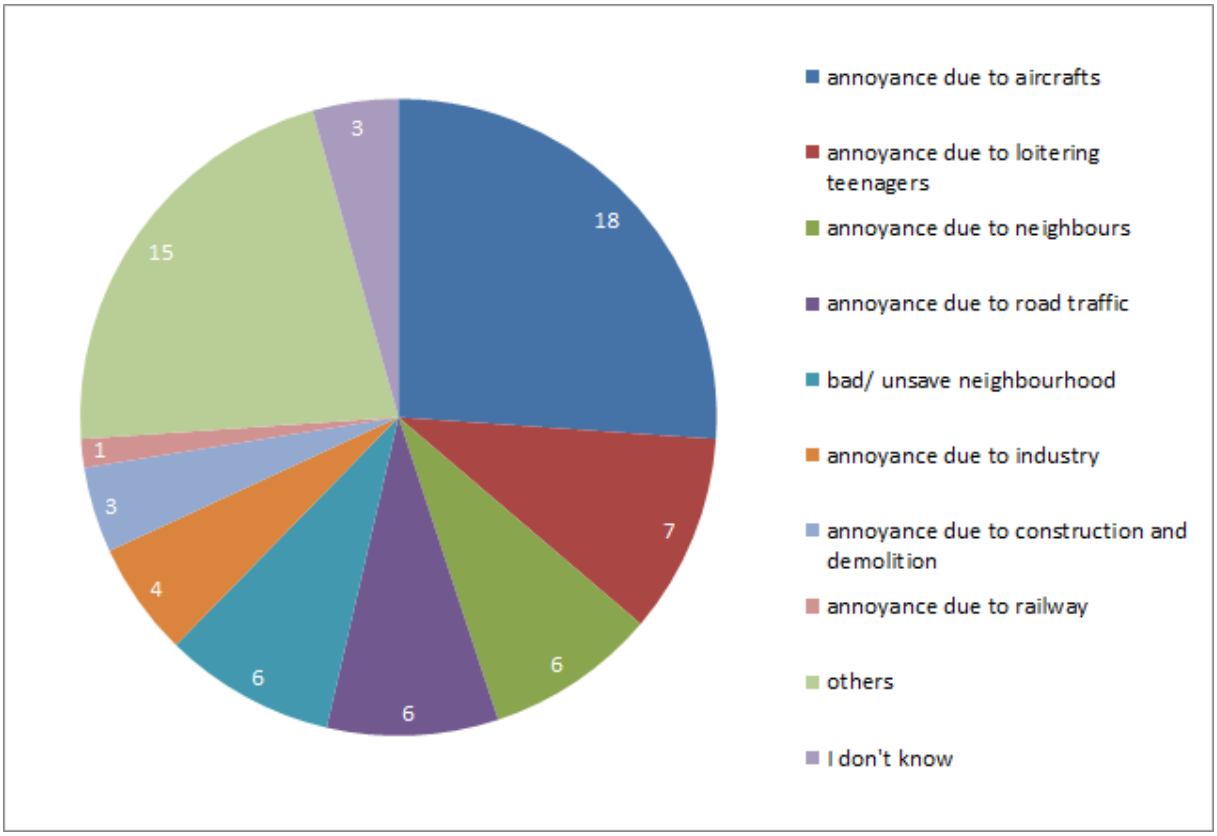

Figure 11: Number of reasons mentioned for dissatisfaction with living environment.

Noise annoyance, sleep disturbance and worries concerning different topics served as predictor variables for residential satisfaction. Table 3 displays an overview of the descriptions of these variables categorized for each study area.

Table 3: Comparison of means (standard deviations) of noise annoyance, sleep disturbances, and worries between groups.

		inner area	**outer area**	**outside noise contour**	**Total**
N		251	722	239	1212
	road traffic	2.93 (2.83)	2.51 (2.72)	2.64 (2.95)	2.63 (2.79)

Noise annoyance 11-point response scale from 0 (not at all) to 10 (extremely)	neighbours	1.71 (2.48)	1.97 (2.57)	1.90 (2.50)	1.90 (2.54)
	railway	.17 (.86)	.50 (1.44)	.71 (1.76)	.47 (1.42)
	aircraft	6.61 (3.11)	4.30 (3.20)	2.97 (2.99)	4.52 (3.35)
	industrial	.88 (1.82)	.67 (1.74)	.76 (1.98)	.73 (1.81)
	construction and demolition	1.46 (2.46)	1.74 (2.46)	2.01 (2.78)	1.73 (2.53)
	loitering teenagers	1.15 (2.17)	1.28 (2.27)	1.29 (2.42)	1.25 (2.28)
Sleep disturbance 11-point response scale from 0 (not at all) to 10 (extremely)	road traffic	1.18 (2.10)	1.04 (2.08)	1.06 (1.93)	1.08 (2.05)
	neighbours	.55 (1.56)	1.02 (2.08)	1.09 (2.00)	.94 (1.97)
	railway	.05 (.37)	.23 (1.04)	.26 (1.12)	.20 (.96)
	aircraft	4.35 (3.64)	2.28 (3.07)	1.26 (2.42)	2.51 (3.25)
	industrial	.35 (1.23)	.29 (1.19)	.32 (1.22)	.31 (1.21)
	construction and demolition	.51 (1.64)	.61 (1.56)	.59 (1.56)	.58 (1.58)
	loitering teenagers	.66 (1.74)	.76 (1.82)	.80 (2.01)	.75 (1.85)
Worries 3-point response scale from 1 (a lot) to 3 (no worries)	safety	2.39 (.73)	2.35 (.71)	2.41 (.70)	2.37 (.71)
	climate change	1.97 (.77)	1.94 (.76)	1.90 (.78)	1.94 (.77)
	CO2-emission	1.96 (.81)	2.02 (.78)	2.08 (.76)	2.02 (.78)

particulate matter, incl. ultra-fine dust	1.81 (.81)	2.01 (.80)	2.03 (.81)	1.98 (.81)
air pollution	1.70 (.77)	1.91 (.77)	1.97 (.75)	1.88 (.77)
noise annoyance	1.89 (.82)	2.32 (.74)	2.47 (.66)	2.26 (.77)
crowded supply routes	2.29 (.76)	2.24 (.79)	2.28 (.77)	2.26 (.78)
parking facilities	2.58 (.71)	2.40 (.79)	2.37 (.77)	2.43 (.77)
public transport connections	2.54 (.72)	2.52 (.74)	2.60 (.65)	2.54 (.72)

It is apparent that participants living in the inner area are most annoyed by aircraft noise rather than any other noise source. Further, noise annoyance due to aircraft noise is rather high compared to other noise sources. A similar result can be found with respect to sleep disturbances. In general, reported worries are highest for air pollution, climate change and particulate matter. The variable that people are least concerned about is public transport connections. A graphical overview of the average worry regarding the different topics can be found in Figure 12.

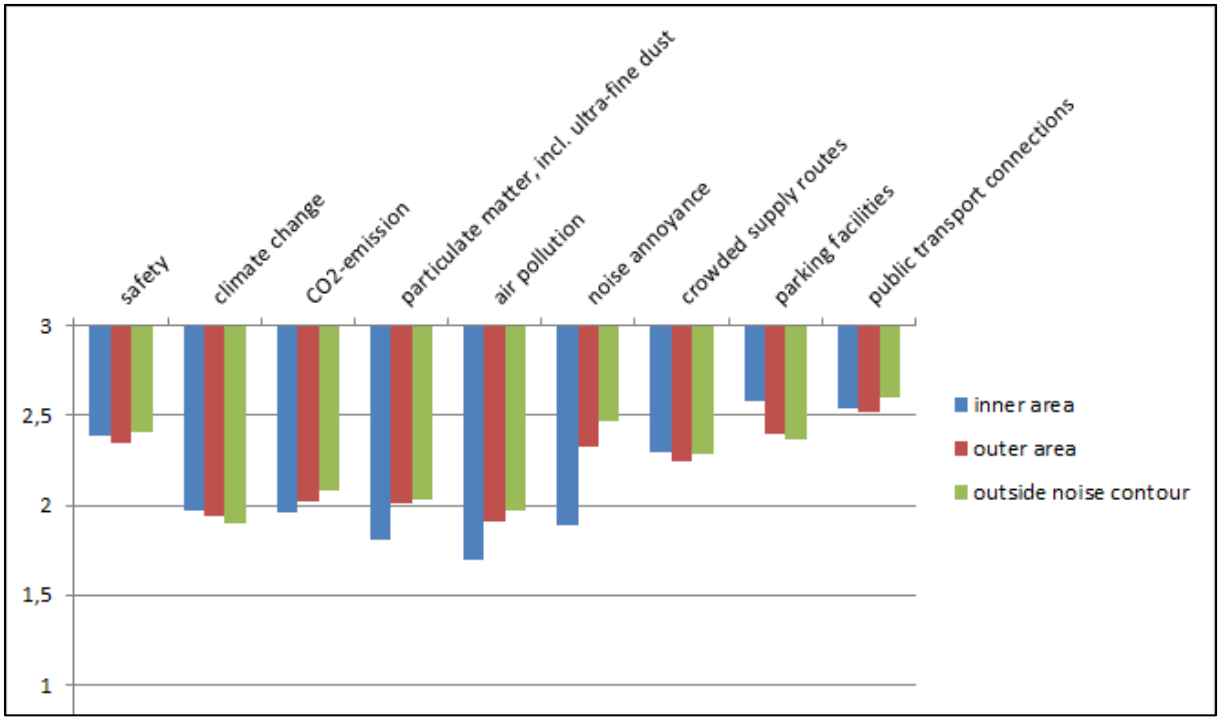

Figure 12: Overview of worry ratings regarding different topics. Rating scale: 1 (a lot) to 3 (no worries).

Participants who indicated certain days or times of a day when they experienced the most aircraft noise annoyance were presented with three follow-up questions for specification. The results are depicted in Figure 13 to Figure 15.

Participants experience more aircraft noise annoyance on weekends than on weekdays. For 20% of participants, lunch-time is the time of a day when they experience the most noise annoyance; followed by the morning hours (14%) and the evening hours (13%). Additionally, the majority of participants experience aircraft noise annoyance at certain times of the year more than at other times.

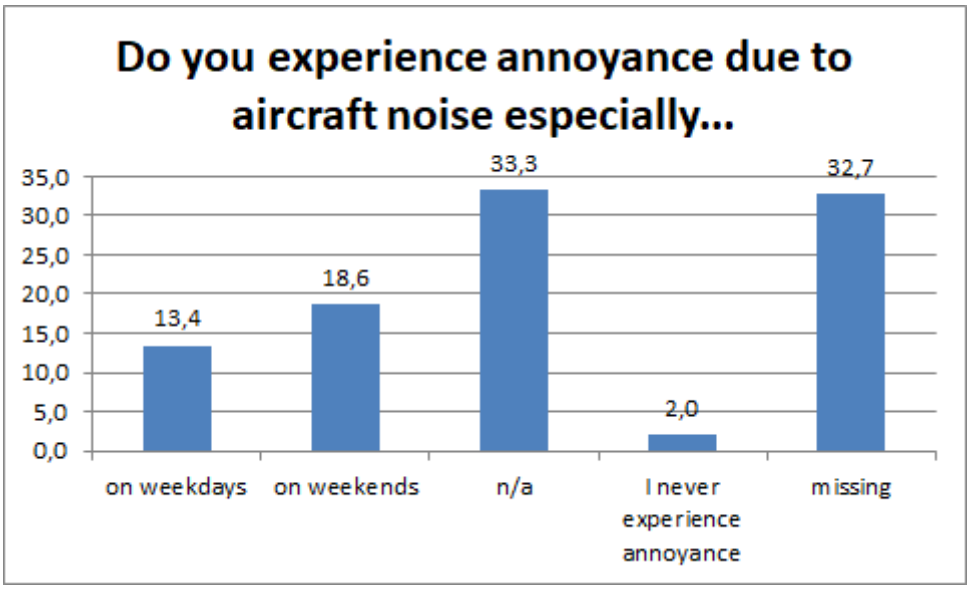

Figure 13: Percentage of participants experiencing aircraft noise annoyance on different days throughout the week. Note: n/a= no answer.

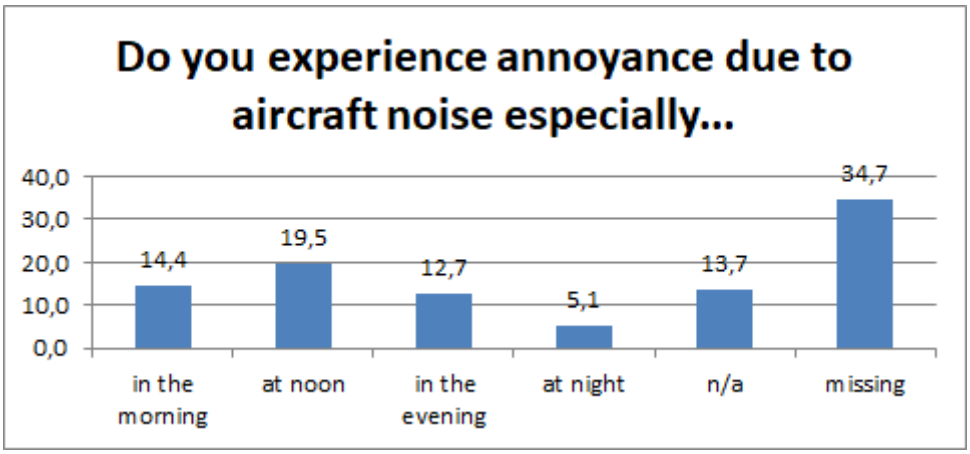

Figure 14: Percentage of participants experiencing aircraft noise annoyance at different times throughout the day. Note: n/a= no answer.

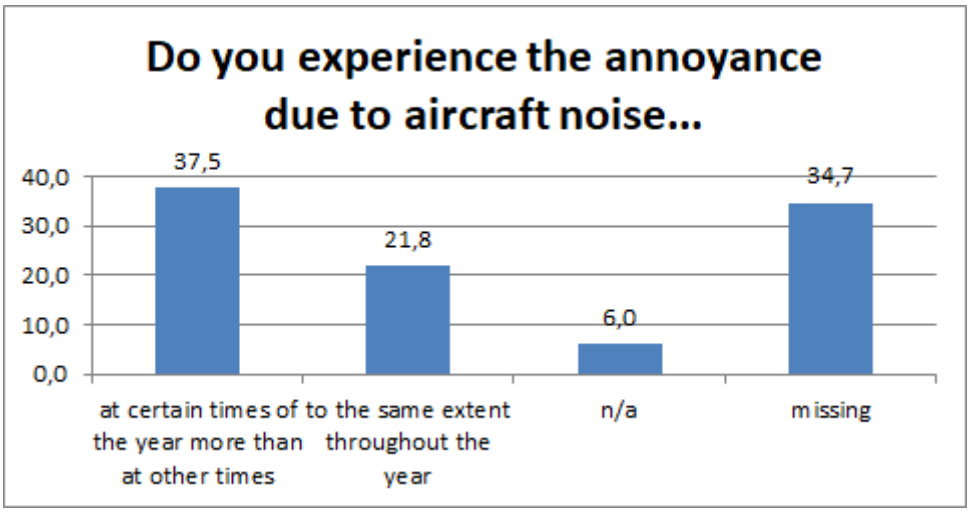

Figure 15: Percentage of participants experiencing aircraft noise annoyance during the year. Note: n/a= no answer.

Figure 16 graphically depicts the strength of the correlations between the different variables. The red colour indicates a negative relationship while the blue colour indicates a positive relationship between the variables. The darker the colour, the higher is the correlation and the stronger is the relationship between the two variables.

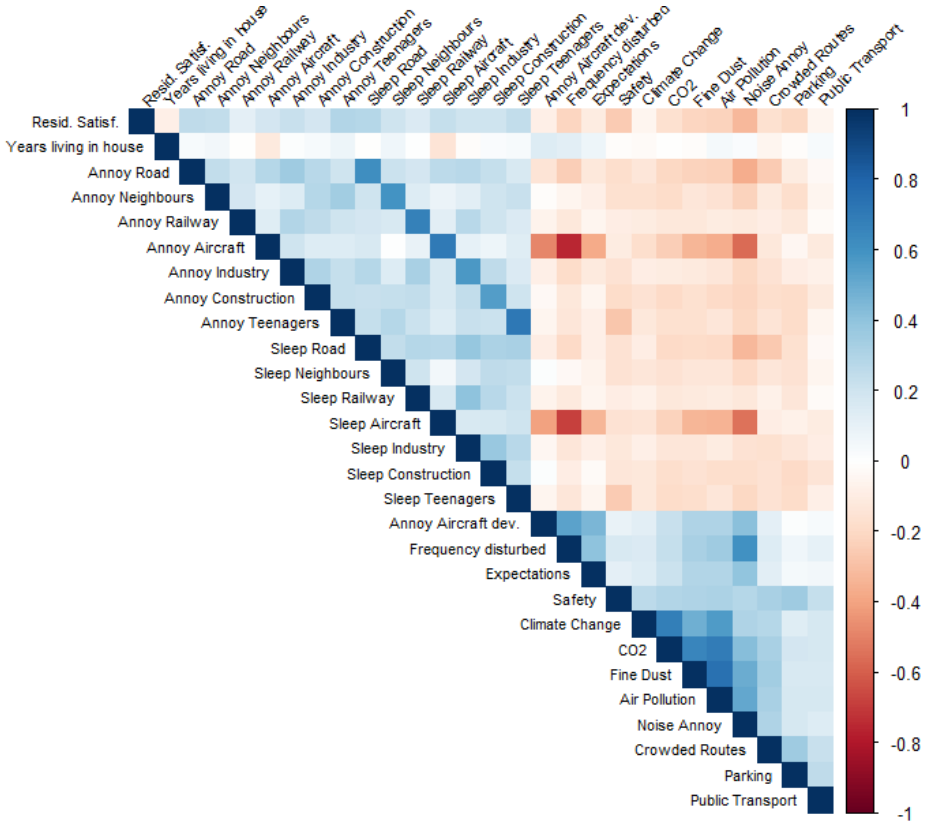

Figure 16: Correlation plot displaying the relationship between the different variables.

The correlation values are depicted in annex 10.1. Residential satisfaction is significantly correlated with all variables of noise annoyance from different sources as well as sleep disturbances due to different sources, showing that higher annoyance and more sleep disturbances are related to a lower level of residential satisfaction. Except for worry concerning climate change and public transport connections, all these variables are significantly correlated with residential satisfaction as well (See Table 10). For example, more worry regarding noise annoyance is associated with less residential satisfaction (r=-.29, p < .01). In addition, the correlations indicate that less residential satisfaction goes along with a higher frequency of aircraft noise disturbance in the past month (r=-.20, p < .01), an increase of aircraft noise annoyance in general (r=-.08, p < .05), and with the expectation of an increase of aircraft noise annoyance in the upcoming 12 months (r=-.10, p < .01).

Aircraft noise annoyance, aircraft noise annoyance development, frequency disturbed by aircraft noise in the past month, as well as expectations for future noise annoyance all correlate significantly with each other. Expectations and the development of aircraft noise annoyance so far are significantly related to each

other (r=.45, p < .01). Participants who indicated that they had been less frequently bothered by aircraft noise in the past month expect their future noise annoyance not to increase (r=.41, p < .01). Further, the more people are annoyed by aircraft noise, the less they expect a decrease of their noise annoyance in the future (r=-.38, p < .01). The more people are annoyed by aircraft noise, the more frequently they have been disturbed by aircraft noise in the past month and the more they do not expect a decrease in noise annoyance (See annex 10.1).

Regression analyses were performed to examine the influence of, e.g., aircraft noise annoyance and sleep disturbances due to aircraft noise on residential satisfaction. Age and sex did not have a significant effect on residential satisfaction. Adding the variable aircraft noise annoyance to the model improves the explained variance of residential satisfaction from 14.1% to 18.6%.The R^2 for the overall model was .186 (adjusted R^2 = .179; $F(11,1198)=24.95$, p < 0.01), indicating a moderate goodness-of-fit (Cohen, 1988). This means that the predictors altogether explain 18.6% (17.9%) of the variance of residential satisfaction. Given that several aspects that are known to be relevant for residential satisfaction such as the social environment (neighbours) and the infrastructure of the residential area (public transport, shopping possibilities) are not included, the variance explained by the predictors is regarded as high.

The regression coefficients for annoyance due to neighbours, industrial noise, loitering teenagers, sleep disturbance due to road traffic and air traffic are significant (See Table 4). This indicates, for example, that a 1-point increase on the scale for sleep disturbances due to aircraft noise is linked to an increase of 0.02-points for residential satisfaction. Due to the scale used (ranging from 1=very satisfied to 5=very unsatisfied), this increase of sleep disturbance is associated with less residential satisfaction. There is no significant effect of aircraft noise annoyance on residential satisfaction. On the other hand, the regression analysis reveals that worries regarding safety and noise annoyance in general have the largest impact on residential satisfaction.

Table 4: Results of the regression analysis.

				95% CI	
Predictor	**B**	**SE**	**p**	**Lower**	**Upper**
Intercept	2.324**	.140	.000	2.049	2.599
Road traffic noise annoyance	-.006	.011	.608	-.027	.016
Neighbour noise annoyance	.034**	.010	.001	.014	.053
Aircraft noise annoyance	-.015	.010	.133	-.036	.005
Industrial noise annoyance	.047**	.014	.001	.020	.075

Construction and demolition	.002	.010	.809	-.017	.022
Loitering teenagers	.052**	.015	.001	.022	.081
Sleep disturbance road	.049**	.015	.001	.020	.078
Sleep disturbance aircraft noise	.022*	.010	.034	.002	.042
Sleep disturbance teenagers	.000	.018	.999	-.036	.036
Worry safety	-.128**	.034	.000	-.194	-.061
Worry noise annoyance	-.161**	.040	.000	-.239	-.084

B = unstandardized regression coefficient, SE= standard error, p = probability of error, *. significant at .05.; **. significant at .01.

To compare the means of the variables between the different study areas, an Analysis of Variance (ANOVA) was calculated. The ANOVA reveals a significant difference between the three study areas regarding residential satisfaction, annoyance by railway and aircraft noise, sleep disturbance due to neighbours, railway and aircraft noise (see Table 5). Further, how participants' aircraft noise annoyance developed in general, the frequency with which participants were bothered by aircraft noise in the past month, as well as expectations regarding one's future noise annoyance differ significantly between groups.

Table 5: Results of the ANOVA analysis.

Measure	Inner area		Outer area		Outside noise contour		F(2,1207)	p
	m	SD	m	SD	m	SD		
Residential Satisfaction	2.04	.99	1.82	.83	1.73	.75	8.62	.000
Noise annoyance due to								
Road traffic	2.93	2.83	2.51	2.72	2.64	2.95	2.06	.128
Neighbours	1.71	2.48	1.97	2.57	1.90	2.50	.92	.399
Railway	.17	.86	.50	1.44	.71	1.76	9.28	.000
Aircraft	6.61	3.11	4.30	3.20	2.97	2.99	86.61	.000
Industry	.88	1.82	.67	1.74	.76	1.98	1.32	.268
Construction and demolition	1.46	2.46	1.74	2.46	2.01	2.78	2.95	.053
Loitering teenagers	1.15	2.17	1.28	2.27	1.29	2.42	.35	.708
Sleep disturbance due to noise from								
Road traffic	1.18	2.10	1.04	2.08	1.06	1.93	.44	.644

Neighbours	.55	1.56	1.02	2.08	1.09	2.00	6.09	.002
Railway	.05	.37	.23	1.04	.26	1.12	3.80	.023
Aircraft	4.35	3.64	2.28	3.07	1.26	2.42	66.75	.000
Industry	.35	1.23	.29	1.19	.32	1.22	.26	.770
Construction and demolition	.51	1.64	.61	1.56	.59	1.56	.38	.684
Loitering teenagers	.66	1.74	.76	1.82	.80	2.01	.42	.658
General development of aircraft noise annoyance	1.32	.52	1.59	.59	1.65	.57	24.02	.000
Frequency bothered by aircraft noise past month	2.21	1.12	2.96	1.08	3.35	.89	75.81	.000
Expectations aircraft noise annoyance	1.43	.54	1.65	.54	1.67	.50	16.52	.000

m = means; SD = standard deviation, p = probability of error

To assess which groups differ from each other, a post-hoc test was conducted. The results can be found in Table 6. Tukey post-hoc analysis reveals a significant difference regarding residential satisfaction ($p < .01$) between the inner area group and the outside area (.21, 95%-CI[.07, .36]) as well as the outside the noise contour group (.30, 95%-CI[.12, .49]). As the rating scale ranges from 1 (very satisfied) to 5 (very unsatisfied), this means that participants living in the inner area report significantly less residential satisfaction compared to participants living in the outer area and outside the noise contour.

A significant difference for aircraft noise annoyance can be found between all three groups. As can be expected, more aircraft noise annoyance is experienced close to the airport, i.e. the inner area, than in the outer area (2.31, 95%-CI[1.77, 2.85]), and more aircraft noise annoyance is reported in the outer area compared to outside the noise contour (1.33, 95%-CI[.78, 1.88]). Similar results can be found for reported sleep disturbance due to aircraft noise (See Table X). For sleep disturbances due to neighbours and railway noise, the opposite is true: people living in the inner area report less sleep disturbances due to those sources compared to the outer area and the area outside the noise contour.

Within the inner area, more people state that their aircraft noise annoyance has increased in general than people from both other areas (-.27, 95%-CI[-.37, -.17]; -.32, 95%-CI[-.45, -.20]). Similarly, participants' expectations regarding their

future aircraft noise annoyance significantly differs between the inner area and the outer area as well as the area outside the noise contour: more people who live in the inner area expect an increase of noise annoyance compared to the outside area (-.22, 95%-CI[-.32, -.12]) and the area outside the noise contour (-.24, 95%-CI[-.36, -.12]).

Not surprisingly, the group from the inner area also reported being more frequently disturbed by aircraft noise in the past month than the outer area group (-.75, 95%-CI[-.93, -.57]) and the group outside the noise contour (-1.15, 95%-CI[-1.38, -.92]).

Table 6: Results of the Tukey post-hoc analysis.

Dependent variable	(I) Area	(J) Area	Mean difference (I-J)	SE	p	95% confidence interval Lower	Upper
Residential satisfaction	inner area (58dB Lden)	outer area (48-57dB Lden)	,21*	,06	,002	,07	,36
		outside noise contour (>48dB Lden)	,30*	,08	,000	,12	,49
	outer area (48-57dB Lden)	inner area (58dB Lden)	-,21*	,06	,002	-,36	-,07
		outside noise contour (>48dB Lden)	,09	,06	,34	-,06	,24
Railway noise annoyance	inner area (58dB Lden)	outer area (48-57dB Lden)	-,33*	,10	,004	-,57	-,09
		outside noise contour (>48dB Lden)	-,54*	,13	,000	-,84	-,24
	outer area (48-57dB Lden)	inner area (58dB Lden)	,33*	,10	,004	,09	,57
		outside noise contour (>48dB Lden)	-,21	,11	,115	-,4572	,04
Aircraft noise annoyance	inner area (58dB Lden)	outer area (48-57dB Lden)	2,31*	,23	,000	1,77	2,85
		outside noise contour (>48dB Lden)	3,64*	,28	,000	2,97	4,30
	outer area (48-57dB Lden)	inner area (58dB Lden)	-2,31*	,23	,000	-2,85	-1,77
		outside noise contour (>48dB Lden)	1,33*	,23	,000	,78	1,88
Sleep disturbance due to neighbours	inner area (58dB Lden)	outer area (48-57dB Lden)	-,46*	,14	,004	-,80	-,13
		outside noise contour (>48dB Lden)	-,53*	,18	,008	-,95	-,12
	outer area (48-57dB Lden)	inner area (58dB Lden)	,46*	,14	,004	,13	,80
		outside noise contour (>48dB Lden)	-,07	,15	,882	-,41	,27

Sleep disturbance due to railway noise	inner area (58dB Lden)	outer area (48-57dB Lden)	-,18*	,07	,028	-,34	-,02
		outside noise contour (>48dB Lden)	-,20*	,09	,049	-,41	-,00
	outer area (48-57dB Lden)	inner area (58dB Lden)	,18*	,07	,028	,02	,34
		outside noise contour (>48dB Lden)	-,02	,07	,940	-,19	,14
Sleep disturbance due to aircraft noise	inner area (58dB Lden)	outer area (48-57dB Lden)	2,08*	,23	,000	1,55	2,61
		outside noise contour (>48dB Lden)	3,10*	,28	,000	2,45	3,75
	outer area (48-57dB Lden)	inner area (58dB Lden)	-2,08*	,23	,000	-2,61	-1,55
		outside noise contour (>48dB Lden)	1,02*	,23	,000	,48	1,56
Has the annoyance from aircraft noise experienced by you (in general)…	inner area (58dB Lden)	outer area (48-57dB Lden)	-,27*	,04	,000	-,37	-,17
		outside noise contour (>48dB Lden)	-,32*	,05	,000	-,45	-,20
	outer area (48-57dB Lden)	inner area (58dB Lden)	,27*	,04	,000	,17	,37
		outside noise contour (>48dB Lden)	-,05	,04	,464	-,16	,05
How often were you bothered by aircraft noise in the past month? Is that…	inner area (58dB Lden)	outer area (48-57dB Lden)	-,75*	,08	,000	-,93	-,57
		outside noise contour (>48dB Lden)	-1,15*	,10	,000	-1,38	-,93
	outer area (48-57dB Lden)	inner area (58dB Lden)	,75*	,08	,000	,57	,93
		outside noise contour (>48dB Lden)	-,40*	,08	,000	-,59	-,21
Future expectations regarding noise annoyance	inner area (58dB Lden)	outer area (48-57dB Lden)	-,22*	,04	,000	-,31	-,12
		outside noise contour (>48dB Lden)	-,24*	,05	,000	-,36	-,12
	outer area (48-57dB Lden)	inner area (58dB Lden)	,22*	,04	,000	,12	,31

	outside noise contour (>48dB Lden)	-,02	,04	,869	-,12	,08

SE = standard error, p = probability of error

4.2.3 Discussion

Overall, the residential satisfaction across the three study areas is quite high. Simultaneously, residents' self-reported aircraft noise annoyance is higher compared to the annoyance due to other noise sources, but is within a moderate range (*M*=4.51, *SD*= 3.35). Although, indicated by the large standard deviation, there seems to be a lot of variance in the sample. Participants who have been more annoyed by aircraft noise in the past 12 months express a general increase in aircraft noise annoyance, more frequent disturbances due to aircraft noise as well as a more negative view when it comes to their expected future aircraft noise annoyance.

Factors such as worries regarding safety and noise annoyance in general seem to be more relevant for residential satisfaction than aircraft noise annoyance, expected aircraft noise annoyance, and frequency of disturbance.

Comparing the three study areas, some significant differences become apparent. In the inner area, the reported aircraft noise annoyance is significantly higher than in the other two study areas. Moreover, more disturbances due to aircraft noise, a general increase in aircraft noise annoyance and an expected increase in future noise annoyance are significantly more often reported by participants living in the inner area. Participants from the inner area report significantly less sleep disturbance due to noise from neighbours and railway traffic, but significantly more aircraft noise-related sleep disturbances. This indicates not necessarily an absence of noise from neighbours, but could reflect the prominent role aircraft noise takes in areas within the airport's proximity.

The results indicate that perceived and expected aircraft noise annoyance is highest for people living in close proximity to an airport, but that overall, there are other aspects more prominent for residents in airport regions.

From a methodological perspective, the use of the standardized questions for noise annoyance and sleep disturbance is positive as it enables comparing these results with other studies. Using a 3-point scale assessing the degree of worries regarding different topics with values ranging from 1= a lot of worry, 2= a little worry to 3= no worries, however, might lead to a lack of variance in the results (Lehmann & Hulbert, 1972).

4.2.4 Conclusion

Overall, there seem to be more prominent factors influencing participants' quality of life than aircraft noise annoyance or sleep disturbances, such as worries regarding safety and noise annoyance in general. However, these variables still have an influence and, if addressed, could positively influence quality of life in regions surrounding airports. An important aspect to keep in mind is that the study areas significantly differ with respect to aircraft noise annoyance. Reducing aircraft noise annoyance might therefore have a positive impact on the residential satisfaction of people living close to an airport. Further, aspects such as worries concerning safety and noise annoyance in general (also regarding

other noise sources) may be targeted with certain interventions, thereby further improving quality of life.

Future studies should specifically examine quality of life by addressing all indicators (See Figure 1) and evaluate various interventions based on these indicators. This could be achieved, for example, by conducting a survey before and after the implementation of an intervention specifically assessing the different quality of life indicators. It is important that all communities potentially affected by this intervention are included in the study to get a thorough picture of the intervention's impacts. The results could serve as a basis for improving existing interventions and developing new interventions. In this way, not only could residents' noise annoyance be reduced, but, at the same time, their quality of life could be increased. If the decision for one particular intervention is not clear-cut and there are different interventions being considered, it could be beneficial to engage the communities in the decision-making process of selecting one intervention to be implemented as well.

4.3 The impact of the radius-fix-turn on quality of life

There is still a need for further research examining the impact of such an operational procedure on the surrounding communities and to allow for drawing specific conclusions. It becomes apparent that - at least in those regions further away from the airport - aircraft noise does not seem to be the most negative factor and not the main source for noise annoyance and sleep disturbance. However, despite there being more negative environmental influences, aircraft noise still represents an environmental stressor for residents potentially affecting their QoL.

What effect the radius-to-fix approach may have on QoL, can be seen by a different intervention, namely the consultation procedure that addressed a potential flight path change (See the following chapter 5).

5 Consultation procedure – Frankfurt Airport

A different intervention, carried out in the Frankfurt Airport region in 2018, is the subject of this chapter. In preparation for making a decision regarding a potential flight path change, a consultation procedure was conducted a priori engaging the surrounding communities and residents. A potential flight path change would lead to less aircraft noise exposure for some communities, but to a higher aircraft noise exposure for others. Integrating the results of the consultation procedure, a decision was to be made regarding the shift and testing of a potential adapted flight path.

Within ANIMA, this consultation procedure was evaluated by means of 27 in-depth telephone interviews as well as a complementing literature search. This chapter describes the work that has been done in detail, and the results and conclusions that can be drawn regarding the intervention's impact on quality of life.

5.1 The consultation procedure

In 2008, the *Forum Flughafen und Region* (FFR, forum airport and region) was founded. It consists of five expert committees with different tasks [members are, e.g., representatives of Fraport AG (operator of Frankfurt Airport), Deutsche Lufthansa AG (airline), German Air Navigation Services (Deutsche Flugsicherung GmbH), aircraft noise commission (Fluglärmkommission, FLK), ministry of economics, Gemeinnützige Umwelthaus GmbH, city of Frankfurt, communities, politics etc.]. Its aim is to foster a dialogue between Frankfurt Airport and the Rhine-Main-region dealing with topics such as noise, health, environment and jobs. One of the expert committees is the Aktiver Schallschutz (active noise abatement; ExpASS), which is the central examining section for active noise abatement of the FFR.

In January 2018, the FFR presented the intervention program "Aktiver Schallschutz" (active noise abatement) to the public, of which one aspect is the proposition to shift the flight path 'AMTIX kurz' to the North (See Figure 17 and Figure 18). Planes using the current 'AMTIX kurz' route for take-off from Runway West to Southeast fly over densely populated districts of Darmstadt.

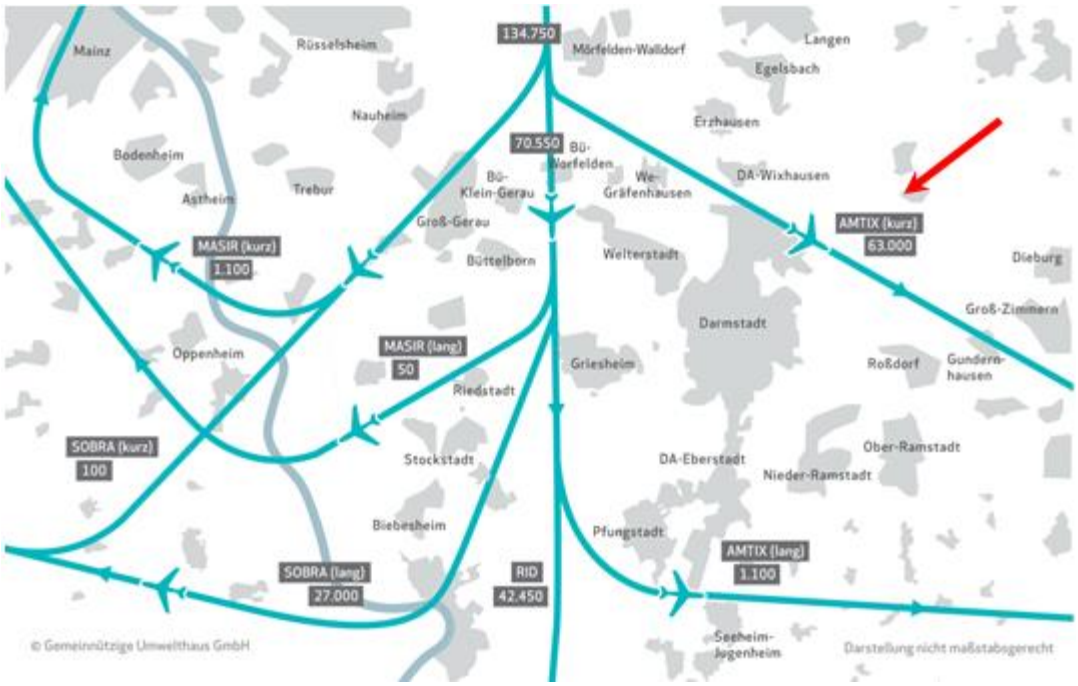

Figure 17: Current flight paths of Frankfurt Airport incl. AMTIX kurz (Gemeinnütziges Umwelthaus GmbH, 2020).

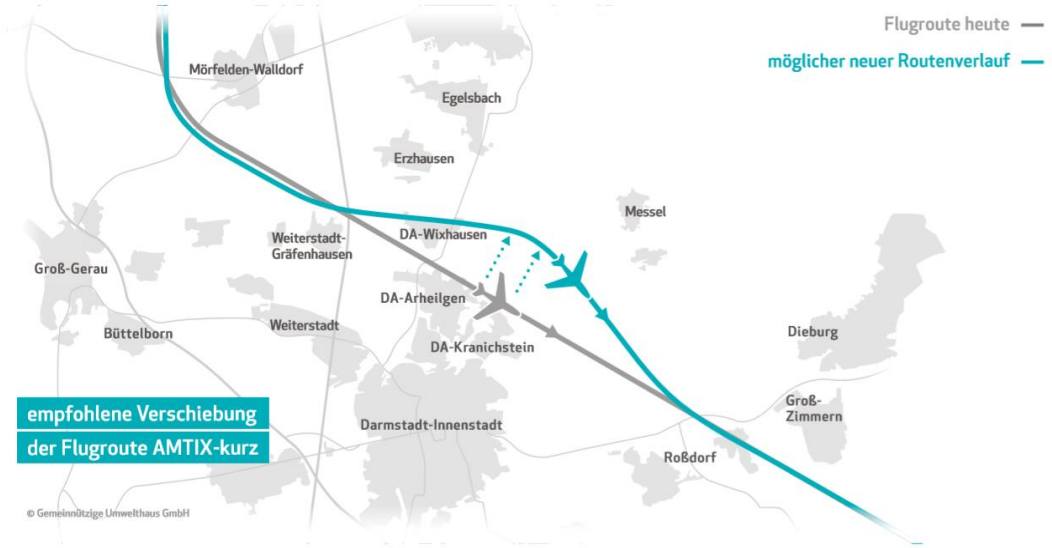

Figure 18: Proposed change for AMTIX kurz (Team Ewen, 2019). Note: Flugroute heute = current flight path; möglicher neuer Routenverlauf = potential new flight path.

Prior to making any decision regarding a potential flight path change, a consultation procedure was to be conducted engaging representatives of the surrounding communities as well as the residents. The consultation had no decision-making authority and served only for further consideration in the FFR bodies and the FLK.

The aim was to engage the public and allow political representatives and residents to share their opinions, concerns, and ideas regarding a potential flight path change. The procedure and the decisions being made had to be transparent and facilitate tracking and understanding the proposed routes and a potential change.

Next to the initial proposed flight path, other alternatives were included and discussed during the consultation procedure as well (see Figure 19).

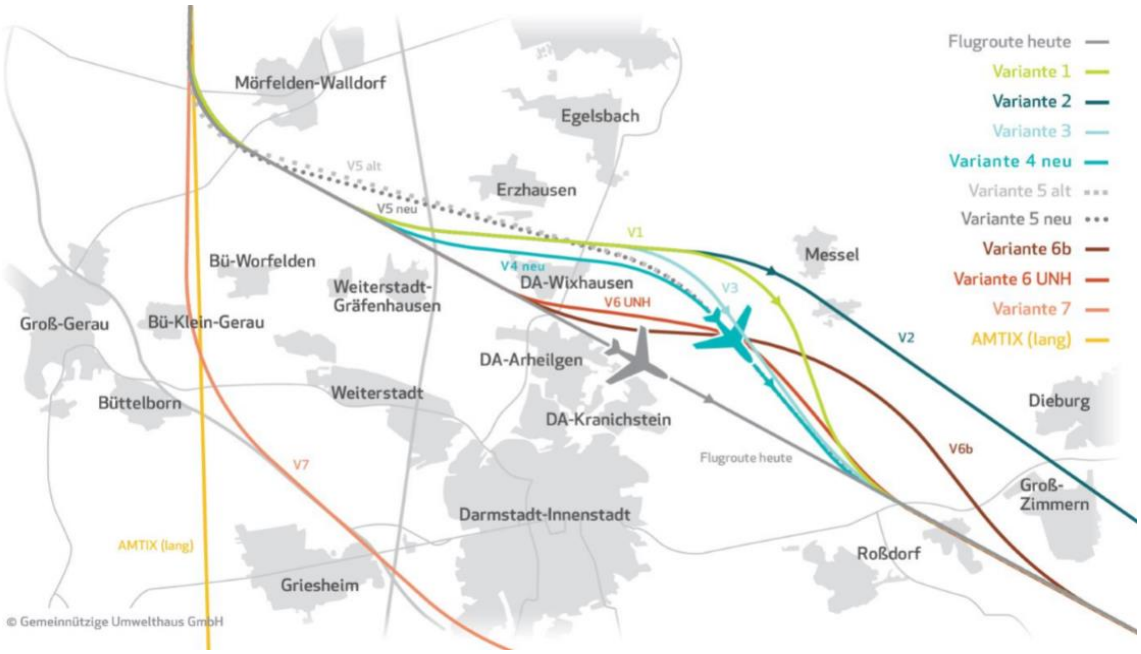

Figure 19: Discussed versions of a shift of AMTIX kurz (Team Ewen, 2019). Note: Flugroute heute = current flight path; Variante = option; neu = new; alt = old.

Each option was evaluated against different criteria:

- Safety
- Capacity
- Noise impact reduction

Each flight path option needed to meet the safety criteria and provide the necessary capacity. For the options that met both, the reduction of the noise impact was calculated using the Frankfurter Fluglärmindex (FFI; Frankfurt aircraft noise index). The FFI needed to be substantially decreased under the new flight path, while keeping the number of newly aircraft noise exposed people as low as possible.

The consultation procedure took place from May to December 2018 and was moderated by a specialized company from Darmstadt. It consisted of four different components:

- Public informative events
- A citizen group
- A group with political stakeholders
- Website

Households in the affected areas received an information letter about the consultation procedure in June 2018. Figure 20 depicts the timeline for the consultation procedure and its components.

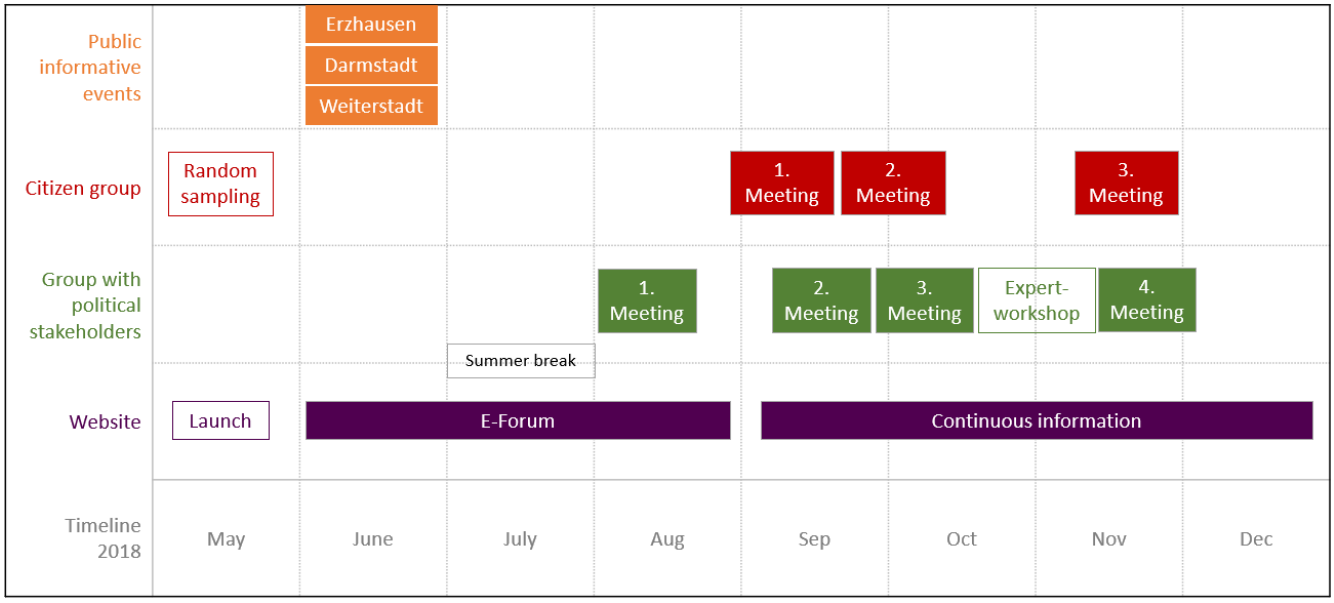

Figure 20: Process of the consultation procedure from May to December 2018.

As can be seen, three public informative events took place in three different communities:

- Erzhausen (11th June 2018)
- Darmstadt (13th June 2018)
- Weiterstadt-Gräfenhausen (20th June 2018)

The informative events were public and aimed to provide all residents of the region with the opportunity to inform themselves about the procedure, ask questions and share their opinions.

To engage people from the general public, a citizen group was conducted with 26 randomly selected residents from the affected areas. A quota system was used considering participants' place of residence, age and gender.

By choosing random sampling, it was intended that recruitment of "regular" residents, whose opinions may otherwise be unheard (the so-called silent majority), would be ensured. The citizen group met four times; the first introductory meeting is not depicted in the timeline.

Another group was put together with political stakeholders. In this group, two representatives from each community participated: the mayor or head of the environmental department and another expert from the community. This group had four meetings, plus an expert-workshop. In the expert workshop, experts from the communities were invited to discuss relevant topics with the expert committee Aktiver Schallschutz from the FFR.

After the consultation procedure had ended, eight options for an adapted flight path remained (See Figure 21). The decision was made to conduct a 1-year test run of *Option 3 new* (= Variante 3 neu; see Figure 22) and monitor it closely, starting in autumn 2020 (for a detailed report see FFR, 2019a). Then, a final decision will be made whether the new flight path will be permanently adopted or the original flight path will be retained.

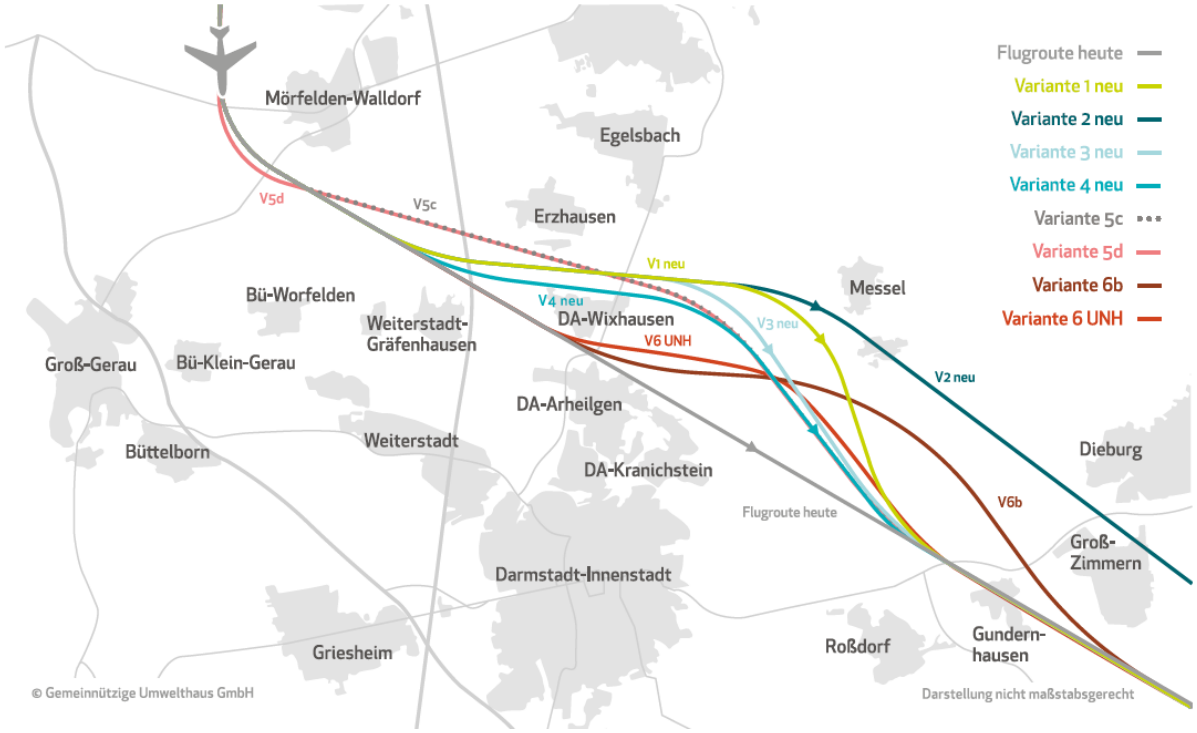

Figure 21: Eight new or adapted options for the flight path change (FFR, 2019a). Note: Flugroute heute = current flight path; Variante = option; neu = new; alt = old.

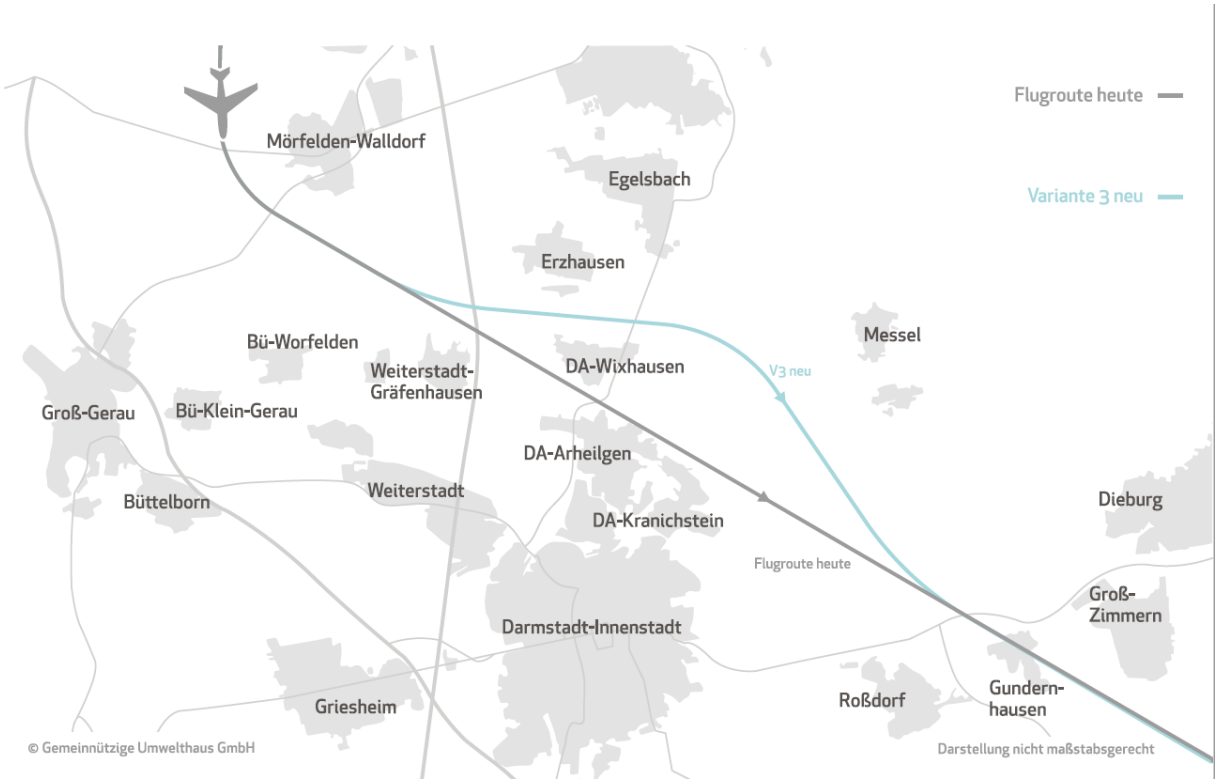

Figure 22: Flight path for 1-year testing and monitoring (FFR, 2019b). Note: Flugroute heute = current flight path; Variante 3 neu = option 3 new.

5.2 Distilling previous learnings

A literature search was conducted to identify potential available studies focussing on the link between the quality of life of residents living in the vicinity of an airport and interventions, specifically, a consultation procedure or communication intervention.

5.2.1 Methodology

To gather relevant literature concerning a consultation procedure's impact on residents' quality of life, a literature search was conducted in August/September 2020 using the databases Pubmed, Researchgate and Google Scholar. The following search terms were used: aviation AND noise annoyance AND quality of life AND intervention OR satisfaction or living environment OR airport consultation. International articles, books, grey literature, meta-analyses, etc. in English, German and Dutch were included. Studies had to be conducted in an airport region and have included an assessment of participants' quality of life (or indicators of it) as well as an implemented communication intervention/consultation procedure.

5.2.2 Results

An overview of the databases and search terms used as well as selection criteria and results can be found in Table 7.

Table 7: Approach and results of the literature search.

Search period	August/September 2020
Databases	PubMed, ResearchGate, Google Scholar
Search terms	aviation OR aircraft OR airport AND noise annoyance AND quality of life OR satisfaction AND consultation OR communication OR intervention
Languages	English, German, Dutch
Criteria	quality of life assessment, implemented intervention
Results	0

No studies meeting the inclusion criteria could be found in the above mentioned databases and with the given search terms. However, there are studies available assessing the relationship between noise annoyance and different quality of life indicators (See section 4.1).

5.2.3 Conclusion

The lack of studies examining the impact of noise mitigating and noise management interventions on residents' quality of life reveals a large research gap and stresses the importance of future studies. A vast number of interventions are being implemented at and around airports worldwide. However, there is little known with respect to their impact on residents' quality of life and whether they are valued by residents. To shed light on this topic, further research is needed including pre- and post-implementation surveys to identify a potential change in/impact on quality of life.

5.3 In-depth interviews

In March and April 2020, in-depth telephone interviews were conducted with residents of the Frankfurt Airport region to gather information and gain insight into how the consultation procedure was perceived and if and how it affected residents' quality of life.

Annoyance is thought to be a psychological stress-related response to noise, which can result in adverse health effects (Van Kamp, 1990). According to the transactional model of stress and coping (Lazaraus & Folkman, 1984), stress is a response to an imbalance of the demands people face and people's available resources to cope with these demands. Therefore, decreasing the frequency, duration and intensity of an environmental stressor (e.g. aircraft noise) and increasing people's resources and enhancing their coping capacity could lead to reduced stress levels. Improving residents' (perceived) control over their noise situation, e.g. by engaging them in a consultation procedure, can result in better coping capacities, less aircraft noise annoyance and an improved quality of life (see e.g. Stallen, 1999).

5.3.1 Methodology

For assessment of the consultation procedure conducted around Frankfurt Airport and its potential impact on residents' quality of life, two different strategies were used. For one, people, who participated in the citizen group of the consultation procedure in 2018, were asked about their quality of life and specifically about their experience with and impressions of the consultation procedure. Second, residents from the general public were asked to participate in in-depth interviews to talk about their quality of life and living environment, as well as their evaluation of the consultation procedure.

To identify the potential impact of the consultation procedure on residents' quality of life, three different communities in the Frankfurt Airport region were chosen (See Figure 23):

- Weiterstadt-Gräfenhausen
- Darmstadt-Wixhausen
- Darmstadt-Arheilgen

Figure 23: Study areas outlined in green, red and orange (FFR, 2019b). Note: Flugroute heute = current flight path; Variante 3 neu = option 3 new.

All of these areas were involved in the consultation procedure; however, the impact of the flight path change on these areas differs. The flight path change will reduce aircraft noise exposure in Darmstadt-Arheilgen (marked in green), but increase aircraft noise exposure in Darmstadt-Wixhausen (marked in red). With regard to Weiterstadt-Gräfenhausen (marked in orange), the situation is different: the total numbers do not indicate a relevant change in noise exposure. However, looking at the city districts, a reduction of noise exposure will take place in the south of the city and an increase of noise exposure in the north.

To recruit former participants of the citizen group, the Gemeinnütziges Umwelthaus GmbH contacted these former participants, describing the current research and asking for participation. Three people were interested and, with two of them, an in-depth interview was carried out.

A company was hired to recruit participants from the three study areas defined above for in-depth telephone interviews (8 per study area). Adults (18 years and older) living in the areas were randomly contacted by phone. An appointment was arranged between the participants and the researcher for the in-depth telephone interviews. For participation, an incentive of € 30,- was offered. With the agreement of the participants, the interviews were audio recorded to facilitate data analysis. The recordings were transcribed according to Kuckartz (2012) and Mayring's qualitative content analysis (2015) was used for data analysis. The questions asked served as main categories, which were then filled in by participants' answers as subcategories.

There were three main topics covered in the interviews:

1. Quality of life and living environment
2. Airport and intervention
3. Intervention and quality of life

5.3.2 Results

In total, 27 interviews were conducted. The sample description is shown in Table 8. The researchers could not identify any influence of the Corona-pandemic and its accompanying interventions and restrictions on the in-depth interviews and the results.

Table 8: Sample description.

						Total
Location		Darmstadt-Arheilgen		Erzhausen	Weiterstadt-Gräfenhausen	
			Citizen group			
n		9	2	7	9	27
Sex						
	female	7	1	0	4	12
	male	2	1	7	5	15
Age (*SD*)		57 (14,3)	54 (18)	72 (7,2)	68 (8,8)	64 (13,4)
	Min	28	36	58	55	28
	Max	76	72	78	81	81

Figure 24 gives a general overview of the results. In the following sections, the results for each main topic are described in more detail.

Overall, there is a lot of overlap between participants from the different locations, but in some cases, the results show minor differences. When applicable, these differences are described.

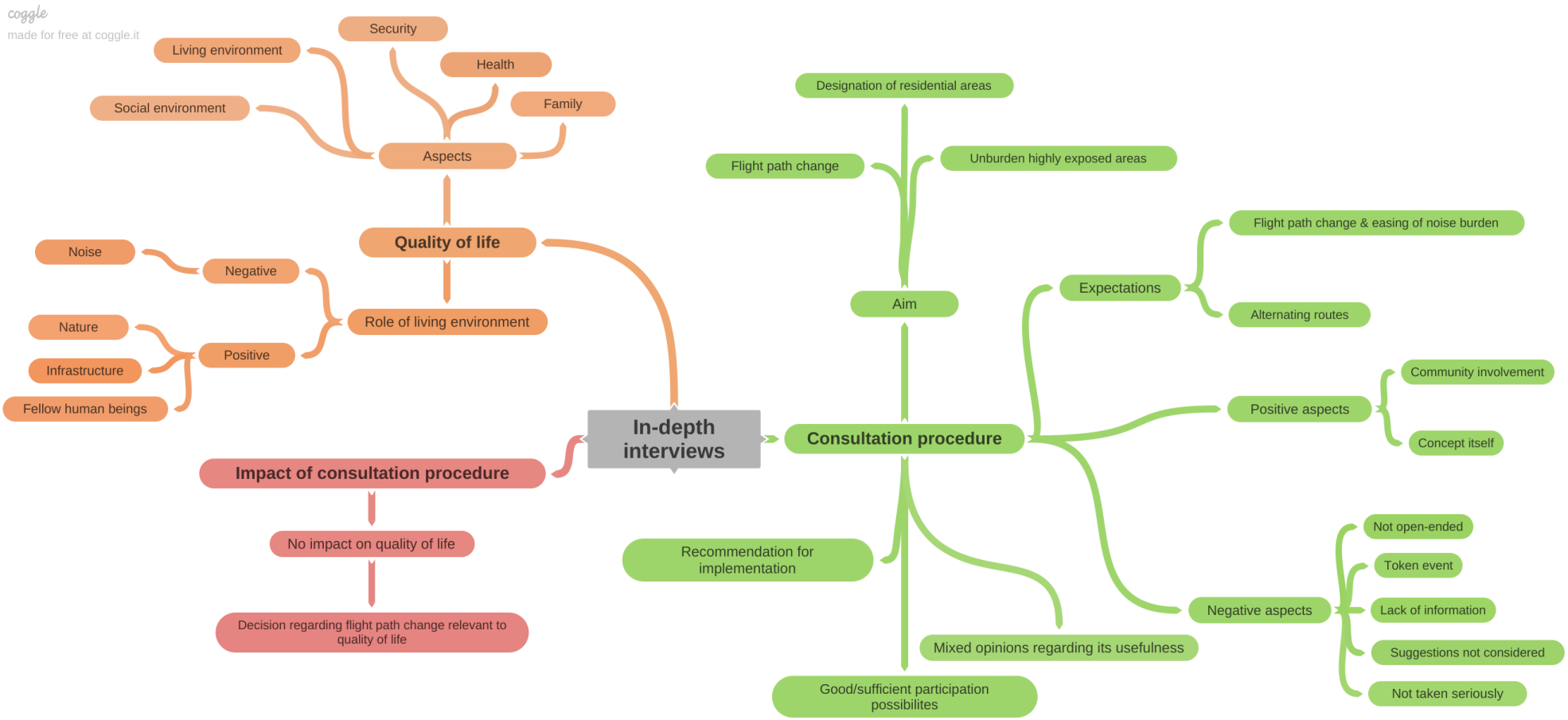

Figure 24: Mind map of in-depth interviews results.

5.3.2.1 Quality of life and living environment

The first main topic dealt with participants' quality in life in general and how their living environment influences aspects of quality of life. When asked about their understanding of quality of life and which aspects are important for their personal quality of life, participants mentioned family, health, social and living environment, nature, and security (socially and financially). Figure 25 depicts the most commonly mentioned aspects.

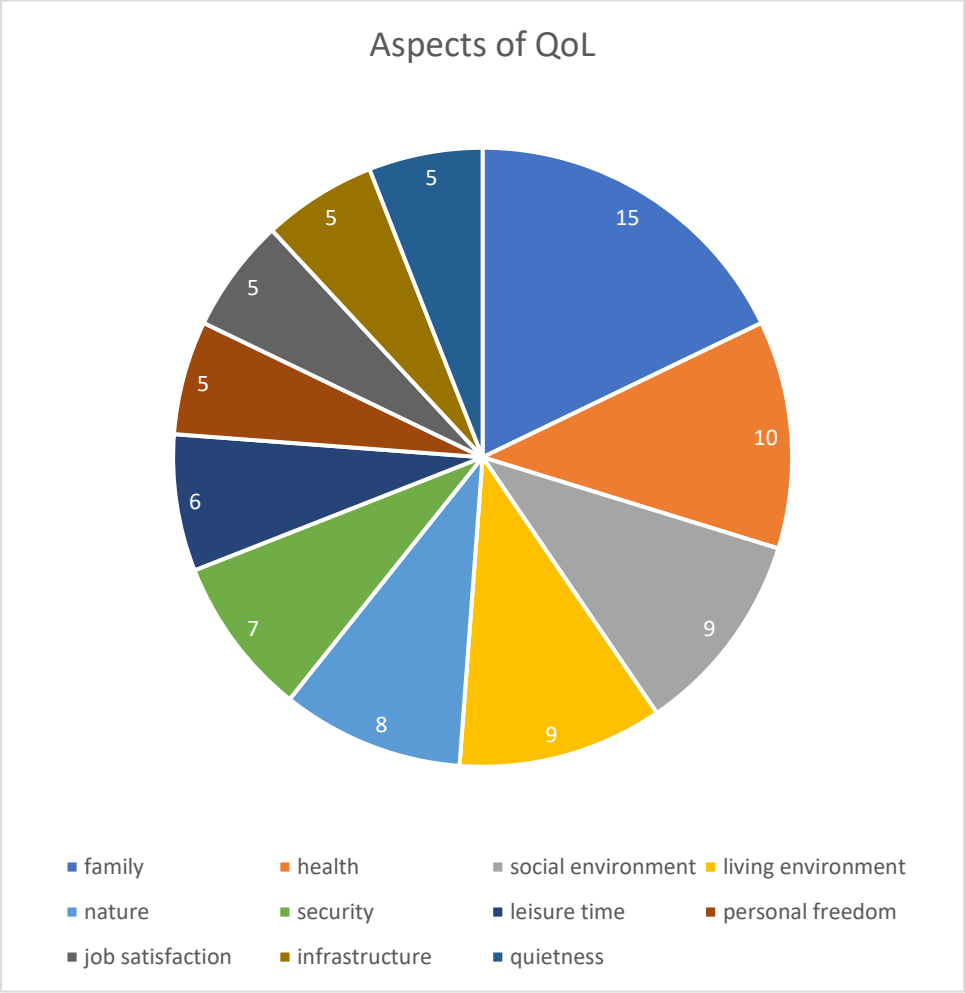

Figure 25: Number of aspects of QoL mentioned by participants.

For the majority of participants, their living environment is crucial and has an important impact on their quality of life. Among aspects of the living environment that influence one's quality of life are neighbours and fellow human beings, infrastructure, nature, but also negative aspects such as noise.

There is a small difference between participants from the different study areas: participants from Darmstadt-Arheilgen mentioned *family* as an important aspect of quality of life more often than participants from the other two areas.

5.3.2.2 Airport and the consultation procedure

The next main topic was concerned with Frankfurt Airport and the consultation procedure. The first question sought to reveal participants' initial associations about interventions of the airport or other relevant stakeholders. Approximately one third of the sample named action groups as such an intervention. Eight

participants listed the flight path change and seven mentioned the sound insulation scheme. When asked directly about the consultation procedure, 24 out of 27 participants were aware of the consultation procedure and knew about it. Two participants did not know about the consultation procedure, but had heard of the discussion about a potential flight path change. Most of the participants received information about it through the press.

The most frequently mentioned aim of the consultation procedure was to reduce aircraft noise for highly noise exposed areas, while six participants believe its aim was to enable the designation of building residential areas in Northern Darmstadt, which is now still restricted due to noise levels. The latter was only mentioned by participants living in Erzhausen and Weiterstadt.

With regard to expectations and hopes for the consultation procedure, the groups differ. Compared to Erzhausen (1), more participants from Darmstadt (7) and Weiterstadt (6) state that they expected or hoped for a flight path change and for the Northern part of Darmstadt to be less exposed. In contrast, people from Erzhausen expected and hoped for a joint solution or other measures such as a mix of routes or technical solutions to reduce noise exposure.

Eight participants (five of whom live in Erzhausen) stated that the consultation procedure was not open-ended as the shift of the flight path was set in stone beforehand. However, one participant did not state this in negative terms, but rather as a neutral fact. According to nine participants, the flight path change would enable Darmstadt to designate new residential areas in the Northern part of the city.

Looking at the sample's engagement within the consultation procedure, it becomes apparent that over two third of the participants did not participate in the consultation procedure (19), neither by attending the public events nor in any other way. Reasons given were, among others, the existence of political representatives, not having the time to participate, and a lack of personal relevance. However, the opportunities for participation in the consultation procedure overall were considered as sufficient and good.

To gather insight into what participants valued about the consultation procedure or what could be improved, participants were asked to name positive and/or negative aspects about this intervention. In total, more different negative aspects (37) than positive (19) were reported about the consultation procedure by participants.

The general concept of a consultation procedure (4) and the community engagement were highlighted as positive (6). For two participants another positive aspect was seeing other residents being engaged in the procedure and working together. Both participants from the citizen group also mentioned the moderation as a positive factor.

Some of the negative aspects mentioned are depicted in Figure 26. It was stated by seven participants that the outcome was not open-ended and for four participants the consultation procedure seemed like a token event. Two participants criticised the lack of consideration for other sources of noise

pollution, especially the airfield Frankfurt-Egelsbach, which is a small landing field near Frankfurt Airport. A potential impact of the airfield Frankfurt-Egelsbach was added to the calculations for the noise reduction at least for the older flight path options, but, overall, did not show a significant effect.

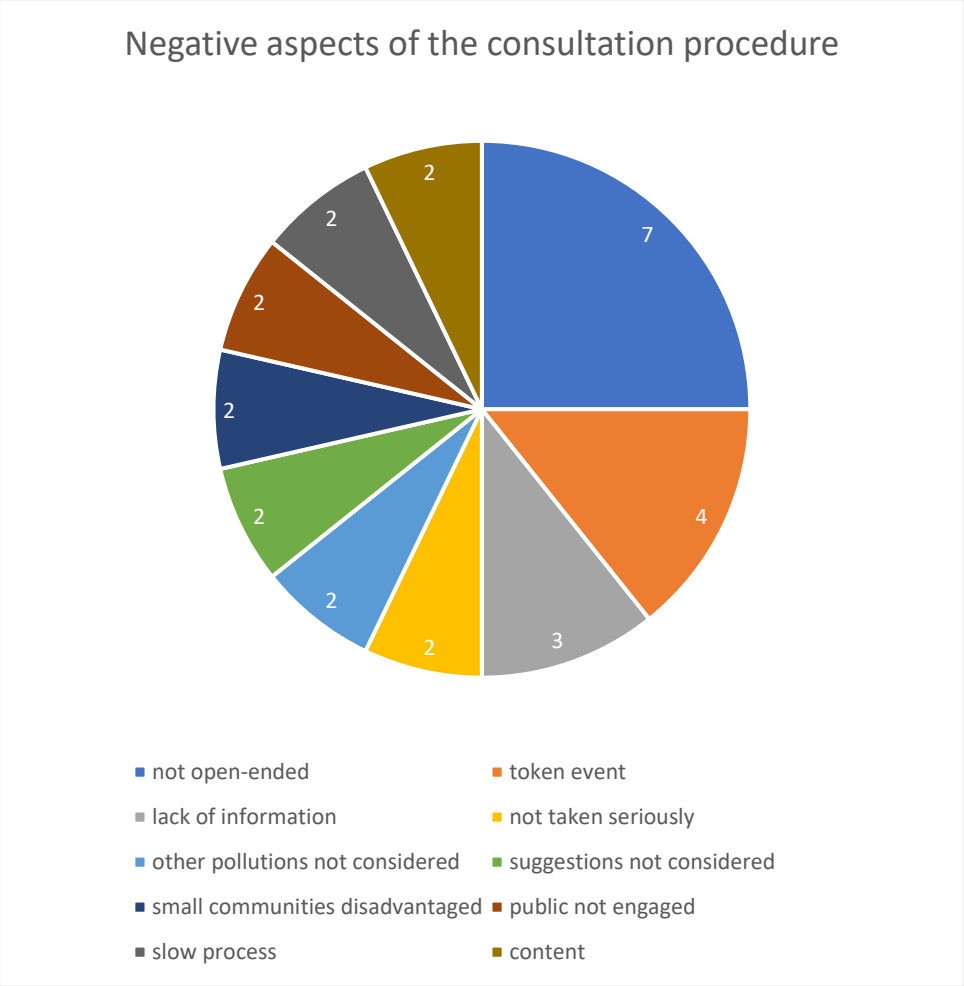

Figure 26: Number of negative aspects mentioned by participants.

Participants of the former citizen group criticised a lack of transparency and information about the citizen group to the public, but also a lack of knowledge in the citizen group as a whole. In their opinion, engaging and inviting people to the citizen group that have more experience in and deal with this topic for a longer period of time would have been fairer and more productive.

The results regarding the perceived usefulness of the consultation procedure are quite mixed: while ten participants rated the usefulness of the consultation procedure from low to none at all, almost as many participants viewed it as positive and preferred having the option to being engaged. The two participants from the citizen group also disagreed on this topic. Interestingly, over half of the participants would view a consultation procedure at a different location as positive and were supportive of this idea.

Some participants mentioned that the different parties were not working together, but that each community was interested in their own benefits.

The majority of participants did not get any information on the results of the consultation procedure. Of those who received information, 70% were satisfied with the information provided to them.

To facilitate taking a different perspective and view the consultation procedure from a different perspective, participants were asked to judge why other people would see the procedure in a positive or negative way. The main reason given was that it depended on the outcome of the consultation procedure, i.e. whether the flight path will be changed or not. Participants could relate to others' perspectives and understood that shifting the flight path would benefit only some areas and increase the noise burden in other regions around the airport.

5.3.2.3 Quality of life and the consultation procedure

The last topic concerned participants' quality of life and the link to the consultation procedure. In general, participants did not perceive the consultation procedure as an intervention on its own, but always linked it to the flight path change. When specifically asked whether the consultation procedure had an effect on their quality of life, the majority of participants stated that the consultation procedure per se did not have an effect on their quality of life, but that it mainly depended on the outcome: a decision for or against a flight path change would have an impact on their quality of life. This result was the same when participants were asked to estimate the impact of the consultation procedure on other people's quality of life.

Only one participant mentioned that the consultation procedure positively influenced his quality of life as he could witness people from his community working together, fostering a sense of social cohesion.

In sum, almost all participants did not see a relationship between the consultation procedure and their and other people's quality of life, as solely being engaged in the process did not have an impact.

5.3.3 Discussion

The consultation procedure at Frankfurt Airport aimed at engaging communities and residents and including their opinions and concerns in the decision-making process concerning a potential change of the flight path AMTIX kurz. The results of the in-depth interviews provide insights into participants' understanding of quality of life and how they relate airport activities to this as an influencing factor; specifically, the consultation procedure conducted in 2018.

Participants' living environment seems to have a major influence on their quality of life, both positive and negative. The consultation procedure itself has seemingly no impact on participants' quality of life. The flight path change, on the other hand, would have a large impact on residents' quality of life: a positive impact for those living in an area where noise exposure would decrease and a negative impact on quality of life where noise exposure increases. Future research should assess this relationship in more detail, as participants might not be consciously aware of the intervention's potential subtle impact on their quality of life.

Further, the negative aspects mentioned by participants indicate some degree of mistrust and a perceived lack of transparency and honesty about the procedure and participating stakeholders. The perception of the procedure as not being open-ended and one city appearing to "benefit" from a flight path change due to the possibility to designate new residential areas, posed an issue for the procedure's authenticity and engaging character.

Although participants criticized several aspects of the consultation procedure conducted around Frankfurt airport in 2018, the majority value the approach as positive and would welcome an implementation of a consultation procedure at other airport locations as well. With respect to the implementation of a citizen group, one additional component could be to add another citizen group, with only people from action groups or initiatives, who have experience with and are knowledgeable on the topic in question. This might enhance the trustworthiness of such a procedure as there was some criticism regarding only conducting a citizen group where the majority of the participants are not familiar with the topics discussed.

Providing people with an opportunity to actively be engaged in such a procedure, having the possibility to express their concerns and ask questions, could enhance their (perceived) control and expand their coping capacities. However, participants perceived the consultation procedure as not being open-ended and some of them mentioned that their suggestions and remarks were not seriously and thoroughly considered. Due to this perception, the consultation procedure might not have provided more perceived control over the situation for the residents living in the vicinity of the airport.

5.3.4 Conclusion

There were quite a few negative aspects mentioned including the consultation procedure's premise and execution. The current consultation procedure was mainly perceived as not being open-ended and participants did seem to experience a lack of trust to some extent. Despite these negative aspects, the majority of participants are in favour of the general concept and the idea of conducting a consultation procedure engaging the public.

These results show residents' general appreciation of such a procedure, but at the same time stress the importance of an open and transparent communication and execution of a consultation procedure.

With regard to quality of life, the consultation procedure itself does not seem to affect participants' quality of life. However, directly asking people about the link between an intervention and their personal quality of life may not reveal any apparent relationship as participants may not be consciously aware of the way in which a consultation procedure affects them. Therefore, a quantitative study linking people's quality of life to the consultation procedure would provide additional, valuable insight into this relationship.

5.4 The impact of the consultation procedure on quality of life

The literature does not allow deriving any conclusion with respect to the impact of a consultation procedure on residents' quality of life as no studies could be found that specifically evaluate this relationship. The results of the in-depth interviews with residents living in the vicinity of Frankfurt Airport suggest that there is no impact of the consultation procedure on residents' quality of life. According to participants, only the topic discussed, namely the flight path change, could actually influence their quality of life. However, assessing the link between the consultation procedure and QoL indirectly would result in a different outcome. Research suggests that providing people with more (perceived) control - in this case being able to take part in a consultation procedure - enhances their capacities to cope with a given situation and can thereby reduce stress (Lazarus & Folkman, 1984; Stallen, 1999). Whether this reduction in stress translates into an improved QoL still needs further examination.

6 Sound insulation – Marseille Airport

Marseille airport is situated in the south of France, which enjoys a mild climate for 6 to 8 months of the year. Marseille airport is involved in the scope of the Air Pollution Control Authority; that is to say that it is a quite large airport in France. With 10,151,743 passengers in 2019, Marseille-Provence airport is the 5th French airport by traffic volume and the 3rd French regional airport. It is served by 33 airlines and offers more than 120 destinations. In France it is the leading airport in express freight. There is a night restriction for noisy "chapter3" aircraft flights from 22h45 to 6h15 and engine test are forbidden too. Marseille airport is currently building an extension of terminal (which is supposed to be finished in 2022) in order to connect all the terminals and enhance the user experience.

It was felt that looking at Marseille Airport, in the context of its mild climate for most of the year, would provide an interesting case to investigate how sound insulation was perceived in an area where people spend a lot of time outside. This provides a contrast to the case described in the following chapter, where sound insulation in the colder climate of Heathrow, is explored.

To better understand the impact of noise on the territory, the flight path maps in both configurations are depicted below: north (Figure 27) and south (Figure 28), for departures (in blue) and arrivals (in pink).

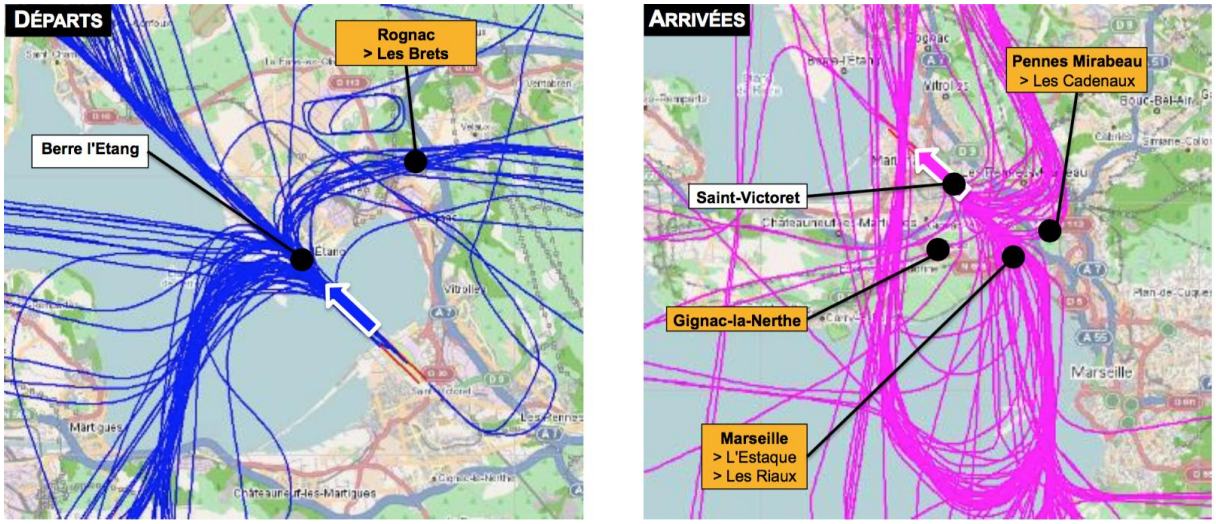

Figure 27: Flight path maps in the north face configuration.

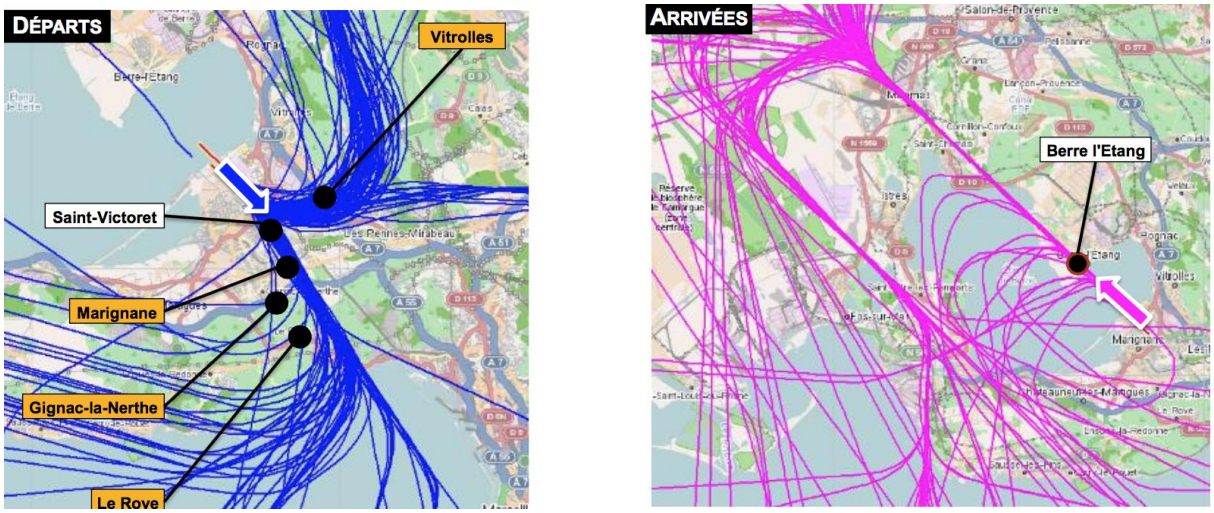

Figure 28: Flight path maps in the south face configuration.

The environmental manager of Marseille airport agreed to work on Marseille airport's insulation scheme program as, according to this manager, progress on the intervention was rather slow and had to be developed with more efficiency. This procedure was part of the second pillar of the balanced approach (land use planning) that we had set out to study.

Since 1997, the French state has implemented a specific system for large airports: soundproofing assistance. With this help, residents affected by noise can carry out insulation work to improve the acoustic performance of their homes. This system was originally managed by the environment and energy management agency in France and financed by the general tax on polluting activities.

Since 2005, the grant has been exclusively financed by airlines via a tax on air noise pollution (TNSA), levied by the DGAC (Directorate General of Civil Aviation) according to the "polluter pays" principle.

Since 2004, the airport manager has been in charge of redistributing the sums received in the form of soundproofing work in residents' homes. The stakeholders gathered, within the advisory committee to help local residents, are consulted to give an advisory opinion on the allocation of this grant. The grant covers 80% and, in some cases up to 100%, of the cost of sound insulation work for residents located in the annoyance noise map.

To get this grant, the accommodation must have been built before the noise annoyance plan had been created and must be situated inside the annoyance noise map contours. If these conditions are met, owners have to call the insulation scheme service delegated by the airport and fill in an administrative form to ask for this grant. The latter assumes that people are aware that this grant exists and this is actually the issue regarding this intervention for Marseille airport. Actually 6,020 housing are situated in the annoyance map. Indeed, since the intervention has been implemented, from 1997 to now, only 53% of housing has been insulated yet. The environment manager suggested that the availability

of the scheme should be better communicated as not all the people who could receive the grant are aware of this possibility.

6.1 Distilling previous learnings

The literature analysis was done for both the Marseille and Heathrow intervention as in both cases sound insulation is evaluated.

6.1.1 Methodology

In order to better understand the impact of insulation schemes on quality of life in our study, we previously selected literature on this topic. The aim of this literature review was to investigate if 1) such research had been carried out previously, 2) if differences between countries can be found in the procedure and, thereby, investigate residents' satisfaction and 3) if there is any available information to help us better understand our results. For the reviews, we used databases like Pubmed, Web of Science, Researchgate and Google Scholar. Unfortunately, it proved difficult to find any articles which were directly related to insulation and residents' satisfaction. Actually, we could find only one article which directly deals with this issue; the others were related to evaluations of other aircraft noise compensation.

6.1.2 Results

As described in Section 5, a main premise in ANIMA is that improving residents' (perceived) control over their noise situation results in better coping capacity and, as a result, less noise annoyance. Arising from this, this work sought to study the role of aircraft noise in people's daily residential and health-related QoL.

The operation and growth of airports generate significant social and economic benefits but also disturbance to residents of neighbouring communities, primarily as a result of aircraft noise. Since it is not possible to completely eliminate aircraft noise, key elements of aircraft noise management strategies are mitigation activities designed to reduce noise exposure inside residential and other premises, where people are subject to high levels of, or step changes in, noise exposure. Sound insulation is the main intervention adopted to reduce the noise people are exposed to while not affecting the operating capacity of an airport (Asensio et al., 2014).

The 'Balanced Approach' to noise management around airports advocated by ICAO (2008) highlights the need to reconcile the delivery of effective and efficient air services with the requirement to protect local communities from the negative consequences of aircraft noise exposure. Where all options for reducing noise exposure in a cost-effective manner have been exploited, noise mitigation and compensation can be used to help alleviate the negative consequences for a given receptor/target; either by reducing exposure in key locations (e.g. inside houses through insulation), or by acknowledging disturbance through the offer of compensation for increased levels of exposure. Significantly, ICAO does not offer guidance on where or how these measures might best be used to reduce noise disturbance around airports.

To better understand the impact of one of those measures on QoL, Schreckenberg (2012) conducted a survey around Frankfurt airport analysing a sound insulation program granted by the airport for a whole city. This insulation scheme was design

to lower sleep disturbance from aircraft noise at night. In this case, insulation scheme took into account triple glazing windows and ventilation in bedrooms. Results showed that insulation scheme program was badly evaluated by residents. Ventilation was considered as noisy and overall, this insulation was associated with an unhealthy indoor climate. Indeed, about half of the households who benefit from the insulation scheme program did not use this system.

Similarly, Asensio, Recuero and Pavon (2014) analysed the influence of excluding compartments in the dwelling from the insulation actions on people's perception and evaluation of the insulation scheme in Spain. To better understand the issue, it is important to recall that, in Spain, not all the rooms are eligible for insulation grants. A different noise level limit is fixed per room. Most of the time the bedroom and living room are insulated whereas the kitchen or even bathrooms are not. In France, it is quite different as there is a financial threshold, all the rooms can be insulated but residents cannot exceed a certain cost per room. The amount threshold is fixed by the location of the dwelling on the annoyance map (actually there are 3 impacted areas).

Authors conducted 689 interviews by phone using a standardized questionnaire. They investigated 5 different airports (Màlaga, Palma de Mayorca, Gran Canaria, Alicante and Bilbao). They asked questions regarding thermal insulation, aesthetic aspects, satisfaction with insulation schemes, improvements that can be done, noise annoyance and noise reduction, management aspects and information referring to personal status. Results show that beneficiaries have a generally positive perception regarding the actions implemented during noise insulation programmes, even if they still perceive aircraft noise as a source of disturbance. They found that 70% of participants noticed an energy efficiency improvement with new installations; and that annoyance was reduced by over 40% with sound insulation schemes. However, there are still some dissatisfied by the insulation program. Authors designated the fact that not all the rooms can be insulated as a "legal factor". Dissatisfaction is significantly linked to this legal factor. Results showed that annoyance is higher in day time and that insulation schemes do not change anything in that perception. Data also showed that the percentage of dissatisfied people is higher when the main residence is concerned and where young children live in the dwelling. Asensio et al. (2014) also observed differences between airports on annoyance levels after the noise insulation implementations.

This result is linked to another study led by Gobert (2010) that demonstrated differences between airports, which conduct compensation actions in different ways such as organizing consultation and mediation conditions or not. This author tried to explore how a compensation procedure can lead to reduced opposition in some cases (Los Angeles airport and Berlin airport) whereas others have little impact (CDG airport in Paris). She did literature and press reviews and conducted some interviews with stakeholders, pressure groups and residents. She concluded that compensation measures are better perceived in Berlin and L.A in comparison to Paris, because the first two were forced to territorialize and democratize their approach so they had a more participatory approach. On the contrary, Paris CDG

only led interventions without consulting residents who were living next to the airport.

From an objective point of view, an insulation scheme is also a procedure that helps to improve house pricing. In this sense, Friedt and Cohen (2019) showed that aircraft noise persistently and significantly reduces the rate of appreciation of abatement for ineligible homes by approximately USD 25,000 per sale compared to eligible houses. And this improvement of house pricing can also have a strong impact on residents' perception.

Picard, Brechet and Dobruszkes (2007) assumed that economic processes cannot be a good solution as the costs and the benefits are not supported by the same people. They suggest that it could be a better offer of compensation regarding noise issues, if annoyance was compensated with a part of the airport benefits. The authors linked that assertion with the NIMBY process (not in my back yard). Indeed, according to the authors, it is almost the same issue as people who are living under the flight path having to suffer personally the annoyance of a common and global service in their garden. In addition to an insulation scheme that is not sufficient for the outdoor time, authors suggest a "silent right" for residents, which can lead to a fair negotiation between airlines and residents.

6.1.3 Conclusion/Discussion

To conclude with evaluation of interventions, a brief review of regulatory and policy guidance (CATE, 2009) revealed considerable variability in the provision of mitigation and compensatory measures across the globe. Consequently, there is little standardisation in these areas, which makes tasks such as benchmarking very difficult as quantitative measures of performance have yet to be agreed upon across the airport sector. Further, the range of possible actions and the need to tailor mitigation and compensation provisions to local needs means that actions that are perceived to be generous and effective in one location may not receive the same response at another airport. Indeed, any ultimate indicator of the effectiveness of these actions (e.g. responses to community outreach, number of noise complaints, etc.) will be the result of a number of other inputs such as the success of communication strategies more generally and the effectiveness of attempts to manage aircraft noise at source.

Nevertheless, considering the literature above, it is interesting to note that results deal with fairness of the insulation scheme and, more widely, of the compensation the airport offers to its residents. Fairness is a non-acoustical factor, which has been shown to largely influence the annoyance experienced. This assumption reveals that fairness needs to be implemented in the way interventions are designed as a concrete resident's participation.

6.2 Focus groups

6.2.1 Methodology

As the authors did in the previous literature reviews, we assumed that insulation scheme perception was going to be different depending on the dwelling's exposure. To be in line with these previous findings we hypothesized that fairness would be valuable also in the way people perceive this intervention. In order to demonstrate

that, we selected 3 areas, two in the annoyance noise map and one outside the annoyance noise map contours, following these criteria:

- Eligible to the grant / non-insulated yet: city of Marignane (Marseille airport)
- Eligible to the grant/insulated: City of L'Estaque (Marseille airport)
- Non-eligible / non-insulated: City of Vitrolles (Marseille airport)

We assumed that people who were situated in the grant area and that were already insulated would be more likely to appreciate the intervention than the others. Moreover, it was important for us to investigate the perception of those people who could be insulated but had ignored the process of the insulation program. Indeed, we hypothesized that the insulation scheme is not well known by people even for those who are eligible for it. This could also have an impact on their perception, because it deals with fairness. Finally, we wanted to investigate this kind of intervention in an area with a mild climate, because we assume that it would not be as well perceived in comparison to colder areas. The conclusion of that could be to better frame the intervention according to the location; that there should be knowledge about the location and potentially a decentralization of the decision-making bodies.

On the annoyance map below the impacted areas are defined by different colours. The red one is the most affected area with a sound level of more than L_{den} = 70dB. The orange one has a sound level between L_{den} = 70dB and L_{den} = 65dB and the last area defined by the green colour is the less impacted area with a sound level between L_{den} = 65dB and L_{den} = 55dB. The annoyance map is a small part of a larger noise map (called exposure noise map) which includes more impacted areas but these are not eligible for the grant for the insulation scheme.

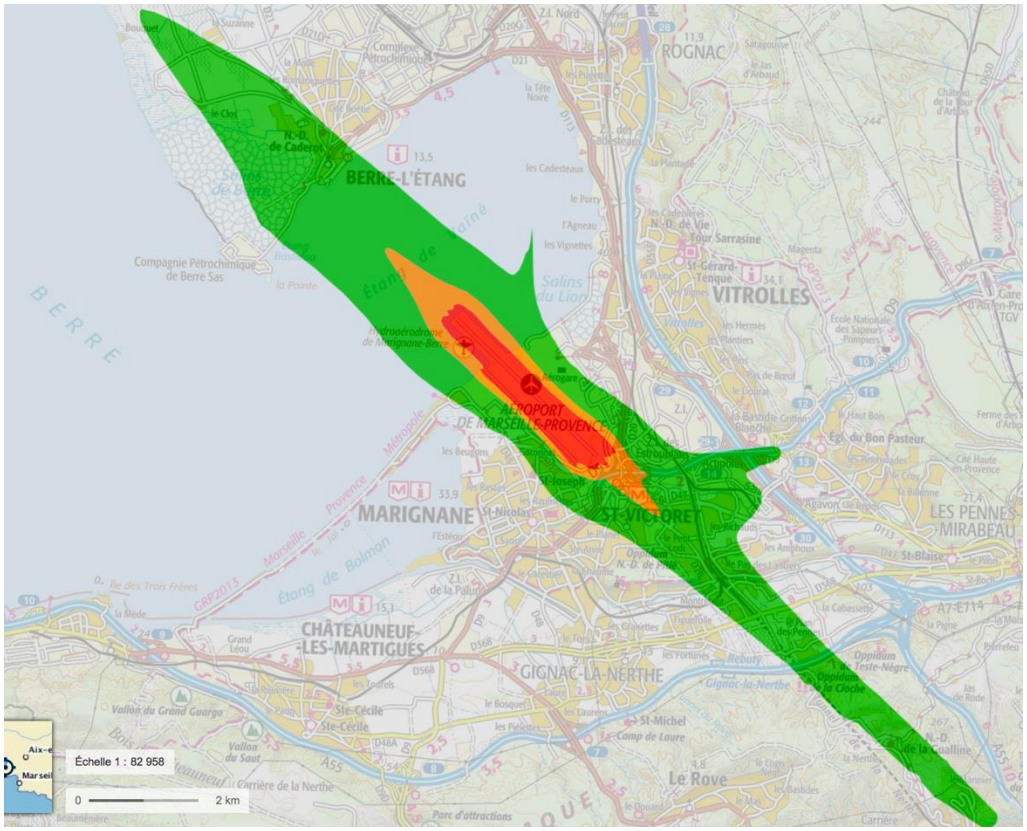

Figure 29: Annoyance noise map contours valuable for insulation scheme in Marseille. Green areas: 55 dB < L_{den} ≤ 65 dB; orange areas: 65 dB < L_{den} ≤ 70 dB; red areas: L_{den} > 70 dB.

Regarding these criteria, 3 groups of participants were created. For two of them, the recruitment was led by a recruitment company. They selected a sample of non-eligible people who were living in the town of Vitrolles, outside the annoyance noise map contours, and another sample of eligible people but non-insulated by the airport yet in the town of Marignane. The last sample was recruited by ENVIRONNONS in L'Estaque with households that had been insulated so far.

So, three focus groups were conducted:

- One in Vitrolles: a small town very close to the airport but not concerned by the insulation scheme, not in the annoyance noise map
- One in Marignane: a small city on the annoyance noise map and really close to the airport with departure and arrivals noise issues.
- One in l'Estaque: a small town situated one a harbour, within a pleasant area, but where noise issues are the same as in Marignane

Another focus group was conducted in order to consult the people involved in the pressure group. All the focus groups were conducted in December 2019 with on average 8 to 10 people per group.

The interview guide covered the following topics:

Part 1 was dedicated to questions regarding **the quality of life** and the **residential satisfaction**. Participants were asked to define their representation

of quality of life and more precisely elements of their close environment that improve or, on the contrary, prevent having a good quality of life.

Part 2 questioned participants about **attitudes toward the airport and knowledge of interventions** that aim to lower the annoyance. In this section, people had to say if they knew interventions that aimed to lower the annoyance and/ or the aircraft noise. If they did not mention the insulation scheme program, the facilitator mentioned it and explained the process to them. After that, they were asked to evaluate this intervention.

In part 3, we asked for opinions and **understanding regarding the sound insulation scheme**. This time, people had to link the insulation scheme program to their quality of life. They were asked whether this intervention improved quality of life in their surroundings or not and, if yes, how? They were also asked to give some recommendations to improve this intervention.

6.2.2 Results

For the visual summary (mind map) of the results see Figure 30 and Figure 31.

6.2.2.1 Sample description

For the sampling we wanted to create 3 groups with one non-insulated at all and non-eligible in order to compare the attitude regarding the intervention with the other group insulated by the airport and/or eligible for the grant for being insulated. Finally, even if there were non-eligible people in this group, their homes were almost all soundproofed. Indeed, in France, there is a new regulation for thermic reasons and energy saving that encourages people to install the insulation in their dwelling. Nevertheless, even with this unexpected data we keep our hypothesis that probably people who were not given a grant by the airport would be more upset about the noise or about the airport than the others who had been insulated by the airport or could be subsidized to do it.

Below you will find a detailed description of the 3 samples.

For the eligible/non-insulated group - MARIGNANE (Gp1) the sample consists of 10 people, 2 men and 8 women. 5 have children at home, 4 of them are in a relationship. 5 live in houses and 5 in apartments. 4 own their homes. The age ranges from 25 to 73 with a median age of 54 years old. 7 of them have soundproofed homes with double glazing but not subsidized by the airport. Concerning annoyance, the sample declares to be more strongly affected by aircraft noise and road traffic noise with a median of 5 and 4 respectively on a Likert scale from 0 (not bothered at all) to 5 (strongly bothered). The participants are not members of local residents' associations. Occupation status between 6 months and 38 years.

For the eligible/insulated group - L'ESTAQUE (Gp2) the sample consists of 5 people, 1 man and 4 women aged between 30 and 72 years old. The average age is 50.4 years. All participants are owners. 3 live in Marseille l'Estaque, 1 in Vitrolles Gare and 1 in Saint Victoret. All have had soundproofing by the airport and are aware that they have. 2 people have been living at their home for over 30 years, 2 for over 15 years, and 1 for 2 years. Concerning annoyance, the sample declares to be more strongly affected by aircraft noise and pollution with

a median of 4.5 and 4 respectively. The participants are not members of local residents' associations.

In the non-eligible group - VITROLLES (Gp3) the sample consists of 9 people, 4 men and 5 women. 7 have children at home, 4 of them are in a relationship. 3 live in a house and 6 in an apartment. 7 own their homes. The age ranges from 31 to 62 with a median age of 45. 6 of them have soundproofing with double glazing; one from ADEME (national agency for environment and energy development), the others by themselves or because of new housing. Concerning annoyance, the sample declares to be more strongly bothered by aircraft noise and road traffic noise with a median of 4 and 4 respectively. Participants are not members of local residents' associations. Occupation status between 1 year and 21 years old, 4 under 10 years and the others above.

6.2.2.2 QoL and residential satisfaction

In the Gp 1 people are generally satisfied with their residential area except for the sound environment linked to air traffic. The proximity to shops, the friendliness of the inhabitants and the safety of the place are quality assets for the participants. However, they also describe annoyance with, and note an increase in, aircraft noise over the years; the difficulty or even unbearable situation in summer because of the planes' overflights. This causes difficulty in social relations (communication, embarrassment when inviting people over, etc.), trouble falling asleep, and embarrassment in leisure activities such as watching television, talking on the phone or even gardening. While two people speak of "habituation" to noise, for the others to "get used" to the noise is impossible and they describe a feeling of unhappiness. 4 people describe a feeling of fear when they are overflown and they have no coping strategies for that. 3 are afraid of aircraft crashes and 1 about air pollution. Moreover, all participants describe the feeling of shame when they invite guests in summer time because of the aircraft noise.

In Gp 2 the participants describe their residential area as being attractive from an aesthetic point of view, which contrasts with strong noise pollution from air traffic according to them. Once again, participants who have lived in the neighbourhood for a long time noted an increase in air traffic. Today it seems unbearable to them. They recall, in particular, that aircraft fly really close to their homes, that when they have a conversation, it is regularly interrupted to come back to it once the plane has passed. Half of the participants also broached the subject of pollution, which they described as a film of fat covering their garden furniture and the water in the swimming pools outside. The participants consider calmness, security, a good neighbourhood, and good air quality as important factors in their quality of life. They also add that the neighbours' association is important for creating social ties.

In Gp 3 participants consider that their city is well located geographically, for example with shops nearby. However, they point out that the price of housing is too high compared to the nuisance they live in. Some people suggest that they will lose money by selling their house and, on the contrary, others noticed that their property has tripled in price. Participants deplore an intensive urbanization in their city, the fact that there is concrete everywhere. This urban densification

leads to an increase in road traffic and makes their daily life unliveable in terms of travel. Half of the participants say that their residential conditions (congestion, noise and concrete) make them stressed in their daily lives. Mobility is strongly criticized by the participants, in particular the lack of public transport regarding the population density. We can note that it is the only group that did not start by talking about aircraft noise.

6.2.2.3 Knowledge and evaluation regarding the insulation scheme program

In Gp 1 half of the participants know the insulation scheme program proposed by airports. They became aware of it through word of mouth in the neighbourhood. For 3 of them, they had already asked insulation but they failed to be granted it because their houses were not located in the annoyance map area. Otherwise, they do not know about other interventions except that one participant who denounces the non-compliance with navigation procedures by the pilots for take-off and landing.

The participants consider the soundproofing procedure to be a good thing but denounce the perimeter defined by the intervention which they consider unfair. They also mention as unfair the fact that the year of building for being insulated or not is considered. Some participants indicate that they should have a "risk premium". Moreover, participants mentioned the season gap of the intervention: the insulation scheme is obsolete in case of warm weather (that represents almost 6 to 8 months of the year in Marseille) as people open their windows or have leisure time in their garden.

In Gp 2 all the participants are aware of the intervention since they have all been insulated directly (they asked for it) or indirectly (the owner before them asked for it) by the airport. Knowledge of the sound insulation procedure is mainly due to word of mouth from their neighbourhood. If the processing times for application files seemed long to them a few years ago, it now seems that the timeframe is fairly short and therefore effective once the file is presented. For participants, the insulation scheme program is helpful to reduce their annoyance in winter time. They feel a real difference with respect to aircraft noise compared to before. However, they point out that this soundproofing is useless 8 months of the year since they open their windows when the weather starts to be nice. Insulation schemes are also perceived of as interesting from a thermal point of view because they improve the energy quality of housing. Despite this intervention, some participants note that they are still disturbed in their sleep when they are overflown at night and when they invite people in summer because communication becomes difficult. On this subject, they describe a feeling of shame towards their guests. They feel "jailed" in summer time and are frustrated that they cannot enjoy their home and garden because of the constant overflights.

In Gp 3 we have mixed answers concerning the knowledge of the procedure. Often this knowledge comes from word of mouth or from the information of a social landlord when people live in social housing. Participants have a favourable attitude to the insulation scheme procedure itself, even though it is considered unnecessary and ineffective for noise outdoors and during the summer period when the windows remain open all day. However, they criticize the delineation of the outline of the noise annoyance map. In addition to this, they wish for the

annoyance map to be scalable according to the increase in traffic and to be reviewed more regularly. Participants regret that the intervention is not highlighted enough and not sufficiently communicated to the general public and potentially eligible people.

6.2.2.4 Impact of sound insulation scheme program on QoL

In Gp 1 participants consider that soundproofing plays a role in reducing stress, reducing nervousness and the feeling of fear. They also indicate that insulation would improve their leisure time indoors as well as their social relations when this is indoors. However, they point out that soundproofing is no longer effective outdoors or against air pollution. When we asked on which aspects of the quality of life could the soundproofing of housing play a role, the participants mentioned 7 things: reducing noise pollution (10 people); improve health, lowering stress and frustration (10 people); social interactions and communication (3 people); reducing fear of aircraft crash (1); improve sleep quality (1); improve wellbeing (1).

In Gp 2, according to the participants, soundproofing helps reduce aircraft noise and, therefore, feelings of discomfort. It helps to reduce their stress when they are inside their home, as well as improving their thermal comfort. Soundproofing also saves them money through thermal insulation. Insulation schemes also improve their leisure time quality inside the house (listening to television, improving concentration, etc.). On the other hand, this feeling of calm stops as soon as they are outside or if they open their windows.

In Gp 3, when we asked on which aspects of the quality of life could the soundproofing of housing play a role, the participants mentioned 6 things: less aircraft noise (8 people), thermic insulation (6 people), calm (6 people), privacy, ecology, the fact that it is not useful over 6 months (6 people) and that it protects against noise from neighbours. People feel that insulation can reduce stress from noise, mostly when they get back home.

6.2.3 Discussion

In order to investigate our results and to shape them in a comprehensive way we created 2 mind maps: One differentiated result on topics per groups in order to validate or not our first hypothesis and one which presents all the results regarding QoL.

Regarding these results it appears that:

- **Differences are found between groups** on the way to begin the discourse and on the fact that noise contours are unfair.

The non-eligible group began the discussion by the feeling of crowding , that is to say the fact that more and more people live in the same area, in their city while the other two groups, who can benefit from the grant, started to talk about aircraft noise.

- Except for those who have been insulated by the airport already, the insulation schemes program remained unknown or partially known.

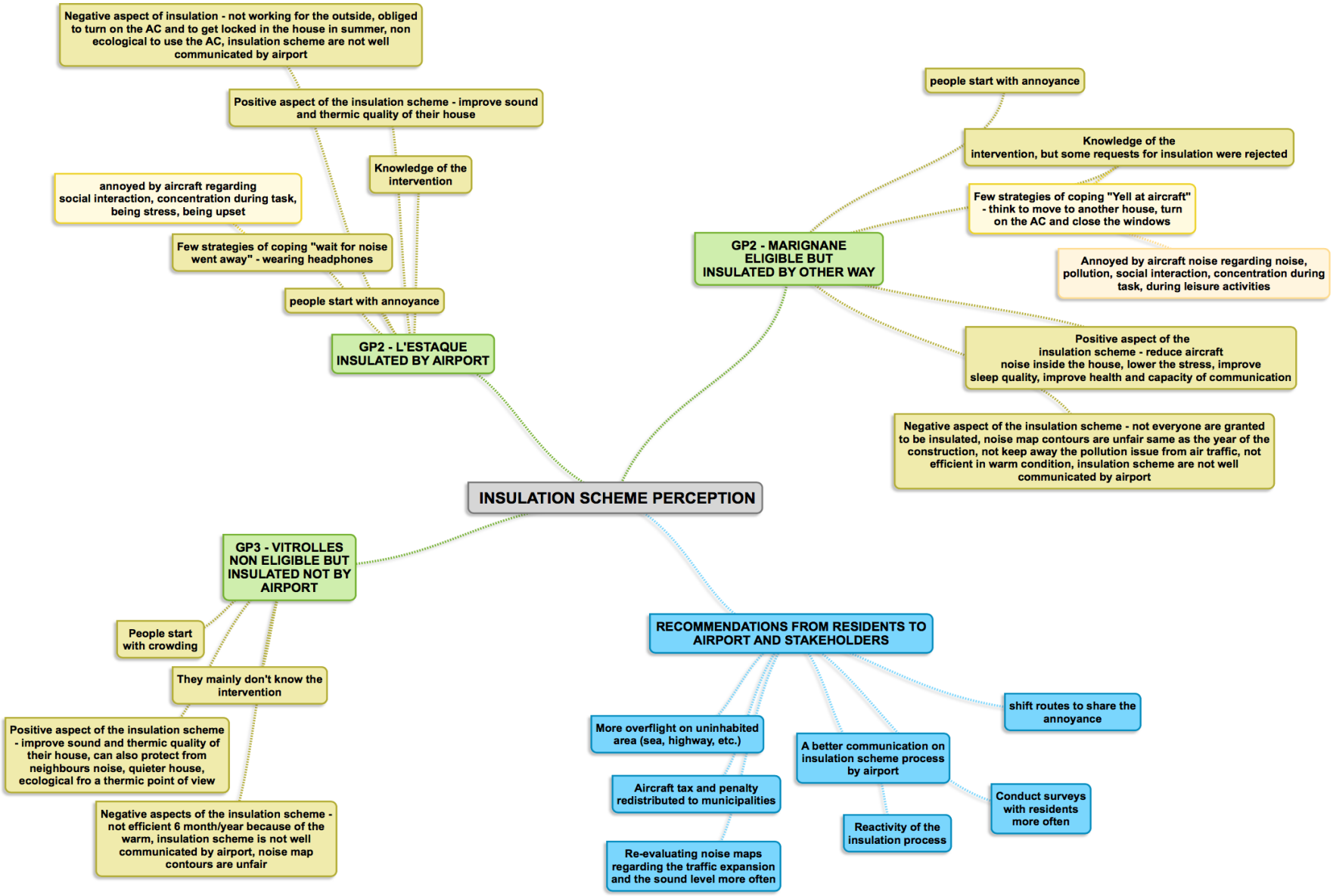

Figure 30: Mind map recalling main results regarding impact of insulation schemes on QoL per group.

People who are aware of this intervention mention that they knew it thanks to word of mouth, by neighbours or even family but not directly from the airport.

- In all groups **people do not have any coping strategies** regarding aircraft noise; they seemed to be in a helplessness situation.
- In all groups, people mention that i**nsulation schemes are not efficient for the outdoors** and said that they **feel ashamed and annoyed when they have guests,** because of the noise, they have trouble in communication.

To better understand our data, we built a mind map with the 9 components of the QoL in link with aviation. In red we note the negative impact on QoL recalled by the respondents and in green the values of this procedure on their QoL.

Regarding these results it appears that:

- Insulation scheme is useful for being away from noise in winter time when windows are closed
- This intervention does not have any effect on air pollution caused by aircrafts
- Insulation seems to be very effective and can reduce stress and fear of crash when people are inside their home
- Intervention is not well designed to lower the annoyance when people are outside
- Insulation scheme improves thermal comfort and favours the reduction of the household energy bills.

Despite that, **the insulation scheme is still well perceived** and shall be pursued according to respondents.

Figure 31: Mind Map recalling the main results regarding the impact of insulation scheme on QoL.

6.2.4 Conclusion

These results reveal that an intervention has to take into account not only the indoor noise but also the outdoor noise exposure. Moreover, **the quality of life goes beyond the sound quality of the living place.** For instance, by remembering feelings like fear, stress or even issues like air pollution **people are talking about their health**. A good residential area must be safe also in this sense. The same applies for the capacity of the intervention to improve social interactions in their residential area and mostly at home. The insulation scheme is still a good way to avoid annoyance, but it must be complemented by other interventions, mostly when impacted areas are situated in a warm climate area.

Moreover, in France, regulations appear to encourage owners to make insulation works in their house. They can get a grant from the state for this. Plus, new buildings are obliged to follow these new thermal regulations. For instance, it seems that new kinds of interventions to lower aircraft annoyance in general (noise but not only) must be thought out.

7 Sound insulation – Heathrow Airport

7.1 Evolution of sound insulation offer at Heathrow

Concerns about aircraft noise impact date back to the 1950s and 1960s when jet engines started to be introduced, and international aviation became more popular (CAP 1165, 2014).

Sound insulation as an intervention to help mitigate aircraft noise impacts around Heathrow began being discussed in the 1960s, resulting in a range of schemes being developed over the ensuing 60 years. A key aim of such schemes is to reduce noise complaints and general community dissatisfaction by reducing noise disturbance attributable to aircraft overflights. It has been widely assumed that this will have helped to maintain good relationships with community stakeholders, although there has been surprisingly little substantive research to investigate how successful this particular type of intervention has been in achieving this objective. It is, of course, well known that increasing the acoustic attenuation loss of building facades, windows, etc. has no effect on sound levels outdoors and becomes ineffective if windows are left open for natural ventilation purposes, although it has never been firmly established to what extent people's attitudes to aircraft noise are primarily determined by the indoor or outdoor experience. There is some evidence that central to the success of such schemes can be the perceived level of 'generosity' or 'reasonableness' of the action (CATE, 2009), although this is impossible to estimate solely on the basis of acoustic measurements alone. For several practical reasons, entitlement to sound insulation grants unfortunately has to be determined by objective measurements of aircraft noise sound levels, which current evidence suggests do not have a particularly high correlation with community satisfaction. In addition, it is well known that in-situ technical performance often falls short of ideal performance measured under laboratory conditions.

The legislation and statutory instruments around these schemes point to the evolution of the legal framework surrounding the airport's noise strategy. Under Section 79 of the Civil Aviation Act (as subsequently amended), the UK government has powers to direct airport operators to implement noise insulation schemes.

Table 9: Chronology of legislation related to sound insulation at Heathrow.

Year	Scheme
1966	London (Heathrow) Airport Noise Insulation Grants Scheme
1972	Heathrow Airport–London Noise Insulation Grants Scheme
1975	Heathrow Airport–London Noise Insulation Grants Scheme
1980	Heathrow Airport–London Noise Insulation Grants Scheme
1989	Heathrow Airport–London Noise Insulation Grants Scheme

Note: (http://www.legislation.gov.uk/uksi/1989/247/section/2/made)

Although the insulation grants scheme legislative statements (published in 1966, 1972, 1975 and 1980) are not readily available in a web-publishable format, the grants scheme for 1989 sets out the relevant legislation that was introduced that year (available @ link above). While some documents still refer to Heathrow being subject to the 1989 legislation, it was actually revoked in 2014 (http://www.legislation.gov.uk/uksi/2014/3233/section/2/made). It is apparent that the principles laid out in the 1989 legislation still pertain but the legislation had to be revoked because all insulation had to be completed by 300992: "The Schemes required Heathrow Airport Limited and Gatwick Airport Limited to pay grants towards the cost of installing domestic insulation in eligible dwellings in the vicinity of the airports".

The last date for lodging an application under the Schemes was 31st March 1991 and all insulation work had to be completed by 30th September 1992. As these dates have been passed the Schemes are spent." (as per Explanatory Note @ http://www.legislation.gov.uk/uksi/2014/3233/pdfs/uksi_20143233_en.pdf).

Latterly, Heathrow has introduced a range of noise control and mitigation measures voluntarily; although the prospect of statutory action is usually highlighted by government if appropriate 'voluntary' actions are not undertaken at UK airports.

7.1.1 Key messages

7.1.1.1 Policy environment

Against the context of planning for runway expansion at Heathrow, in early 2017, the DfT published a draft UK Airspace Policy with a consultation response published in October that year. The response stated that the Government:

- § expects airport operators to offer acoustic insulation to noise sensitive buildings, such as schools and hospitals, exposed to outdoor sound levels of 63dB LAeq,16hr or more
- § expects airport operators to offer financial assistance towards acoustic insulation to residential properties exposed to levels of noise of 63dB LAeq,16hr or more.

The Government went on to publish the Aviation 2050 consultation in December 2018 which proposed the following noise insulation measures:

§ to extend the noise insulation policy threshold beyond the current $L_{Aeq,16hr}$ 63dB contour to $L_{Aeq,16hr}$ 60dB.

§ to require all airports to review the effectiveness of existing schemes. This should include how effective the insulation is and whether other factors (such as ventilation) need to be considered, and also whether levels of contributions are affecting take-up.

§ the government or ICCAN (Independent Commission on Civil Aviation Noise) to issue new guidance to airports on best practice for noise insulation schemes, to improve consistency.

§ for airspace changes which lead to significantly increased overflight, to set a new minimum threshold of an increase of $L_{AeqT3dB}$, which leaves a household in the $L_{Aeq,16hr}$ 54dB contour or above as a new eligibility criterion for assistance with noise insulation.

It is understood that these newer measures have not yet been adopted.

7.1.1.2 Current schemes

A voluntary daytime noise insulation scheme was introduced in the mid-90s, followed by a voluntary night noise insulation scheme early in the following decade. By 2014, Heathrow started to offer the Quieter Homes Scheme for those residents living closest to the airport within the 69dB $L_{Aeq,16hr}$ aircraft noise contour.

Brief details of the existing noise schemes at Heathrow (Heathrow Expansion Consultation, 2019 @https://aec.heathrowconsultation.com/wp-content/uploads/sites/5/2019/04/190329-hep-nip-framework-v3.pdf):

§ The **Quieter Homes Scheme (QHS)** applies to homes based on the 2011 69dB $L_{Aeq,16hr}$ contour. It covers the full cost of carrying out the work which can include loft and ceiling insulation, double-glazing or external door replacements and loft and ceiling over-boarding. Around 1200 homes located close to the airport are entitled to this scheme (https://www.heathrow.com/noise/what-you-can-do/apply-for-help/noise-insulation-schemes). Thus far, around 750 homes have been in receipt of this offer.

§ The (Residential) **Day Noise Insulation Scheme** (or Day Scheme) is based on the 1994 69dB $L_{Aeq,18hr}$ contour and is designed to protect those homes exposed to the aircraft noise in the day, including in the early morning arrival period before 06:00. These properties are eligible to receive 50% of the cost of replacement windows and external doors, or free secondary-glazing, and free loft insulation and ventilation. 9300 homes fall into this scheme's boundary (https://www.heathrow.com/noise/what-you-can-do/apply-for-help/noise-insulation-schemes)

§ The **Night Noise Insulation Scheme** (or Night Scheme) is designed to address the impact of night flights on local residents. The scheme boundary is based on the footprint of the noisiest aircraft regularly operating between 23:30 and 06:00. These properties are eligible to receive 50% of the cost of replacement bedroom or bedsitting room windows, or free secondary-glazing of bedroom or bedsitting room windows, and free loft insulation and ventilation. Approximately 37000 homes fall within this scheme's boundary (https://www.heathrow.com/noise/what-you-can-do/apply-for-help/noise-insulation-schemes).

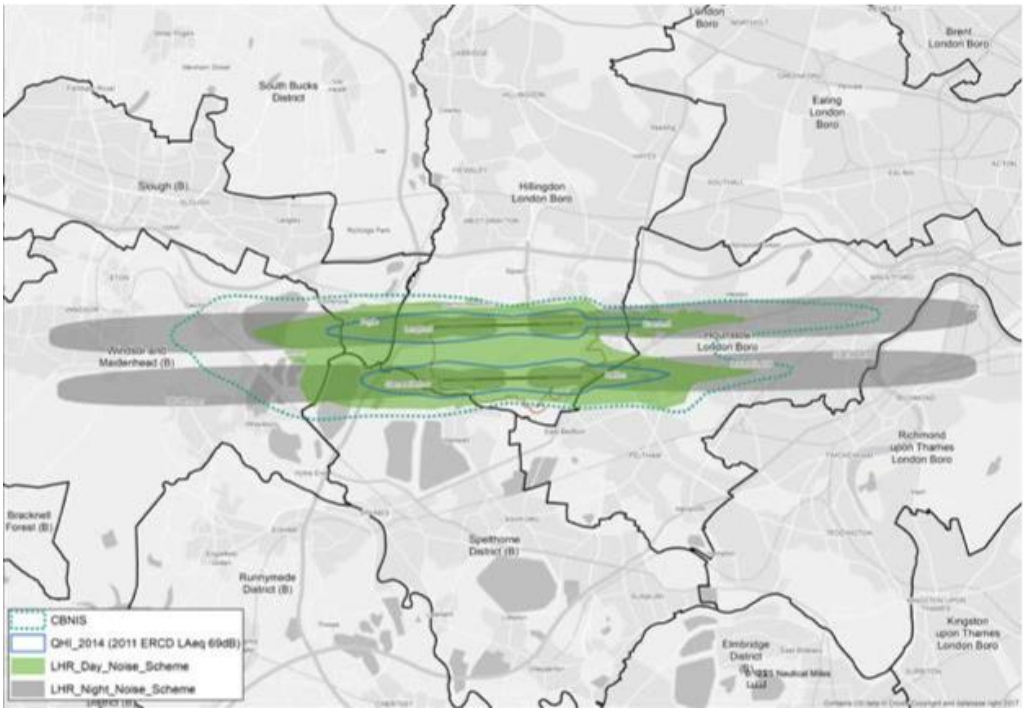

Figure 32: Boundaries of existing noise schemes.

In addition, in their runway expansion consultation document, Heathrow describe the **Community Buildings Noise Insulation Scheme** which applies to noise-sensitive buildings around Heathrow that are exposed to a medium to high level of noise (within the 2002 63dB $L_{Aeq,16hr}$ noise contour). Buildings included are hospitals, schools and colleges, nurseries attached to schools and hospices, nursing homes, registered nurseries, libraries and community halls. The scheme pays for buildings to make noise-insulating modifications such as double-glazing, replacement windows and ventilation. Eligible buildings are those in widespread use within the community, where people spend long periods of time, or where they are vulnerable.

7.1.1.3 Summary of research and key messages

While there has been a history of sound insulation at Heathrow, the effectiveness of the schemes for improving people's quality of life is not readily evident. The interventions, in their various forms, appear to be considered 'good' for their own sake, rather than there being evaluation of how they have contributed to quality of life, perceptions of value, 'fairness' and 'licence to operate'. A potential improvement would be a systematic evaluation of the effectiveness of the schemes in addressing the problem of noise disturbance. One approach is to set a targeted level of sound attenuation; another is to investigate customer satisfaction with the insulation provisions. The latter requires an investigation of the impact of the scheme on perceived levels of noise disturbance and, thus, levels of satisfaction with airport efforts to mitigate noise impacts. This could help inform future actions and determine the cost-effectiveness of this type of mitigation provision. This is not to suggest that the airport does not consult on new mitigation and compensation initiatives; rather that on-going feedback on existing measures would add considerably to the efficacy of future decisions as to the most appropriate and cost-effective range of measures in a given location.

A key aim of sound insulation schemes is to reduce noise disturbance experienced by local communities and thereby maintain good relationships with this key stakeholder group and a 'licence to operate'. Central to the success of such schemes is the perceived level of 'generosity' or 'reasonableness' of the action, yet this is another dimension that has not received substantial attention, either amongst residents in general or those specifically affected by aircraft noise.

The materials reviewed, and other sources, suggest that the lack of 100% take up of insulation schemes may illustrate that these are far from optimal offers. Indeed, discussions with local residents suggest that, as sound insulation does not impact on noise outside the home, or when windows are open, the offer cannot be most advantageous for full use of one's residential environment. Nevertheless, as a part of a suite of offers that are tailored to local circumstances (e.g. alongside financial support to groups and infrastructure in communities, etc.), sound insulation does appear to have some value.

7.2 Resident interviews

7.2.1 Methodology

In order to understand peoples' experience of living in the vicinity of/under en-route paths to/from Heathrow and their views on sound insulation, telephone interviews were carried out in September 2020. Participants were recruited through a local civic group, HACAN (Heathrow Association for the Control of Aircraft Noise), and included ten respondents. This group was purposively selected as their membership of HACAN, whose role is to be a voice for those under Heathrow flight paths, indicated that they would have some willingness to discuss issues related to aircraft noise. It should also be noted that there was a likelihood that some of the group may have had a willingness to oppose the airport and its activities too. This is something that the research team were aware of but it was agreed that the group's views would still provide insight into individual views amongst a small self-selected population. The interviews covered residents' satisfaction with their area and issues affecting their quality of life, their views about the airport and about the sound insulation offer, and an exploration of the value they placed on the intervention.

7.2.2 Results

It is important to reiterate, at the outset, that this was not a randomly selected group of interviewees but a group for whom noise was clearly already a factor. Thus, there needs to be a caveat about the representativeness of the results. Nevertheless, this was a motivated group of individuals who were willing to give their time to discuss quality of life in relation to

aircraft noise - something that was of immense value to the researchers during continued restrictions due to the COVID-19 pandemic which prevented the initially planned questionnaire and focus group approach.

All ten interviewees were located to the East of the airport and variously affected by westerly arrivals (close in at Hounslow and further out along the arrival path) or easterly departures (one under the flightpath taking 40% of easterly departure traffic). All had been in their properties for long periods, except for one participant who had moved from an area near the airport to one which was even closer and had been surprised by the apparent increase in noise intrusion, feeling that she had made a mistake with the move. All were owner occupiers; there were 6 females and 4 males; all had either retired from, or were in, professional jobs. The age distribution was: 1 in age band 35-44, 2 in 45-54, 1 in 55-64, 4 in 65-74 and 1 in 75-84.

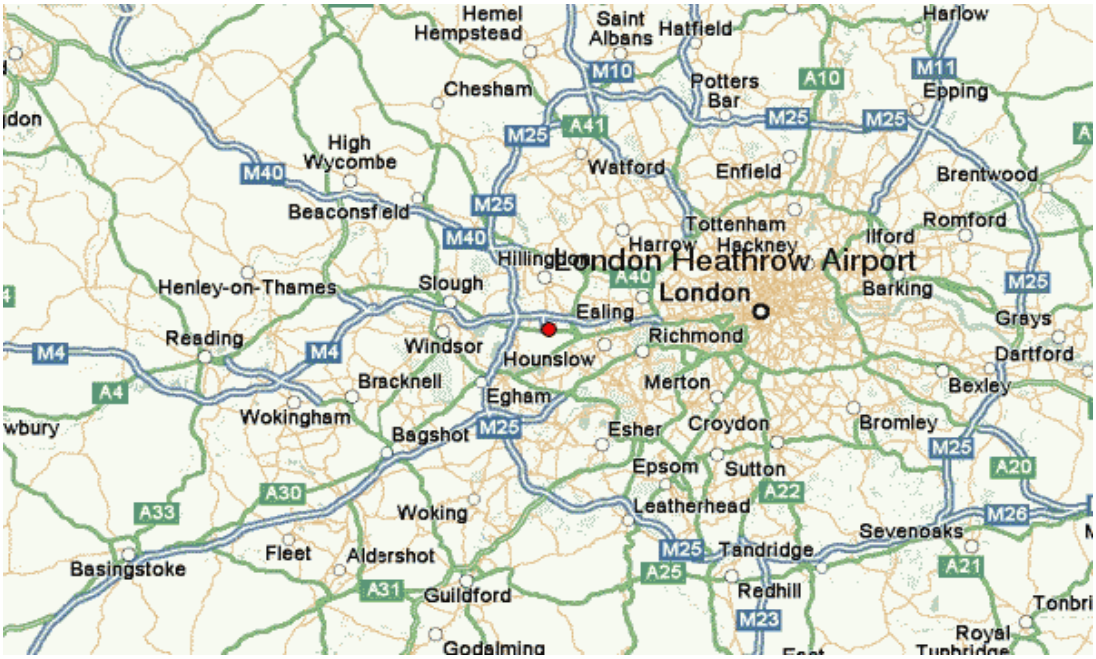

Figure 33: Location of Heathrow Airport.

7.2.3 Discussion

The findings of the qualitative interviews are set out in Figure 34. In this section, a number of main themes explored with interviewees are discussed. Where participants are described as 'uninformed', the views were expressed prior to the interviewer providing information about the sound insulation schemes and activities at the airport.

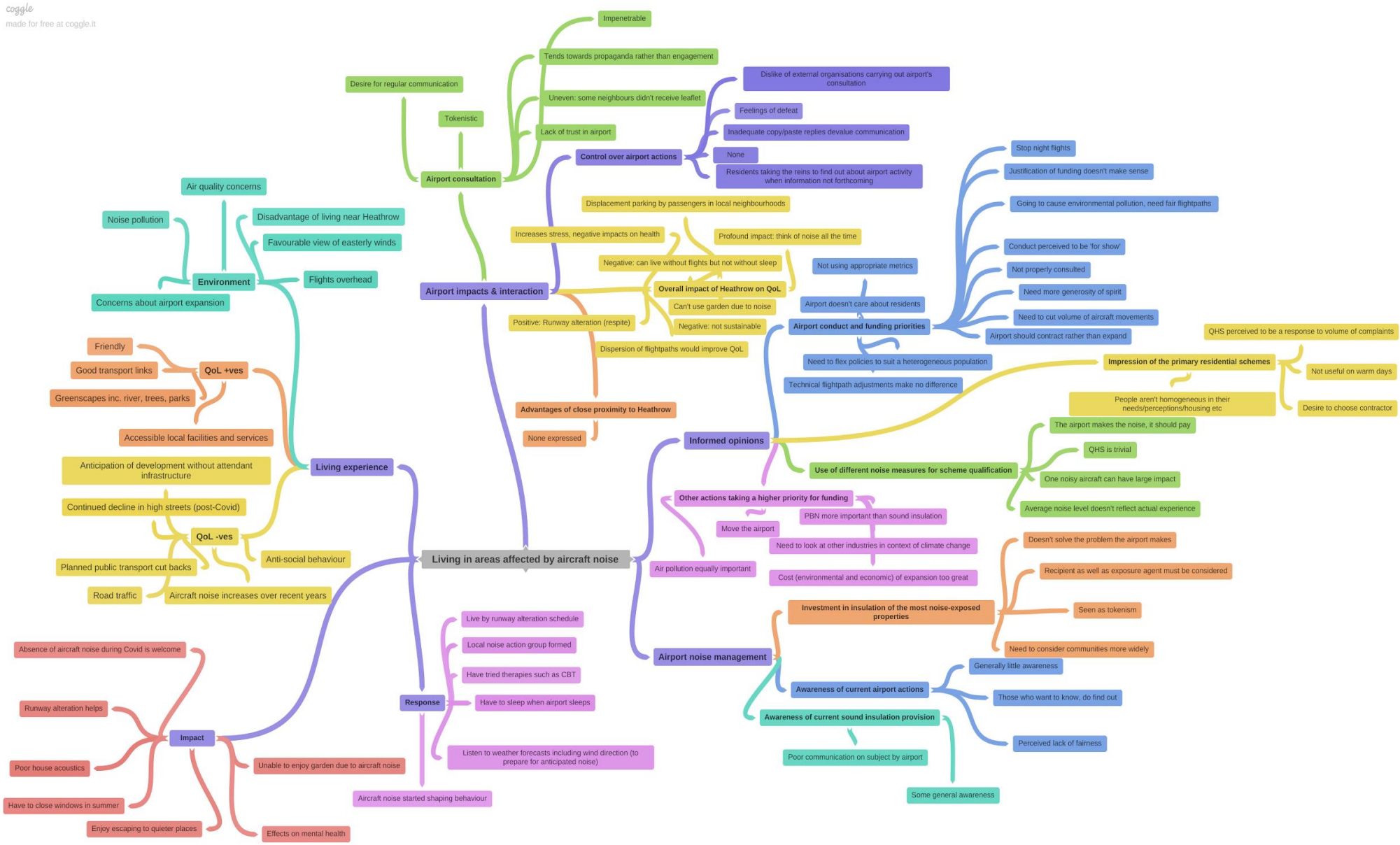

Figure 34: Main findings of in-depth interviews – Heathrow.

7.2.3.1 Environment and QoL

Generally, there was a low level of awareness of what the airport does to minimise noise exposure. Interviewees reported that there had been very little/no direct contact from the airport regarding their activities, except for some more recent communication on runway expansion. Most people had actively pursued information: indeed, HACAN was a primary source. However, while there was little evidence of a systematic understanding of noise management, there was better appreciation of general airport operations and impact of alternation and westerly/easterly modes. This led some to comment on noise sharing, which was generally supported, although opportunities for greater sharing linked to runway three were not agreed with, all felt more traffic would mean more noise for them

There was some cynicism about governance in general and feeling that communications were largely manipulative and tokenistic. In addition, there appeared to be a general lack of transparency/fairness.

There was a low level of awareness of insulation provision. Participants generally agreed with the principle of addressing the most noise affected, although the means for determining this was criticised (with some either suggesting that L_{eq} did not adequately reflect lived experience or simply that insulation should extend further out and take account of the increase in numbers of aircraft over the years).

Only one participant in the area (in Hounslow, very near to Heathrow) was covered by an insulation scheme (night). This work had been done before she moved in, and when she tried to get further work done during conversion of an attic, this was seen to be outside scheme provision as it was a new alternation. Ultimately, she paid for sound-insulated windows, which have improved the situation but not fully remedied it.

7.2.3.2 Heathrow Insulation provision (informed)

All interviewees understood the various sound insulation schemes once they were explained (they had been sent an information sheet on the schemes for use during the interview) and the use of L_{max} footprint for the night scheme seemed to be sensible. Overall progression of schemes was not very evident, especially as QHS only covers a small number of properties. The 50% offer to pay towards insulation was seen to be unfair – why should residents have to pay to rectify a problem of the airport's making? Generally, interviewers had to work hard for any evaluative comments about sound insulation as an intervention, with participants feeling it was impossible to provide a view without speaking to recipients. Nevertheless, some relevant comments were:

- Future airspace plans are more important
- Respite is more of a contribution than insulation
- Description feels technical
- What's the performance of the insulation provision?
- Offer needs to go further for different scenarios (i.e. consider each operational mode as you are exposed throughout the time when on a particular mode)
- Full costs coverage is a clear improvement
- Good use of money but other things are important
- Would be concerned about contractors and quality of installation
- Offer makes sense from a business perspective, it 'looks good'
- Looks good on paper but what's the real impact?
- Can vulnerability be factored into the qualification for insulation?

7.2.3.3 Airport impacts and interactions

Participants were generally happy to acknowledge the economic benefits from the airport, although personal access was less of a perceived benefit. The interviews also raised the negative issues around frequent fliers and wider environmental problems (carbon and emissions). There was universal agreement that noise disbenefits outweighed any positive contribution from the airport to local communities. Much of this conversation was overlaid with concerns about the airport's expansion through runway three: the decision in favour of which was seen to be misplaced, leading to much criticism of named politicians and processes of decision-making, with communities being 'treated with total contempt'.

The participants described very little direct information from the airport and what little there may have been as tokenistic, leaving people with a feeling of no control. Some had participated in consultations which they felt had some influence (e.g. over departures after 11.30pm) but momentum seems to have waned.

There was a desire to be consulted but there were also fears that the airport would control the agenda and, thus, outcomes. There was clearly room for improvement in communication over how operations can be enhanced to allow for influence over things that currently feel out of control.

7.2.4 Conclusion

Amongst the individuals participating in this study, QoL was generally reported to be good and positive attributes of their environment were readily articulated. When the theme of aircraft noise was introduced, participants did not tend to overtly link it to QoL, referring instead to adopted behaviours and activities in reaction to changes in sound level. There was little awareness of Heathrow's actions in relation to aircraft noise, although there was some familiarity with runway alternation. These individuals tended to be unaware of the sound insulation schemes offered by the airport but, once given information on the topic, expressed concerns around fairness and sound measurements used. Ultimately, this group of participants suggested that there was little communication from the airport and called for more effective engagement on issues that directly impact residents.

7.3 The impact of the sound insulation scheme on quality of life

The empirical work carried out suggests that, for the participants, there is little connection between sound insulation and quality of life. While aircraft noise is a concern, there is no obvious link drawn by the participants between the offer and any positive effect on quality of life. This may be because only one participant had been in receipt, indirectly, of the intervention, and others had not, suggesting that participants may have avoided any assertion which could only really have been conjecture. Equally, it may also be that each individual's experience is distinctive, with no single unique pathway of effect of sound changes across different people.

8 Key learnings & recommendations for stakeholders

This research has sought **to gain insights into the relationship between historic sound interventions and quality of life** of residents. While there has been little evidence found on the direct link between the interventions and people's quality of life, the work has revealed **some of the critical success factors which may contribute to the development of an airport** offer that is more nuanced in meeting residents' expectations and, thereby, of increased likelihood of influencing their lived experience.

The mind map below gathered together all the questions we addressed to understand the impact of interventions on residents' quality of life. The aim was to understand the impact of the interventions investigated on residents' acoustic perception, on their social and leisure activities, on their health, on their natural and living environment, on their material living conditions, on governance and their rights, and on their productivity and main activities.

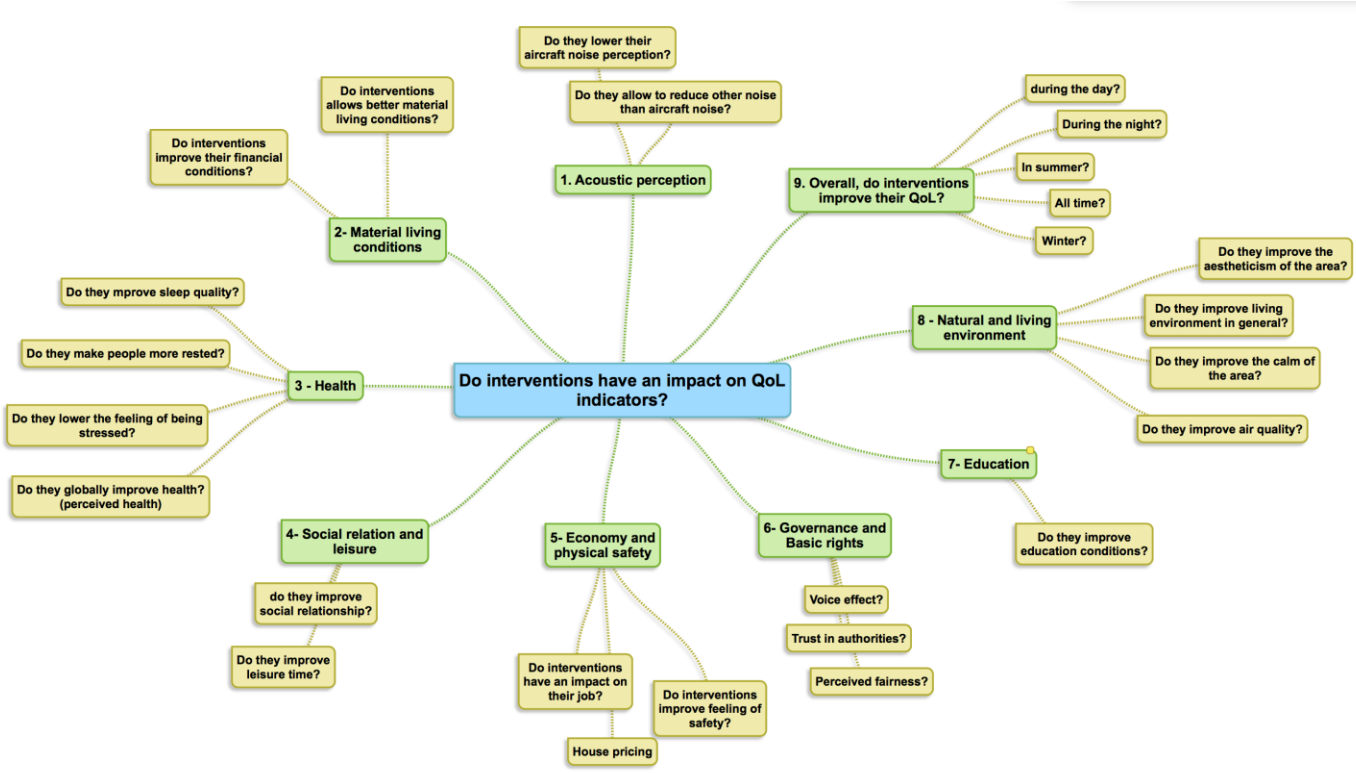

Figure 35: Research questions addressed.

In this research, we also examined what the interventions had in common regarding their impact on residents' quality of life and how they contrasted in this context. We also sought to understand in what aspects they differed. Based on these results, recommendations for aviation stakeholders were developed.

Before moving forwards, it is important to note that the results have suffered the effects of trying to carry out qualitative research during a period when people were unable to meet face-to-face due to pandemic-related social distancing. This is particularly relevant to the findings from Frankfurt and Heathrow where there were challenges for recruitment of participants and, in the case of Heathrow, in particular, difficulties in contacting airport managers as a result of furloughing of staff. Indeed, the entire methodological approach that had been planned for the

research overall – using a survey to then shape follow up focus groups – became a victim of the constraints posed by the pandemic. Nevertheless, while we recognise the limitations of the study we could conduct, we have taken the research findings and set them in the context of previous learning to make our recommendations.

8.1 Do interventions improve residents' quality of life?

The four interventions investigated showed no strong link between the implementation of an intervention and residents' quality of life. As they are designed now, sound insulation and flight path changes may **partially lower noise exposure** and **effective consultation may help people better understand the need for change** but the research findings demonstrate **that overall the interventions studied have few impacts on residents' quality of life.**

Some of the interventions can improve, for example, objective factors that could have a small impact on the way people live with noise: for example, the capacity of the insulation scheme to improve thermal comfort or to make a small contribution to the economic value of the property. But residents could not truly say that an intervention improves their quality of life as this concept is much more complex than a singular focus on lowering noise levels when one is at home. It appears that noise has been assumed to be the central concern related to air traffic and was the only parameter taken into account by airports to frame and shape their interventions. While this may have proved to be true in the past, it appears that residents are now interested in a wider range of issues than noise alone. **Even if noise still remains an important issue for residents,** who still suffer from it despite the intervention that aimed to lower it, results showed also that **residents were worried about their health, the impact of noise on their leisure and their capacity to be a part of the fairest possible project for their living environment.** For instance, in Marseille, despite the insulation scheme, people felt discomfited, when they invited guests into their garden, because of the noise. This result may be linked to notions of personal identity. Indeed, buying or choosing to live in a house is strongly correlated to the way of life we choose and could represent a marker of our identity. In this case, people may feel an element of cognitive dissonance as their choice of a particular house may appear to be incongruent with their expectations. This dissonance could affect their quality of life too, in addition to the noise annoyance they face. Thus, this highlights that intervention design would benefit from taking into account more quality of life variables, such as social life, for example, because air traffic can hugely impact on this factor. In this case, social life and leisure are functions of aircraft noise when people are at home.

There appears to have been a lack of understanding about quality of life from the airports. In addition, it was not clear which aspects of the residents' quality of life are related to aviation activity and how operational improvements and interventions may impact the residents' quality of life. Therefore, the first recommendation we would make to stakeholders is **to include quality of life aspects more widely in their intervention development including, to this end, residents in the decision-making process.** This involvement needs to be genuine and effective participation and not more perfunctory consultation as we have seen that such approaches are less successful, for example, reflecting on the perception of the consultation procedure in Frankfurt. The intervention and associated air traffic changes may be more likely to be acceptable to the public if they feel that they have been able to fairly contribute to the decision-making.

8.2 How to build a constructive intervention with respect to quality of life?

In general, more awareness about the residents' quality of life and how airports can positively contribute to people's living environment needs to be developed. To achieve this, airport managers could work towards a better understanding of the residents' perception of quality of life in their communities. However, since some of the research participants perceived consultation procedures as a 'token-events', it is important to note that **a proper community engagement strategy is essential to succeed in fruitful communication and collaboration with residents.** Proper community engagement requires early engagement, transparency, the possibility to have a voice and a real choice. **Across the different case studies, participation was always appreciated by the residents.** Indeed, residents who participated in the consultation procedure in Frankfurt, for instance, welcomed the opportunity to express themselves. The difficulty for them was that they could not change anything in the intervention itself. This is the reason that this intervention, which was initially regarded as an opportunity to be involved in the process, was quickly seen as an additional element by which to mistrust the airport and a contributor to increasing negative attitudes toward aircraft noise management. The same effect was observed among residents around Marseille airport who asked for more surveys and meetings enable them to better shape the interventions.

In summary, **to better include quality of life, an intervention must take account** totally or, at least partially, of the following criteria:

- **Participation/Fairness** (capacity of the intervention to include residents in the decision making process)
- **Health** (capacity of the intervention to lower the pollution, noise, and stress effects of air traffic and to improve sleep of residents)
- **Social life and leisure** (capacity of the intervention to lower the impact of air traffic on these activities)
- **Living environment** (capacity of the intervention to address the indoor AND the outdoor impact of air traffic)

8.3 How to involve people in the process?

People have to be enabled to genuinely participate, not in meetings that simply present information on the evolution of air traffic or on the latest predetermined interventions, but in the decision-making process around interventions. That is, they should be included in all decisions that may affect them from the initial discussions of any planned change (for example, the construction of a new terminal, the development and implementation of a new intervention, idea generation on solutions to reduce noise, *etc.*). Referring to the findings of the literature review in Chapter 6, Los Angeles and Berlin both undertook democratic decision-making approaches, including residents that helped to reduce opposition regarding the airport.

Pressure groups, as well as those who are not involved in such entities, are **entitled to be heard and have equal rights to participate in decisions that may affect them**. A suggestion of how this form of engagement may work would be to create a group with two

representatives of an area potentially affected by aircraft movements and invite them to meetings where decisions are to be made regarding air traffic. In this new "decision group", it would be important to also have some neutral moderators of the discussion who ensure that all the information presented is true.

8.4 How can airports better align themselves with residents' quality of life?

It is clear that trying **to establish any change in quality of life in relation to the interventions was always going to be difficult** and, even more so, with the restrictions and social distancing required during Covid-19. Nevertheless, **there are a number of considerations that may assist airports as they move forwards to development of new interventions**. We consider the following issues to be central to improved airport thinking about residents and quality of life:

- It is **important to know what you are trying to do** and to establish from the start what methods you can use to evaluate whether you have achieved your goals
- There **needs to be a consensus between airport operator and residents** about what is seen as effective.
- Airports would **benefit from efforts to gain a better understanding and awareness of QoL** in their communities
- Use **citizen science[3] approaches to engage with communities** rather than using what can appear to be random consultation methods
- Think about **new methods of assessment of success** (e.g. well-being evaluation techniques)
- Airports may find it helpful to **address the apparent lack of understanding in the community** of how the operator's contribution could be beneficial to residents
- Try to **work innovatively** to share aviation benefits with residents
- **Ask residents what they expect or wish for**

8.5 Final comments

Empirical evidence from D3.6 demonstrates that **airports need to broaden conversations with communities** beyond focusing solely on noise management if they are **to better understand and respond to things of value to communities and, by extrapolation, optimise contributions to community wellbeing.**
Evidence further shows that **this is not an easy task especially when discussing QoL in the abstract**. For dialogue to be more meaningful and thus attract interest and willingness to engage in these discussions, they need to be linked to concrete intervention options. This should enable a **discussion as to the value of potential interventions** and, by inference, the priority attached to a suite of possible intervention options. In this way airports can be supported by communities in:

- **Mapping** out a programme of interventions that address issues valued by communities
- **Understanding** the attributes of interventions that are valued and that have the potential to be monitored over time.

[3] Citizen science involves the adoption of citizens as research partners. The term was coined in the mid-1990s by UK sociologist Alan Irwin. He defined it as "science which assists the needs and concerns of citizens" and as "a form of science developed and enacted by the citizens themselves". It builds on social forces such as a desire for data, transparency and accessibility of science. Citizen science has been used in many areas but, particularly, in the environmental sector, for example, in air quality, water quality, biodiversity and for measurement of radiation exposure post nuclear disaster in Japan. (Irwin, A., 2018).

- **Validating** outcomes through review of performance against identified quantifiable outcomes with further subjective assessments as appropriate

This **validation step against pre-agreed success criteria makes for a direct link back to things of value and thereby community wellbeing/QoL**. In this way an airport can **build up a portfolio of interventions demonstrably contributing to community wellbeing** (i.e. an evidence base of direct contributions to QoL, rather than relying on *post hoc* attempts to make links from specific interventions to broad QoL indicators).

8.6 Conclusion

Within this study, the impact of interventions from four airports - Schiphol, Frankfurt, Marseille and Heathrow - have been studied. These four airports each have an average of more than 400,000 flight movements per year. They are considered to be pathfinder airports and are under constant and rapid development.

Despite being leading airports, current noise interventions are not directly developed to target and improve residents' quality of life. In addition, those interventions that have been implemented are only seldom evaluated. This can lead to repeated implementation of the same intervention in different contexts and/or continuation of interventions that may not be successful and may not result in the desired outcomes. For example, results from Marseille and Heathrow Airports show different impacts of sound insulation schemes on residents' quality of life. Depending on climate conditions of a region, sound insulation schemes can greatly differ with respect to their impact on people's lives.

Results from the in-depth interviews around Frankfurt Airport stress the importance of the context in which an intervention is being implemented as well. The perception of the consultation procedure as not being open-ended, for example, can lead to mistrust towards the airport or other aviation stakeholders involved and undermine the intervention's potential benefits for local residents. Yet, when implemented correctly, that is, having an open discussion about different potential alternatives and having one's suggestions taken seriously, the majority of research participants would recommend a consultation procedure at other locations as well. Being offered the possibility to participate and engage in decision-making processes - or at least having the option to voice one's opinion - seems to be a relevant and welcome aspect for residents. Thus, a consultation procedure could provide residents with a feeling of control, thereby reducing their noise annoyance and improving their quality of life (i.e. residential satisfaction, health-related quality of life).

Our results show that evaluating the implemented interventions is essential, especially as interventions may not lead to the airport's desired outcome or may have potential unintended side effects. By evaluating the interventions, such side effects can be identified on a timely basis, addressed and the intervention improved accordingly.

For interventions to be successful in improving residents' quality of life, they need to be transparent, open and engaging. They need to involve residents in the decision-making process on which interventions should be implemented. It is **only by fostering effective communication and open dialogue between an airport and its surrounding communities that steps can be made towards successful interventions that are fair and of value to residents.**

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10 Annexes

10.1 Correlation table

Table 10: Correlations between relevant variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1. Residential satisfaction	-																											
2. Annoyance road	.23**	-																										
3. Annoyance neighbours	.23**	.25**	-																									
4. Annoyance railway	.11**	.19**	.19**	-																								
5. Annoyance aircraft	.16**	.30**	.10**	.14**	-																							
6. Annoyance industry	.22**	.34**	.14**	.28**	.21**	-																						
7. Annoyance construction & demolition	.18**	.29**	.30**	.25**	.13**	.29**	-																					
8. Annoyance teenager	.28**	.21**	.34**	.20**	.14**	.24**	.25**	-																				
9. Sleep disturbance road	.27**	.61**	.20**	.18**	.18**	.28**	.22**	.22**	-																			
10. Sleep disturbance neighbours	.20**	.21**	.60**	.16**	.01	.16**	.25**	.28**	.23**	-																		
11. Sleep disturbance railway	.16**	.19**	.15**	.67**	.11**	.33**	.24**	.22**	.28**	.20**	-																	
12. Sleep disturbance aircraft	.21**	.27**	.09**	.12**	.71**	.17**	.15**	.15**	.29**	.06*	.17**	-																
13. Sleep disturbance industry	.21**	.28**	.14**	.28**	.11**	.57**	.24**	.23**	.37**	.19**	.42**	.16**	-															
14. Sleep disturbance construction & demolition	.19**	.24**	.22**	.21**	.09**	.23**	.54**	.21**	.31**	.26**	.28**	.19**	.38**	-														
15. Sleep disturbance teenagers	.24**	.17**	.24**	.17**	.14**	.18**	.21**	.71**	.31**	.26**	.23**	.21**	.29**	.25**	-													

16. Worry safety	-.24**	-.21**	-.17**	-.09**	-.13**	-.15**	-.18**	-.26**	-.17**	-.15**	-.09**	-.16**	-.13**	-.15**	-.25**	-											
17. Worry climate change	-.05	-.17**	-.17**	-.10**	-.21**	-.10**	-.17**	-.13**	-.13**	-.14**	-.08**	-.16**	-.09**	-.14**	-.13**	.27**	-										
18. Worry CO2	-.14**	-.23**	-.19**	-.11**	-.27**	-.12**	-.20**	-.17**	-.22**	-.16**	-.13**	-.25**	-.14**	-.17**	-.19**	.29**	.68**	-									
19. Worry fine dust	-.18**	-.24**	-.14**	-.12**	-.36**	-.13**	-.16**	-.16**	-.21**	-.15**	-.12**	-.34**	-.13**	-.16**	-.17**	.30**	.51**	.66**	-								
20. Worry air pollution	-.20**	-.26**	-.16**	-.10**	-.39**	-.14**	-.19**	-.14**	-.23**	-.14**	-.10**	-.36**	-.11**	-.18**	-.14**	.31**	.58**	.70**	.75**	-							
21. Worry noise annoyance	-.29**	-.38**	-.23**	-.11**	-.57**	-.21**	-.21**	-.20**	-.34**	-.21**	-.13**	-.55**	-.16**	-.18**	-.21**	.28**	.32**	.43**	.50**	.53**	-						
22. Worry crowded supply routes	-.15**	-.27**	-.13**	-.10**	-.15**	-.16**	-.18**	-.15**	-.28**	-.15**	-.09**	-.11**	-.18**	-.17**	-.16**	.33**	.30**	.33**	.36**	.34**	.31**	-					
23. Worry parking facilities	-.19**	-.12**	-.17**	-.12**	-.06*	-.11**	-.19**	-.17**	-.17**	-.13**	-.13**	-.08**	-.14**	-.20**	-.18**	.36**	.14**	.18**	.17**	.18**	.18**	.34**	-				
24. Worry public transport connections	-.04	-.07*	-.06*	-.02	-.14**	-.08**	-.09**	-.05	-.07*	-.06	-.02	-.12**	-.09**	-.12**	-.08**	.23**	.18**	.20**	.18**	.20**	.17**	.24**	.25**	-			
25. Years living in house	-.08**	.03	.06*	.00	-.12**	.01	.06*	.07*	-.01	.10**	-.00	-.14**	-.02	.02	.03	-.01	-.03	-.01	-.03	.04	.02	-.04	-.00	.04	-		
26. Annoyance aircraft development	-.08*	-.15**	-.01	-.06	-.49**	-.08*	-.04	-.05	-.11**	.02	-.07*	-.40**	-.05	.00	-.06	.10**	.14**	.23**	.30**	.30**	.42**	.12**	.02	.05	.14**	-	
27. Frequency disturbed by aircraft noise	-.20**	-.25**	-.06*	-.13**	-.77**	-.20**	-.11**	-.14**	-.20**	-.05	-.12**	-.70**	-.15**	-.10**	-.14**	.17**	.18**	.26**	.34**	.37**	.59**	.15**	.07*	.13**	.13**	.53**	-
28. Expectations	-.10**	-.12**	-.08**	-.06*	-.38**	-.12**	-.05	-.08**	-.09**	-.06	-.06	-.34**	-.08**	-.02	-.06*	.11**	.14**	.22**	.30**	.30**	.40**	.12**	.05	.07*	.07*	.45**	.41**	-