

Land Use Planning: A Key Approach to Reduce Airport Noise Annoyance

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For further information about ANIMA, take a look at www.anima-project.eu

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Introductory remarks

Marius Nicolescu, Secretary General, Airport Regions Conference



Dear reader,

On the 18th of February 2019, the ANIMA project organised the event Land Use Planning: A Key Approach to Reduce Airport Noise Annoyance in Brussels to discuss about noise mitigation and its close relationship with land use planning.

The meeting was hosted by the Airport Regions Conference (ARC), which is the association of regional and local authorities across Europe with an international airport situated within or near their territories. ARC brings together a wide range of expertise at the interface of airports and air transport with local and regional policies. We strive to maximise the benefits generated by airports and to minimise their environmental impact.

For the members of our organisation, aviation noise and mitigating it has been an issue on the agenda for a very long time. The ANIMA project is a step in the right direction, because it has meaningfully involved local communities and authorities in this extremely important topic. Moreover, acknowledging that land use planning is a key solution in this case is offering better understanding to both communities and local authorities as to what their role is and how they can meaningfully shape the future of noise in airport areas.

Being able to bring together local authorities, airports, industry, European institutions and international organisations in one room to discuss about how aviation noise can be dealt with proves that only together we can build coherent, science-based solutions to our issues.

In the pages of this publication you will gain further understanding about the work that the ANIMA project is doing in the field of noise mitigation through novel approaches, and you will learn about the different pieces of the puzzle that need to be put together in order to effectively respond to the needs of citizens and aviation actors alike.



Laurent Leylekian, ANIMA Coordinator, ONERA (the French Aerospace Lab)

ANIMA is a research project supported by the European Commission and by its Innovation and Network Executive Agency (INEA). The project started in October 2017 and lasts four years, gathering 22 partners from 11 countries. ANIMA endeavours to develop new methodologies, approaches and tools to manage and mitigate the impact of aviation noise, with the prospect to enhance the capacity to respond to the growing traffic demand.

Among its key objectives, ANIMA aims at exploring so-called non-acoustical factors: why some people complain about given noise patterns and why some don't? How far is it a matter of education? Of wealth? Of compensation? Of mitigation measures? Of the capacity of authorities to build a trustful and constructive relationship? Replying to this kind of questions is one of the central missions of ANIMA.

ANIMA unites research centres, universities, SMEs and four partnering airports – Schiphol, Heathrow, Ljubljana and Kyiv. Like every other airport, the above airports are very different in terms of traffic sizes and typologies. That is why it is highly important to share the best practices, which will certainly be different from one type of platform to another.

ANIMA's duty is to bring solutions and to propose some consensual way of addressing these issues with all parties involved and communities to preserve both the competitiveness of the European aviation sector and the highest living standards of our fellow European citizens.



Views from the European Institutions



Marco Paviotti, Policy Officer, DG ENV, European Commission

The EU Policy on Land Use Planning

Noise and health effects

The number of people exposed to noise above 55 dB L_{DEN}^1 (average day evening night noise level) from major airports is less than that exposed to roads and railways. If we would add up those who are exposed inside and outside the urban areas the number would reach around 4 million people inside the EU.

Health effects from noise, established by the most recent scientific evidence include ischemic heart disease (IHD), lack of good sleep, high annoyance of the residents, and low performance of students.

WHO recommendations and EU obligations

The environment action program to 2020 'Living well, within the limits of our planet' would have required to significantly decrease the people exposed to noise above the WHO (World Health Organization) recommended day, evening and night noise levels.

For the yearly average noise exposure, WHO strongly recommends avoiding the population to be exposed above 45 dB L_{DEN} and, during the night, above 40 dB L_{night}^2 as aircraft noise above this level is associated with adverse effects on health.

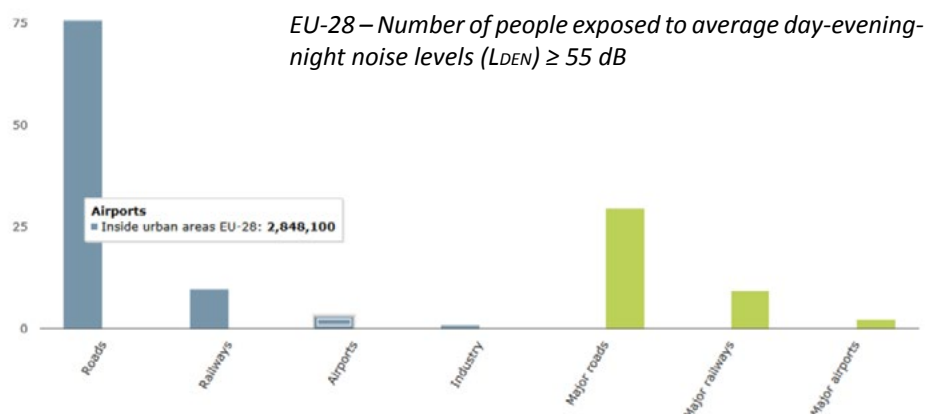
For specific interventions the WHO recommends implementing suitable changes in infrastructure.

The EU legal obligations require to assess the noise levels, prepare and adopt an action plan which would also include the participation of the public and, following the balanced approach, a specific assessment method and prioritization of cost-effective measures. This prioritization shall consider removing the noisier aircrafts, making use of land-use planning and management, introduce noise abatement procedure and, only if the previous is not effective, introduce operational restrictions.

Conclusion

Although the results of noise reduction at source and noise abatement procedures have shown good outcomes, the progress to achieve the targets foreseen was far too slow with the result of having instead, considering the growth in traffic, increasing the number of people exposed. At the same time, land use planning did not provide any measurable outcomes yet.

In conclusion, authorities should be more determined in considering land use planning to reach the strong reduction of noise that WHO guidelines are asking for.



1 Day-Evening-Night noise level.

2 A-weighted equivalent noise level over the 8 hour night period of 23:00-07:00, also known as the night noise indicator.

Dr Daniele Violato, Head of Sector Aviation Research, European Commission, Innovation and Networks Executive Agency (INEA)



Breakthrough Research Under H2020

Daniele Violato presented INEA's projects on reducing aviation noise and the role of ANIMA in looking for new approaches to reduce noise annoyances, with a clear emphasis on developing innovative solutions to alleviate noise annoyance encountered by communities surrounding airport areas

INEA and H2020 in short

The main role of the Innovation and Networks Executive Agency ¹(INEA) is to implement parts of the Horizon 2020 ²(H2020), the biggest EU research and innovation programme, and most of the Connecting Europe Facility ³(CEF), which is a key EU funding instrument to promote growth, jobs and competitiveness through targeted infrastructure investment at European level. The total EU budget implemented by INEA is €33.9 billion.

INEA's main objective is to increase the efficiency of the technical and financial management of these two programmes, H2020 and CEF, concerning the transport, energy and telecommunication sectors.

INEA is currently supporting more than 2000 projects, of which nearly 300 are currently focused on transport research and innovation funded by the Horizon 2020 'Smart, green and integrated transport' Societal Challenge.

INEA supports H2020 collaborative aviation R&I

INEA is supporting a €389 million portfolio of more than 70 projects in aviation research and innovation funded by the Horizon 2020 'Smart, green and integrated transport' Societal Challenge'. The number of aviation projects will increase further by 2021.

INEA's implementation of H2020 makes an important contribution towards achieving the EU's strategic goals in aviation, in its vision 'Flightpath 2050' ⁴. The Agency supports R&I aviation projects that are not only improving already existing solutions but also, and more importantly, developing disruptive, game-changing technologies that could further accelerate the achievement of EU goals.

1 <https://ec.europa.eu/inea/en>

2 <https://ec.europa.eu/inea/en/horizon-2020>

3 <https://ec.europa.eu/inea/en/connecting-europe-facility>

4 <https://ec.europa.eu/transport/sites/transport/files/modes/air/doc/flightpath2050.pdf>

INEA-managed aviation projects contribute to the EU policy priorities, which are outlined in the Flightpath 2050 vision. In particular:

- decarbonising and increasing the sustainability of aviation, including reducing noise emissions;
- enhancing and maintaining the global leadership and competitiveness of the EU aviation industry;
- further increasing safety;
- further integrating air-transport for a seamless and faster travel experience.

The newly published INEA's aviation brochure¹ showcases key results and the impact of completed projects, as well as highlight the objectives of those still on-going, thus demonstrating the effective contribution that the Agency makes to supporting aviation R&I in Europe.

The projects managed by INEA have been selected via competitive calls for proposals, which are designed to identify the best projects contributing to the achievement of the Flightpath 2050 goals. They are all efforts of collaborative research and innovation by multi-partners consortia.

Several aviation projects include efforts for International Cooperation with non-EU countries to leverage resources, mitigate risks and effectively address global challenges, such as air transport decarbonisation. These efforts are strengthening the role of the EU as a Global Actor (see page 36, of the INEA's brochure).

World-class research infrastructure plays a key role in INEA projects as they offer testing and validation capabilities required not only to sensibly advance aircraft technology developments, but also to assess disruptive game-changing configurations (see page 35, of the INEA's brochure).

An increasing number of projects focusing on safety and certification issues have been monitored by the European Aviation Safety Agency with the aim to further accelerate technology development and safe deployment, as certification is the gateway from research to market.



1 https://ec.europa.eu/inea/sites/inea/files/aviation_brochure_2019-web.pdf

Example of aviation projects supported by INEA

A comprehensive overview of the Horizon 2020 funded aviation projects managed by INEA and their specific contribution to the FlightPath 2050 goals is provided in the INEA brochure. Some of these projects have concluded, delivering promising results for the aviation research community, whereas others are still running projects that are currently investigating novel technologies and systems.

As an example, INEA funds projects focusing on developing new technologies in the following areas.

- Novel wing/body configurations (PARSIFAL), new aerodynamic and propulsion-airframe designs and advanced aerodynamic wings (CENTRELINE, SMS) which would allow reducing the consumption of fuel and the GHG emissions.
- Hybrid/electric (H3PS, MAHEPA, ASuMED), bio-fuel (JETSCREEN) and hydrogen (ENABLEH2) propulsion systems, which would allow reducing the GHG emissions.
- Advanced multidisciplinary-design optimisation tools (AGILE) which would allow developing the next generation of greener aircraft design in a cheaper and faster way.
- Advanced numerical simulation and experimental tools (TILDA, HOMER) which would allow performing accurate predictions and validations.
- Faster long-distance connections using sustainable/low-sonic boom supersonic flights (RUMBLE) and hypersonic flights in the stratosphere using liquid-hydrogen propulsion systems (STRATOFLY).

There are also emerging research areas on drones (MoNIfly, AW-Drones) and Urban Air-Mobility, which is going to be addressed in a dedicated call in 2020.

Reducing Aviation Noise: a key-programme of INEA's aviation research portfolio

Reducing aviation noise (on the aircraft and the ground) is a key policy objective of the EU. With nearly €40 million funding supported by INEA, several aviation projects are developing noise-reducing technologies. The project IMAGE developed innovative airframe and engine noise-reduction technologies. TURBONOISE BB focuses on tackling the noise generated by turbofan engines. AERIALIST develops metamaterials that would reduce noise around nacelles and trailing edges; ARTEM develops noise-reducing solutions that could be embedded in new aircraft architectures (e.g. BWB), providing an assessment of the overall noise emissions. RUMBLE is focusing on the production of the scientific evidence requested by national, European and international regulation authorities (including the ICAO's Committee on Aviation Environmental Protection, CAEP) to determine the acceptable level of overland sonic booms and the appropriate ways to comply with it.

The ANIMA project

Among the various projects supported by INEA, ANIMA occupies an important role as it focuses on reducing noise at, and near, airports. The project aims at developing a holistic approach for managing and mitigating aviation noise impact, including tools relevant for improving land-use planning and operations at airports. This project is an important effort towards improving the quality of life of communities surrounding airports.

Additionally, ANIMA is a strategic project for the EU because it is in charge not only of fostering the coordination between national/EU research activities on aviation noise but also of further improving the EU research roadmap for aviation noise.



Workshop presentations



Dr Delia Dimitriu, Research Fellow, Manchester Metropolitan University



A Pan-European Review of Land Use Planning Policies: Lessons Learned

Land use planning (LUP) is consistently cited as a key challenge, but also as one of the best ways to reduce exposure by keeping noise sensitive developments away from airports. The biggest challenges include competing priorities of airports and local authorities (to drive regional growth). Experience also shows that insulation does not solve the issue, it just reduces the internal noise levels with the aim of reducing the perceived impact. It is worth noting that just a few countries provide legislation on LUP, making it difficult for airports to prevent developments in noise sensitive areas. There is not yet a clear instrument at European level to tackle LUP responsibly.

Airport case studies – Iasi, Cluj and Catania

Iasi airport (RO) is located 8 km away from the city centre. Associations of residents from Iasi metropolitan area and villages around the airport are complaining about the aircraft noise, while acknowledging the socio-economic benefits owing to the airport growth. No one at the County Council was aware of the noise impact on health. Residents were not involved in the planning process, neither by the airport, nor by the local authorities. There were issues with understanding the LUP concept by different stakeholders, and confusing positions on the future hospital, which is supposed to be built 2 km away from the runway, generating political sensitiveness.

In short, there is a need for a local forum, where competing priorities can be discussed with the aim of reaching consensus on how to address them, while allowing the airport to grow within the environmental limits. The need for knowledge transfer from those impacted by LUP was expressed by several stakeholders, while learning-by-doing remains a priority for the airport.

Cluj airport (RO): there are not many complaints, but the airport is rapidly growing and has ambitions to build an intermodal

hub: aviation-road-rail, for passengers and cargo to serve the Northern Transylvania region (5 million passengers). The airport needs advice on how to balance the growth with the upcoming environmental challenges, to start a relationship with its community, and to understand how to better engage in a dialogue with its residents. Preparing the pathways towards the aviation-road-rail hub remains a priority and as such, the LUP is a critical factor that needs to be better explored.

Catania airport (IT) is a new city airport and has received no complaints, even though it is located not far from the city centre (7km). This is a research-oriented airport, with a clear motivation to contribute with data to the research challenges, LUP being one of them.

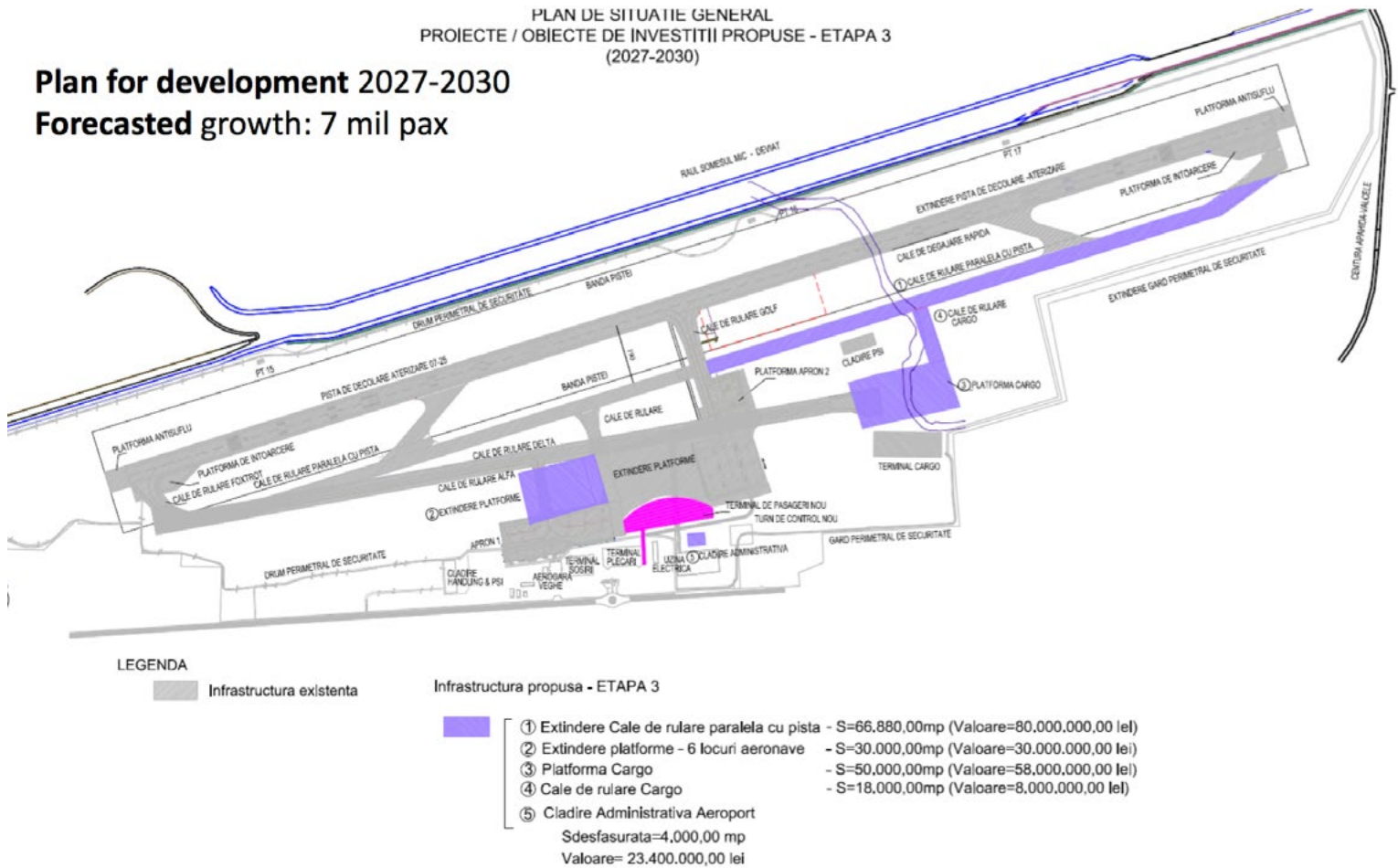
Catania airport needs extra land to build a second runway. Societa'Aeroporto Catania (SAC) is currently monitoring noise levels (several sites) and has recently implemented a real-time info point for passengers and is planning to implement a new approach based on ADS-B (GPS data from aircraft) to produce more reliable and real-time paths (radar is not currently available). SAC is committed to a continuous dialogue with the Local Authority to enable an effective land use planning process to be put in place while keeping in touch with operational needs of the airlines using this airport remains a priority.

One important assumption of the illustrated case studies is that each airport case is different, and the local culture is important to find the best way to identify the influential stakeholder(s) and to acknowledge the need to develop trust amongst residents, policy makers and airport operators. The right communication tool will constitute an essential characteristic of responsible noise management processes, together with the dissemination of noise data and engagement through dialogue forums.

PLAN DE SITUATIE GENERAL
PROIECTE / OBIECTE DE INVESTITII PROPUSE - ETAPA 3
(2027-2030)

Plan for development 2027-2030

Forecasted growth: 7 mil pax



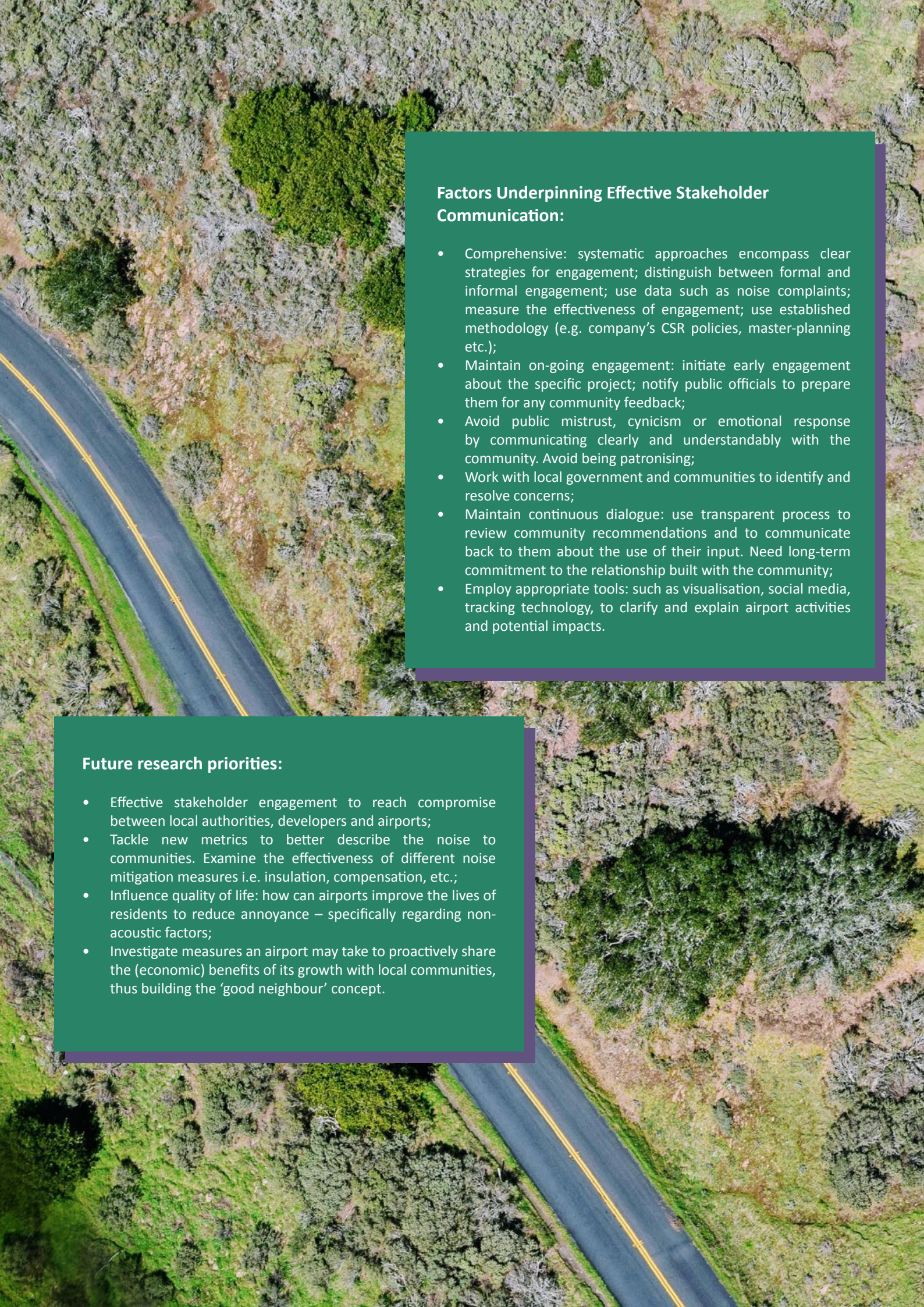
Cluj Airport: plan for development 2027-2030

Conclusions

Stakeholders were proactive and eager to involve and interact with the ANIMA project but have limited knowledge of LUP and residents' complaints. There are differences in stakeholders' approaches, barriers in communication between different policy makers, gaps in understanding the LUP concept and little engagement with the residents from the airports' side.

Additionally, there is confusion over the decision-making power: airports need to get involved in the decision-making process on their strategic development, securing land for expansion constituting the starting point. Thus, the airports are often in a weak position concerning the land use planning due to the ownership of land around the airport with local authorities, private owners, lack of legislation in place and a poor stakeholder engagement process.

So far, the research is not complete and there is not enough information gathered to propose a framework on how to tackle land use planning at European level. LUP is a challenging topic, but, once conducted responsibly, it offers significant potential for development, avoiding further operating restrictions. Another significant outcome relates to the compensation schemes which need to be further explored by different types of airports, including the rapidly growing ones, or starting the journey airports, as defined in ANIMA.

An aerial photograph of a two-lane asphalt road with yellow double lines, winding through a landscape of dense, dry vegetation and some green shrubs. The road curves from the bottom left towards the top left. The background is a mix of green and brownish-grey foliage.

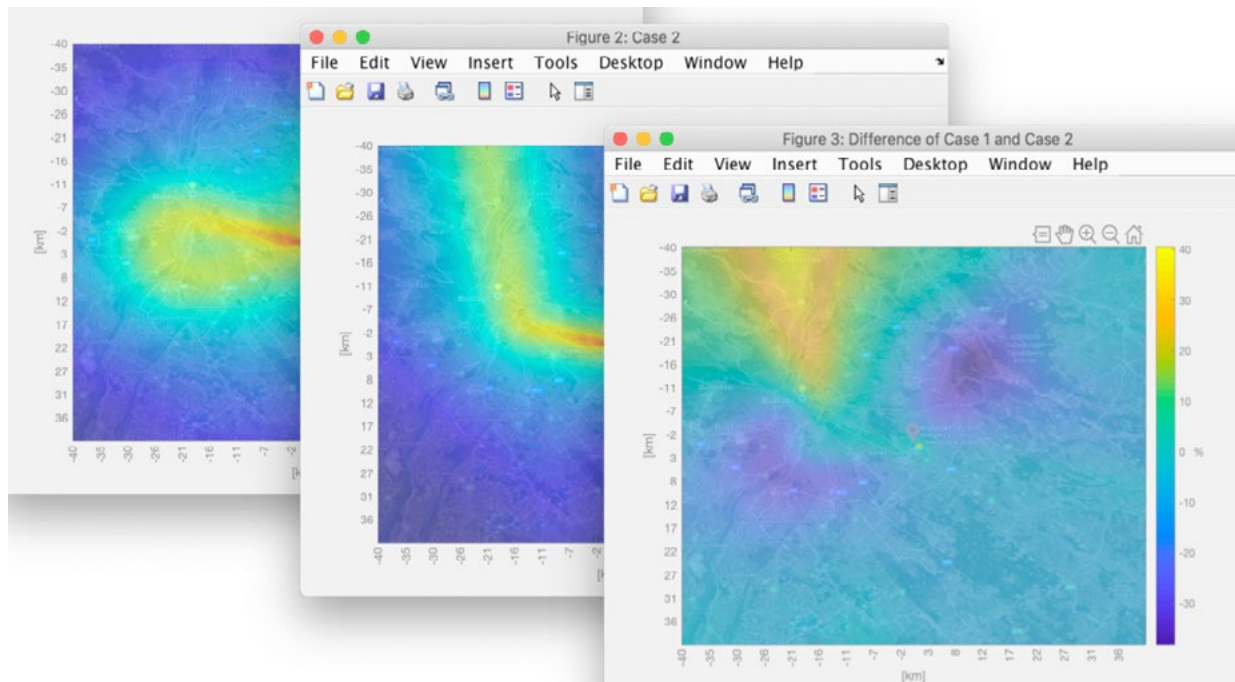
Factors Underpinning Effective Stakeholder Communication:

- Comprehensive: systematic approaches encompass clear strategies for engagement; distinguish between formal and informal engagement; use data such as noise complaints; measure the effectiveness of engagement; use established methodology (e.g. company's CSR policies, master-planning etc.);
- Maintain on-going engagement: initiate early engagement about the specific project; notify public officials to prepare them for any community feedback;
- Avoid public mistrust, cynicism or emotional response by communicating clearly and understandably with the community. Avoid being patronising;
- Work with local government and communities to identify and resolve concerns;
- Maintain continuous dialogue: use transparent process to review community recommendations and to communicate back to them about the use of their input. Need long-term commitment to the relationship built with the community;
- Employ appropriate tools: such as visualisation, social media, tracking technology, to clarify and explain airport activities and potential impacts.

Future research priorities:

- Effective stakeholder engagement to reach compromise between local authorities, developers and airports;
- Tackle new metrics to better describe the noise to communities. Examine the effectiveness of different noise mitigation measures i.e. insulation, compensation, etc.;
- Influence quality of life: how can airports improve the lives of residents to reduce annoyance – specifically regarding non-acoustic factors;
- Investigate measures an airport may take to proactively share the (economic) benefits of its growth with local communities, thus building the 'good neighbour' concept.

The Virtual Community Tool



Dr Ferenc Márki, Associate Professor, Budapest University Of Technology And Economics



Today, we consider ‘noise annoyance’ as the most obvious and immediate impact reaction to transport noise. According to the World Health Organisation (WHO), transport noise, after sleep disturbance, is the second biggest cause of noise related loss of healthy life years (DALYs¹), in the European Union.

However, not only acoustical factors contribute to aircraft noise annoyance. At best, just about one third of annoyance reactions can be explained by acoustic features. At least another third is due to the personal characteristics and traits (for instance attitude towards the noise source, perceived procedural fairness, etc.) or social variables, the so-called non-acoustical factors. This leads to annoyance ratings between the individual studies at different airports to differ significantly and vary over time. It is, therefore, a prerequisite that an annoyance study is made at each airport to be able to draw reliable annoyance maps for different airports. These studies should also be repeated regularly.

Physiological measures, on the other side, for example, the noise-induced awakening reactions during the night usually do not depend on non-acoustical factors. They are therefore more stable and can be calculated for different airports without having made studies there. Studies show that the noise-induced awakening reaction is mainly related to acoustics: maximum sound level, event duration, silence levels before a noise event, number of events, etc. Consequently, this indicator could be computed based on measured or computed (reliable) acoustical data and shown in a map.

Tool measurements

There is a need for a tool that could be used by non-experts, for instance – decision-makers – to have an idea of the real annoyance experienced by people. The ANIMA project is developing such a tool, called the ‘Virtual Community Tool’ which will be able to predict awakening-probability and to plot a map accordingly.

To develop this first function, the tool must be fed with a list of operations, in this case, the list of flights of a specific airport and information including take-off/arrival time, aircraft type, runways use, flown flight track (STAR/SID). As a result, the tool will produce maps allowing to show traditional acoustical parameters like L_{Aeq}^2 , L_{DEN}^3 or L_{Night}^4 , as well as more human-oriented indicators such as the awakening-indicator.

The tool is supported by a user interface to interact with the outcomes. For example, the end-user will be able to reorganise traffic time-distribution or replace an aircraft partly or completely with another type, change the usage of the runways per each hour, be able to see how they influence the probability of the noise to produce additional awakenings.

1 One DALY can be thought of as one lost year of ‘healthy’ life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.

2 A-weighted equivalent continuous sound level in decibels measured over a stated period of time.

3 Day-Evening-Night noise level.

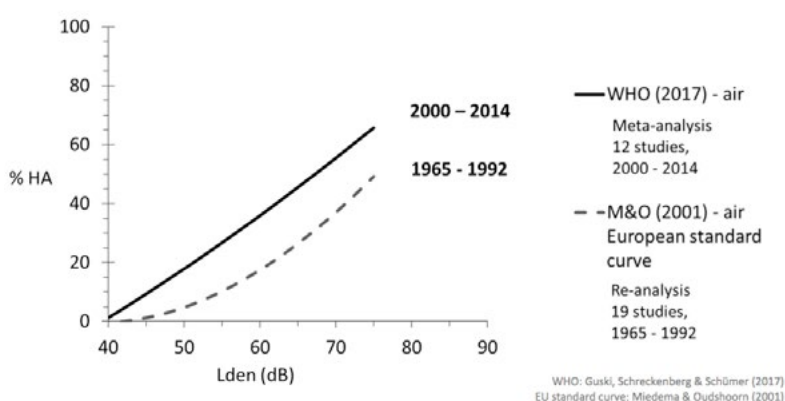
4 A-weighted equivalent noise level over the 8 hour night period of 23:00-07:00, also known as the night noise indicator.

WHO Guidelines and Research on Communities' Noise Perception

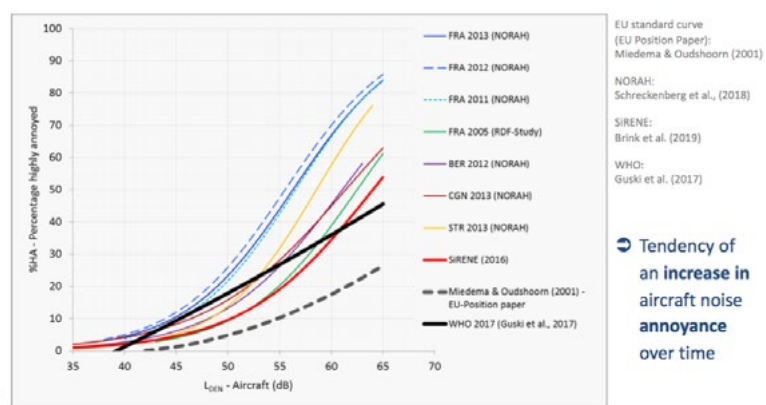
Health outcome	Relevant risk increase	Road		Railway		Aircraft		Wind turbine		Leisure	
		L _{den}	L _{night}	L _{den}	L _{night}	L _{den}	L _{night}	L _{den}	L _{night}	L _{Aeq,24h}	L _{night}
IHD (incidence)	5% rel. risk increase	59.3	--	--	--	52.6	--	--	--	--	--
% HSD	3% absolute risk	--	45.4	--	--	40		--	--	--	--
% HA	10% absolute risk	53.3	--	53.7	43.7	45.4	--	45	--	--	--
Perm. hearing impairment	No risk increase	--	--	--	--	--	--	--	--	70	--
Reading/oral comprehension	1 months delay	--	--	--	--	55	--	--	--	--	--
Guideline exposure level (rounded)		53	45	54	44	45	40	45	--	70	--
Recommendation *		strong		strong		strong		conditional		conditional based in WHO (1999)	
Remarks											

* Criteria: quality of evidence, balance of benefits and harms, values and preferences, resource use

Guideline exposure levels



Percentage highly annoyed (%HA) by aircraft noise



Results on %HA aircraft noise of recent studies published after 2014

➔ Tendency of an increase in aircraft noise annoyance over time

Dirk Schreckenber, Senior Researcher, ZEUS - Centre for Applied Psychology, Social and Environmental Research, Germany

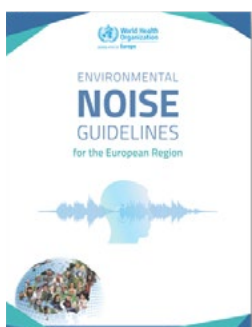


What are the effects of noise on health?

The effects of noise on health are usually highly related to general health factors. Mainly, we speak about two kinds of effects – auditory and non-auditory. While auditory effects lead to hearing impairments, non-auditory effects include stress-related factors outside the hearing system. Typically, stress tends to appear when environmental demand exceeds the natural regulatory capacity of an organism, in particular in situations that include unpredictability and uncontrollability.

The perception of the noise as something harmful, disturbing and unwanted increases the noise annoyance. Meanwhile, the capacity to cope with noise and its associated stress depends on the psychological and physiological resources of each person and can make noise annoyance levels decrease. Predictability, perceived control and social support from authorities (e.g. investment in the recreational areas of the neighbourhood) are factors that can increase the capacity to cope with noise and therefore to reduce annoyance levels.

The World Health Organisation (WHO) published the *Environmental Noise Guidelines for the European Region*. In the guidelines, 'Critical' health outcomes include annoyance, sleep disturbance, cardiovascular diseases, cognitive impairment as well as hearing impairment and tinnitus. Additionally, health outcomes include diabetes and metabolic diseases, adverse birth outcomes and generally affect the quality of life.



The guidelines were driven by the WHO steering group, splitting the work in two groups: Systematic Review Team (responsible for systematic evidence reviews on the health impacts of environmental noise) and Guideline Development Group (responsible for evidence-based recommendations). Additionally, there was an External Review Group.

The methodology through which the guidelines were developed was based on systematic reviews of evidence in to define the relationship between noise exposure and health risk outcome and meta-analysis for environmental noise annoyance per each noise source.

Guideline exposure levels – noise exposure levels above which the Guideline Development Group is confident that there is an increased risk of adverse health effects.

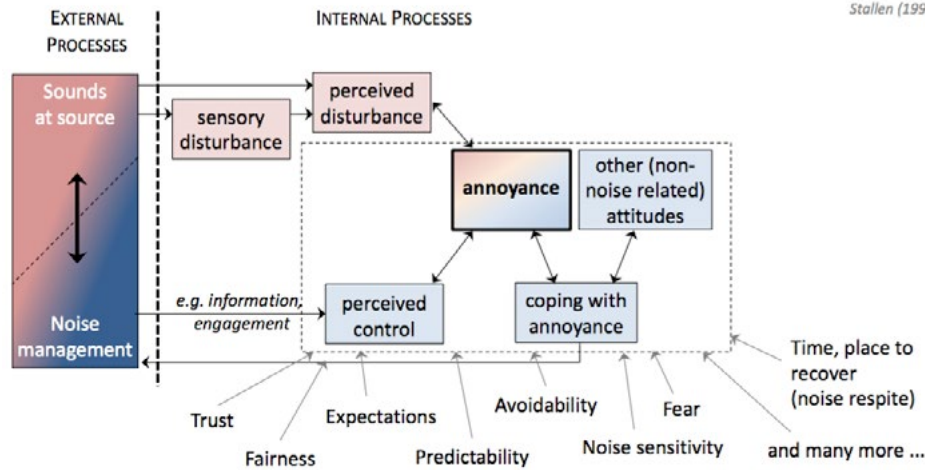
Factors of noise annoyance

Noise annoyance relates to many contextual factors. It is estimated that personal, social and situational factors represent 33% of noise annoyance, while average sound levels represent another 33%. The rest 33 % is unknown; however, it is likely that other sound-related metrics in aviation like time, number of flights max level, psycho-acoustics, situational factors and so on represent part of the rest % factors of noise annoyance.

Noise annoyance consists of three elements (Guski et al., 1999):

1. the experience of occurring disturbances often combined with a behavioural coping response;
2. an emotional/attitudinal response to the sound and its disturbing impact;
3. the perceived lack of capacity to cope with noise (a distressful insight that one cannot do much against the unwanted noise situation).

These factors are highly similar to the concept of 'psychological stress'.



Stress-related model of aircraft annoyance

The stress-related model of aircraft noise annoyance of Stallen (1999) is distinguished into two parts: external processes and internal processes. The external process includes sounds at source and noise management. However, internal processes take upon many more factors, like sensory disturbance, personal expectations, predictability, avoidability and more.

Environmental noise and mental health

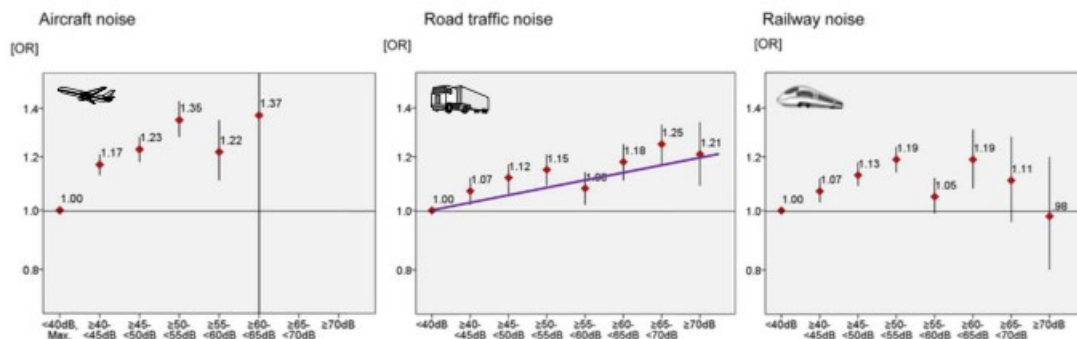
According to the WHO Review (Clark et al, 2018), evidence of environmental noise impact is inconsistent and often is of low to very low quality. However, new studies show some evidence between transportation noise and mental health, for instance, depression.

According to the graphs, noise annoyance is health-relevant – reducing noise annoyance might improve persons' well-being. Therefore, reducing noise annoyance could contribute to improving the quality of life.

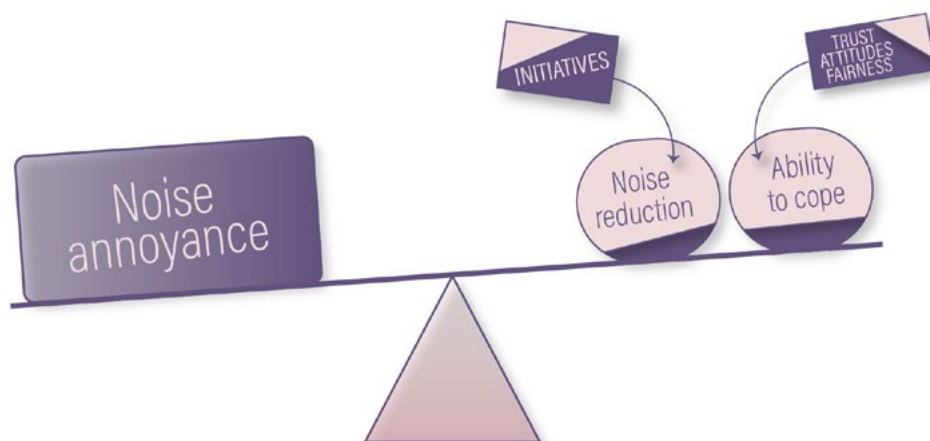
How can noise annoyance be reduced?

- by reducing sound levels and/or numbers;
- by improving the capacity to cope with the noise situation.

A comprehensive approach to deal with noise annoyance should consider both acoustical as well as contextual factors.



Relative risk (OR) for depression (Seidler et al., 2017) based on health insurance data of persons from whom individual socioeconomic status was known (n = 655,541)







Dominique Lazarski, President, European Union Against Aircraft Nuisance

Views From the Local Communities

About UECNA

UECNA (European Union Against Aircraft Nuisance) is a federation of residents' organisations across Europe created more than 50 years ago. UECNA shares experience and knowledge and tries to influence European policy in favour of the communities. UECNA claims to be the voice of the population overflowed at low altitude. The organisation also works closely with EASA and is a member of two working groups on noise within the ICAO environmental committee.

Why does one choose to live under the flight path?

This is probably the first question people think of and often comment upon. The issue is that in many cases people did not choose to live under a flightpath because it was not there when they moved in. There are several reasons for how that changed: new runways with new routes, change of flight procedures, the concentration of flight paths, new cargo carriers.

In many of these situations, people thought they were safe from aviation noise. The area, where they bought or built their home, was not affected by noise at the time, or at least it was not included under an official noise footprint. However, after some time aviation noise reached them. They had no idea that this would happen to them, they had not foreseen it and did not know of any project. The information they had initially received was not enough.

Land use planning – a tool to reduce people exposed to aviation activities

The European Aviation Environmental Report (p. 7) drafted jointly by EASA, the European Environmental Agency and EUROCONTROL states, that while the average noise energy per flight has reduced, the number of people exposed at the main European airports is growing, especially in the last three years: an increase of 14% between 2014 and 2017 within the L_{den} 55 dB noise contour (only 12% increase compared to 2005).

The forecast is that the number of airports handling more than 50,000 movements a year will increase before 2040 and this will result in more people being affected by aircraft noise. Planning legislation should prevent this increase of population in territories where noise will harm the inhabitants, under the official noise footprints. On the other side, the legislation should also dissuade people from moving into a territory where their health could be harmed. The noise is not confined in the official noise footprints, and people in those areas cannot claim insulation rights. An increase in communication and improved information provided to the communities is necessary to move forward.

Case of Paris Region – is noise contour enough?

A good case study of communities affected by airport noise is that of the Paris region. The map below shows the locations around the airport where people are complaining about aircraft noise. The map demonstrates that people are annoyed by aircraft noise much further away than the published noise contours. So maybe the current noise contours are not adapted to the annoyance of the people.



Places where the communities are complaining

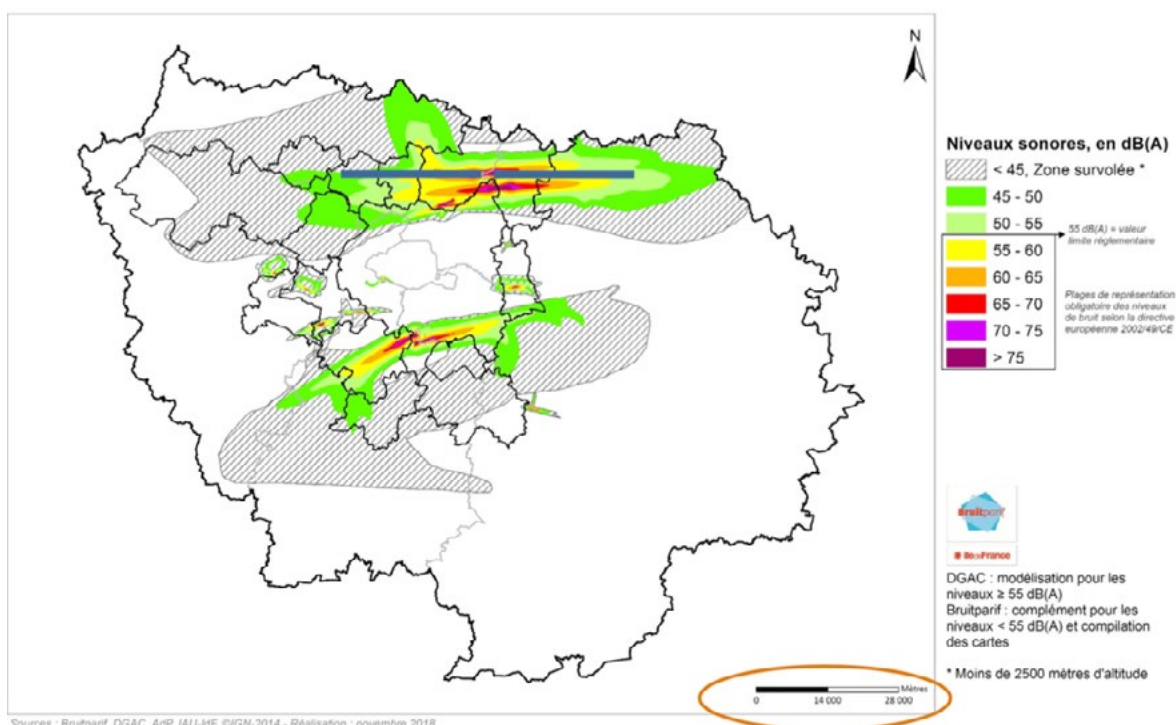
The new noise guidelines published by the WHO in October 2018 recommend a level of noise not exceeding 45 dB L_{den} . They are consistent with the residents' experience. BruitParif, a French non-profit environmental organisation, responsible for monitoring the environmental noise in the Paris agglomeration, produced a map (the map is partial, as it is limited to the Ile-de-France region administrative contour) of the noise contour designed in accordance to the WHO recommendations. The additional area from 45 dB to 55 dB L_{den} covers most of the places where residents express annoyance.

The L_{den} indicator is important, as it acknowledges that evenings and nights are sensitive periods, but it is better fitted for continuous noise such as road noise. It is much less adapted to aviation noise, which is a series of events with the emergence of the aircraft noise above quieter background noise. It leads to the conclusion that L_{den} does not show the actual annoyance.

Furthermore, the L_{den} indicator is very complex to understand for the general public. The confusion on long-term (and annual) indicators and the instant indicators is consequently common. When people hear that the noise in an area is 60 dB, they tend to check internet sources finding that 60 dB is a normal conversation and it is nothing to be afraid of. In this case, when it is an area exposed to 60 dB of L_{den} , one may lose two to three years of life in good health. Residents do not recognise the level of noise they experience, and families should be fully informed of the noise they will have to endure if they move inside a territory overflowed by aircraft. An index based on the number of flights above L_{max}^1 would give a better idea of the annoyance in a specific area.

Once people have the correct information and can make decisions based on the information given, they should not be deceived later. The situation needs to be stable – when someone buys a house, the biggest investment most will make in their lives and often for the place where they will spend the rest of their life, one needs confidence in the future.

Planning regulations are made to give this security and protection to the population. Urban planning is a long-term science. Future growth of aviation must be balanced with public health impacts and already today we need to take into account new technologies such as drones and urban aircraft that will be buzzing very soon near our homes.



Noise mapping according to the WHO

1 maximum sound level, during a measurement period or a noise event



Airport case studies

Maarten van der Scheer, Senior Advisor Stakeholder Strategy & Development, Royal Schiphol Group, the Netherlands



Schiphol Case Study: Spatial Planning Framework, Current Challenges and Possible Solutions

Introduction to Schiphol Airport

Schiphol Airport is the main international airport of the Netherlands. It is located in the southwest of Amsterdam, in the municipality of Haarlemmermeer, North Holland. It is the third-busiest airport in Europe in terms of passenger volume – every year it is used by more than 70 million passengers and offers direct flights to 326 destinations.

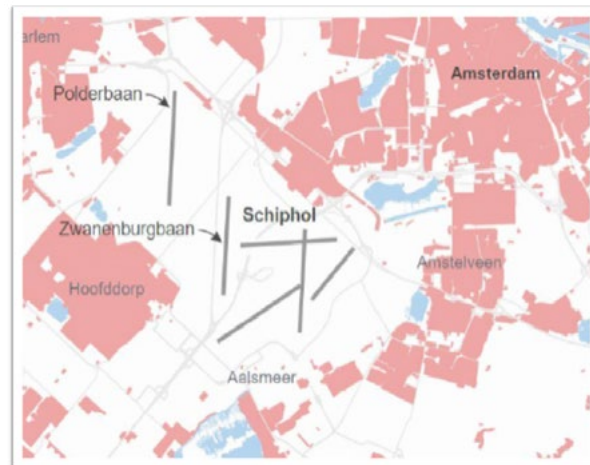


Polderbaan

The Polderbaan runway was opened in 2003 to relieve the densely populated Amsterdam area. The runway was planned for many years and land use in the surrounding of the runway was constrained accordingly. It has reduced the number of highly annoyed people drastically. On the other hand, one disadvantage of the Polderbaan is its heavy annoyance because of non-acoustic factors, e.g. new hindrance.

Land use planning framework

Land use planning and management are key to future noise reduction. In the Schiphol area, there are five different constraint zones which are based on L_{den} contours – up to $48L_{den}$ – and covered by national law. Current WHO guidelines suggest that the sound level should not reach higher than $45L_{den}$. Future modifications of the law in this sense could have an enormous effect on land use planning.



Polderbaan



Five constraint zones

Plans until 2050

The current challenges in need of solutions by 2050 are: the western part of the Netherlands has a huge demand for residences; market supply is short of demand and the prices are high. Considering this, the national government is pushing for new housing developments. Almost 80.000 new residences are planned to be built until 2050, close to or within the 48L_{den} contour. Because of these plans, 15.000 of the new residents are expected to be heavily annoyed by aircraft noise. Since, by law, the growth of Schiphol airport is limited by the number of heavily annoyed people, this could reduce the future growth of the airport. How to cope with different societal challenges – housing on the one hand and mobility on the other hand?

Good practices

In the case of Kronenburg, a plan was prepared by the local government to accommodate 2.500 students – young people with temporary stay purposes and less annoyed by noise. Another good example is the Rijsenhout village, where the local community works towards a joint approach, including clean up, renovation and temporary housing.

What does the local authority expect?

Local authorities around Schiphol ask for clear and stable noise contours and constraint zones as well as for space for new housing development. Additionally, clear information should be provided to new citizens.

Martijn Lugten, Consultant, Amsterdam Metropolitan Region, the Netherlands



Land Use Planning Around Schiphol Airport

Introduction

Urban design around fly tracks could improve the environment, especially the noise environment – measured noise and noise perceived. A real example is being researched and developed around Amsterdam airport.

Looking at the current situation

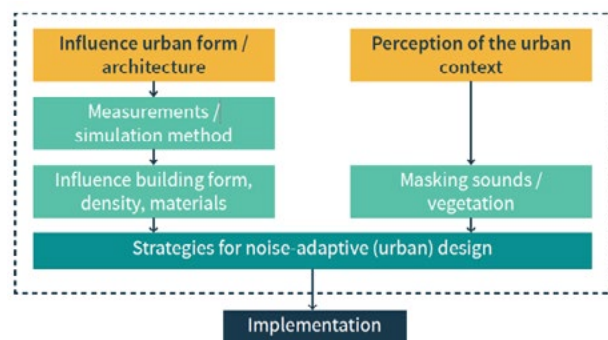
Acoustically, it is represented by the noise footprints and the position of the buildings regarding this.

From a perception point of view, the urban noises could be classified into three groups: negative (cars, bikes, planes), pleasant/positive (water, natural features, birds) and neutral.

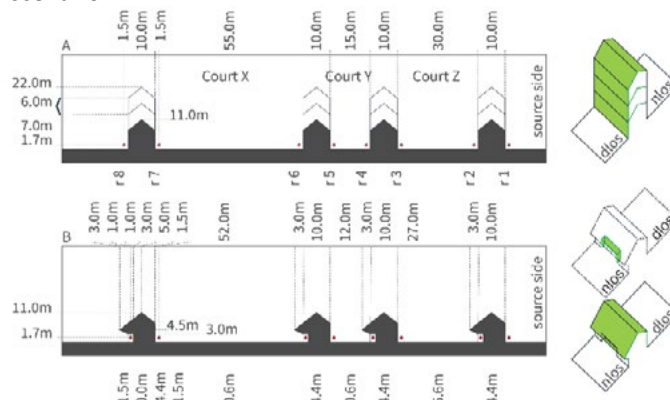
From an urban point of view, there are too many challenges to take into consideration: housing, energy transition, data centres, circularity, expansion of the airport after 2020, protection of local identity.

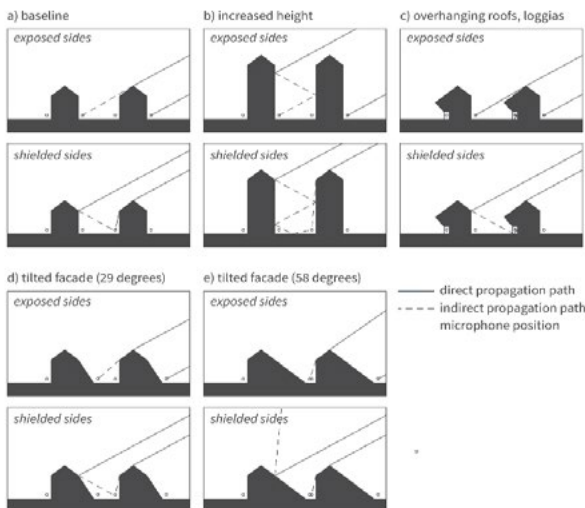


In the urban context, the structure research was divided in two different ways, one focused on the measures – influence urban form/architecture, and one focused on the perception – perception of the urban context.

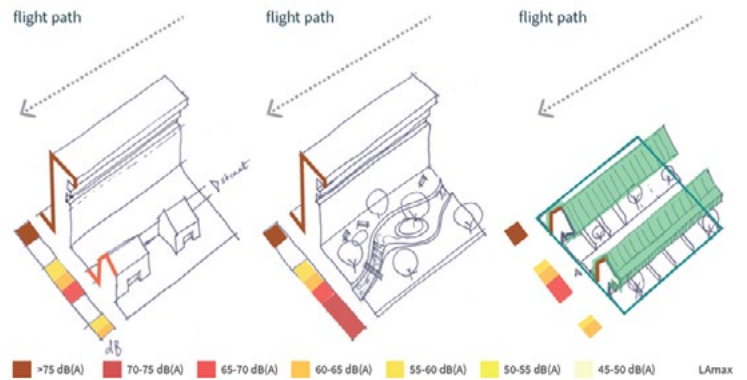


A strategical network of measurements provided essential information to play with. It managed to calibrate the model for more aircraft noise simulations and more data to use with different roof tilted, facade tilted, the distance between buildings and high of buildings, green facades, compared with the baseline scenario.





Playing with with natural features: vegetation and moving water.



The implementation phase developed some guidelines for design to be mixed with urban programme.



Conclusions

Recent research on the influence of architectural and urban design showed that:

- 1) urban form and materialisation has a significant impact on the sound levels around buildings exposed to aircraft noise;
- 2) natural features can improve the perception of aircraft noise and/or shift attention away from fly-overs.

The results, which are based on measurements and numerical studies, are seen as promising by the Dutch government and will be used to study the possibilities to reduce noise stress using urban design guidelines in the Amsterdam Metropolitan Area.

At the moment, the application and optimisation of the numerical

models is studied for a series of case studies around Schiphol. Aside from the case studies, a consortium of research partners, Schiphol supervised by governmental authorities, is considering the possibility to up-scale the experiment and built a pilot area where findings will be applied, and more on-site data can be collected. The ambition is to develop alternatives methods of noise mitigation measures linked to urban design and land use planning in the Amsterdam area. Ideally, the measures should go hand-in-hand with the ambition to reduce the urban energy-consumption, building materials and improve the air quality in residential areas. The consortium currently considers links between these fields and single solutions that may serve multiple challenges. More results are expected by 2020.

Further research will be needed on noise-adaptive design, good urban microclimates and circular building methods.

Thomas Lurz, Attorney at Law, Vice-President, Frankfurt Airport Services Worldwide

Frankfurt Case Study: New Runway 2011

Expansion of Frankfurt Airport

The expansion of Frankfurt Airport was legally approved in December 2007. The new, fourth, runway was opened in 2011; Terminal 3 is scheduled to open by 2021 (Pier G) respectively 2023. The total expansion includes a new landing runway, a new terminal and new taxiways. After the airport expansion, passengers' number is projected to reach 88.3 million and cargo should count for 3.16 million metric tons.

Noise protection measures at Frankfurt Airport

In the case of Frankfurt, there are two categories of noise protection measures – those determined by authorities or legislation and those not legally binding (voluntarily). Because of the legally binding measures, these changes were introduced: scheduled aircraft movements were banned from 11 PM to 5 AM and loud aircrafts had to be scheduled at certain times of the day. Not legally binding protection measures include noise emission ceiling, noise respite periods and noise abatement operational procedures, for instance, minimum noise routes.

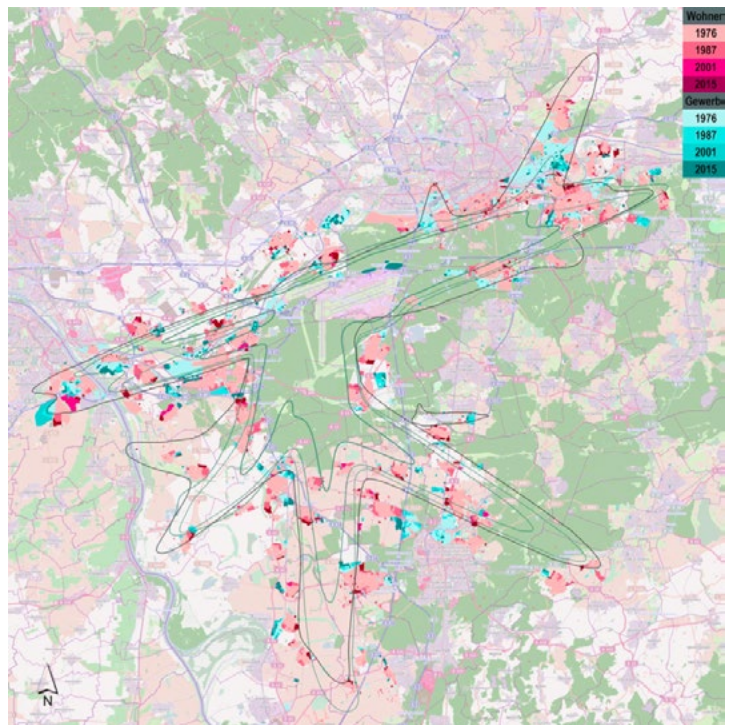
Development of residential and industrial areas

Development of residential and industrial areas at Frankfurt Airport was based on the study 'Development of residential areas in the vicinity of airports', from the University of Bonn (Prof. Wiegandt et. al.) and RWTH Aachen (Prof. Selle et al.) on behalf of BDL (German Aviation Association). The study covers six airport regions: Cologne Bonn Airport (CGN), Düsseldorf Airport (DUS), Frankfurt Airport (FRA), Hanover-Langenhagen Airport (HAJ), Hamburg Airport (HAM) and Munich Airport MUC.

The findings of the study state that building developments are getting closer and closer to airports, thus new conflicts and an increase in the number of people affected by aircraft noise can be expected. This is particularly regrettable from the airport's perspective because the endeavours to reduce noise are counteracted. Additionally, the growth of airport regions is partly triggered by airports.

The study highlights that noise abatement is highly related to residential development management and recommends managing its activity through land use plans instead of granting building permits (based on German Federal Building Code) to broach the issue of conflicts and balance interests in a better way.

Therefore, regional and state planning should designate consistently appropriate residential restriction zones to prevent conflicts. Improvements in active noise protection should not lead to a reduction of the restriction on residential areas. Confidence-boosting measures, such as discussion groups and joint data collection, are highly recommended.





Joachim Wempe, Senior Advisor, Metropolitan Region FrankfurtRheinMain

Land Use Planning Around Frankfurt Airport

Land use plans, according to the German Federal Building Code, safeguard sustainable urban development and socially equitable utilisation of land for the general good of the community, shall contribute to securing a more humane environment and to protecting and developing the basic conditions for natural life.

While developing the land use plan particular attention has to be paid to living and working conditions, social and cultural needs of the population, housing requirements, preservation and maintenance of historic documents, religious organisations, environmental protection and many others. In a nutshell, developing a land use plan is to plan for the next generations, following the legal framework and balancing all the diverse interests while trying to solve current and future problems.

Regionalverband FrankfurtRheinMain is a regional authority which is responsible for setting up a land use plan for the region which covers an area of 2.500 square kilometres including 75 towns and cities with 2.3 million inhabitants.

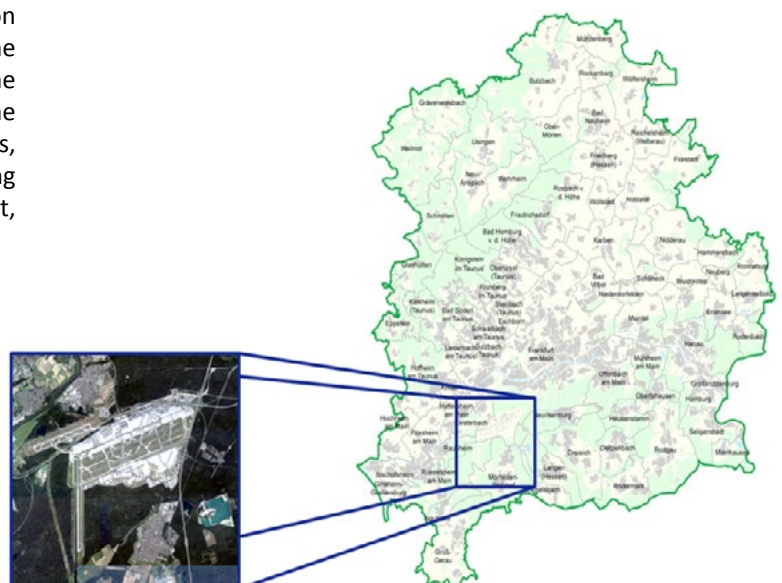
Planning levels

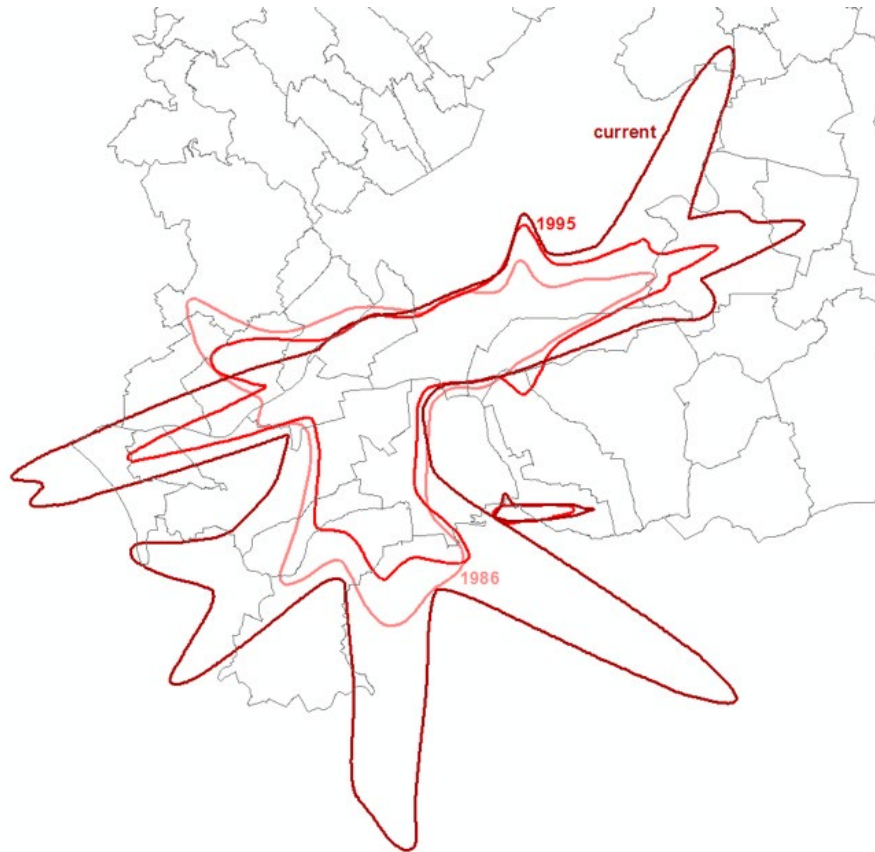
The regional land use plan for the FrankfurtRheinMain region is one of three planning levels: the development plan of the land (determines the main features of the planning), the regional preparatory land use plan which is developed by the regional authority (adds the establishment of residential areas, commercial, mixed used and industrial areas) and the binding land use plan developed by towns and cities (determines amount, kind, size and the shape of buildings).

The main challenge for setting up the regional land use plan is to provide affordable living space. Because of a growing population, it is forecasted that by 2030 there will be 165.000 more inhabitants in the Frankfurt region. Since currently there is already a significant lack of living space, by 2030 there will be a need of 230.000 additional houses and flats.

Where to find the space for the needed residential areas?

The relevant regulations state that no new residential areas or additional housing should be planned within protected areas such as nature conservation (flora, fauna, habitats), water protection areas, aircraft noise zones, etc. As a result, in the Frankfurt region, there is a lack of affordable housing which leads to a strong pressure to build dwellings.





Noise zones around Frankfurt Airport

Aircraft noise zones around Frankfurt Airport: challenges **Action: 'Lärmobergrenze'**

Using noise zones in land use planning to avoid future aircraft noise problems has a long tradition in the FrankfurtRheinMain region. Over the years, noise zones have dramatically changed in shape and size, since previous noise zones were based on projections of airport movements that did not always prove to be completely accurate, due to unforeseen routes and traffic changes. Thus, residential areas were developed in zones which later became noisy. Additionally, in different cases, the noise meant there would be no more possibilities for cities or towns to develop further which led to compensation requests.

The Hessian Minister of Economics, Energy, Transport and Housing, Lufthansa, Condor, BARIG (Board of Airline Representatives in Germany), Fraport AG, Forum Airport and Region and Aircraft Noise Commission developed a voluntary agreement about an upper noise limit ('Lärmobergrenze'): areas affected by aircraft noise more than 55 and 60 dB should not become larger than a special limit value. This area has to be monitored every year (if areas are exceeded, actions to reduce noise must be taken by the airport and companies), it is expected that this measure could help to establish a lasting noise zone.

Action: new regulation and compensation system

Finally, in 2018, a new Hessian regulation established an amount of money for towns/cities depending on a number of affected inhabitants and extent of noise pollution (funding comes from the dividend of the Land of Hessen's company shares of Fraport AG). Compensation funding will be spent for social matters, education, employment, childcare and apprenticeship initiatives, improving public buildings' noise insulation and air conditioning, building and maintenance of public recreation areas.

Conclusion

Land use planning can contribute to avoiding future aircraft noise problems in airport regions. For this to succeed, reliable forecasts are needed, but usually, additional noise mitigation measures are required as well. Thanks to participative processes and structures, the FrankfurtRheinMain region has managed to implement night-flight bans, noise mitigation packages, noise respite and other measures to reduce aircraft noise.



Dirk Schreckenberg, Senior Researcher,
ZEUS - Centre for Applied Psychology, Social
and Environmental Research, Germany

Frankfurt Airport Case Study: Noise Respite Project 'Laerm pausen'

Frankfurt Airport is the largest airport in Germany and has been the subject of considerable debate about aircraft noise issues for many years. A six-hour ban on scheduled night flights was imposed in November 2011, almost at the same time as the opening of the new fourth runway. In April 2015, as a one-year trial, the night cut-off time was brought forward by one hour in the late evening period in certain areas around the airport and extended by one hour in the early morning period in other areas to provide a seven hours night curfew. In those areas, by redistributing the shoulder hours approaching traffic between three of the four runways – the so-called 'Laerm pausen' (noise respite) project began.

The idea of the Laerm pausen

The plan is to re-distribute approaches in shoulder hours (10-11 PM and 5-6 AM) between runways to bring forward the night cut-off time by one hour in the Frankfurt Airport region.

Timeline

1. Surveys: October – November 2015
2. Trial period: April 2015 – March 2016
3. Final implementation – May 2016

The survey was conducted using phone calls to 1.533 residents and eight focus groups of altogether 85 participants. Focus groups included people living around the airport who were included in the Laerm pausen trial zones ('relief' group) and those who were not included ('burden' group) in these zones.

Expectations

There are differences between 'relief' and 'burden' groups:

- less annoyance and disturbance in shoulder hours;
- higher perception of noise respite in shoulder hours;
- more positive evaluation of Laerm pausen approach.

Results

- group differences do not correspond to the area group definition of 'relief' and 'burden';
- noise respite in evening shoulder hour is almost not noticeable;
- noise respite in morning shoulder hour is marginally noticed;
- vague concepts of Laerm pausen that seems to have more to do with the information provided than actually observed changes.

Perception of change

51% of the respondents directly reported to having a perceived change in air traffic since 2014 (before this project).

29% of the respondents stated since when they have noticed a change:

- 81% of them dated the change to the year 2014 (before Laermphausen started);
- 19% mentioned elements of Laermphausen operations but in vague and incomplete terms;
- Responses seem to depend more on information provided to residents than on observed changes.

68% of the respondents reported having heard about the term Laermphausen.

35% of the respondents reported knowing something about the concept of the Laermphausen approach.

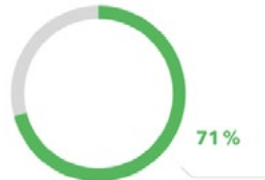
Results of the focus groups

Focus groups mainly demonstrated spontaneous reactions and subjective concepts, for example, low awareness of the Laermphausen operations. Laermphausen was rarely mentioned spontaneously and often associated with these words: peace (night-time, siesta), night curfew, time without any noise, break-in flight movements etc. Reactions about the project were often sceptical or dismissive.

Opinions about the noise respite intervention

Positive – willingness to relieve the resident population from aircraft noise.

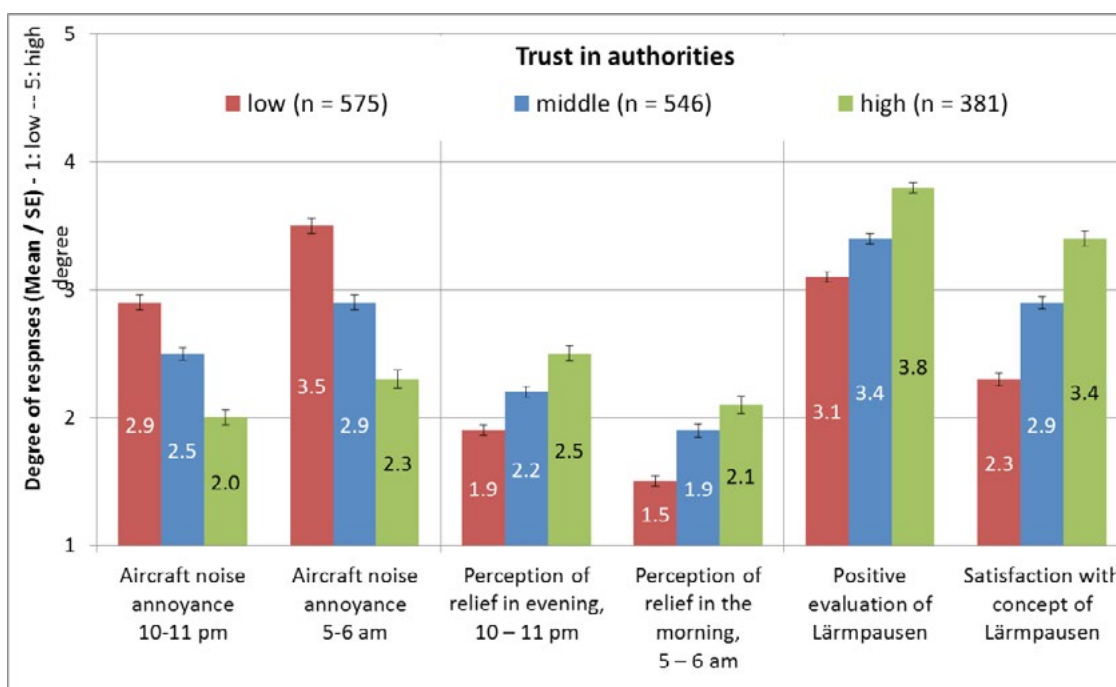
Critical – the fairness of the distribution of aircraft noise and the cost-benefit relationship. However, criticism did not lead to the refusal of Laermphausen in general.



71% of the respondents commenting on the continuation of the Laermphausen operation after the trial project agreed to the continuation.

Conclusion

Noise abatement would benefit not only from informing but also engaging communities right from the start (all stakeholders in all phases). Suitable engagement method is a matter of future research and scientific evaluation.

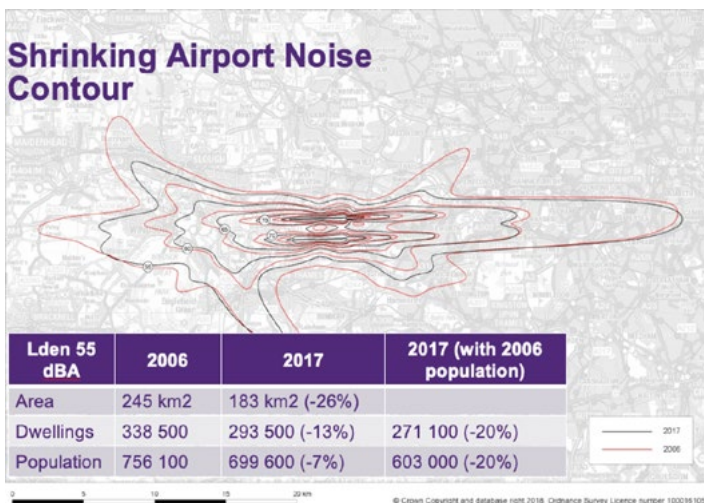


Trust in authorities related to annoyance and perception of noise respite



Xavier Oh, Noise Strategy Manager, Heathrow Airport

London Heathrow Case Study: Third Runway



The noise from aircraft operations at Heathrow Airport impacts more people than at any other airport in Europe. But the airport is also under pressure from encroachment¹ with population growth in noise impacted areas. From 2006 to 2017 while the area inside 55 dB Lden decreased by 26% from 245 km² to 183 km², the population living within this contour decreased only by seven per cent.

Without encroachment and with a static population at levels of 2006, the decrease in people living inside the contour would have been 20%.

The draft of the UK Aviation Strategy was published in 2018. It contains proposals on land use planning and noise insulation schemes (NIS) such as:

- tailored guidance for house building;
- improved flight path information for prospective homebuyers;
- improved NIS for existing properties, particularly for short term noise exposure and sleep disturbance;
- reviewed NIS cost-effectiveness, needed for ventilation;
- extended NIS threshold to 60 dB LAeq for 16 hours (from 63 dB);
- new commission (ICCAN) to issue guidance on NIS;
- NIS of airspace to change the cause of 3 dB increase.



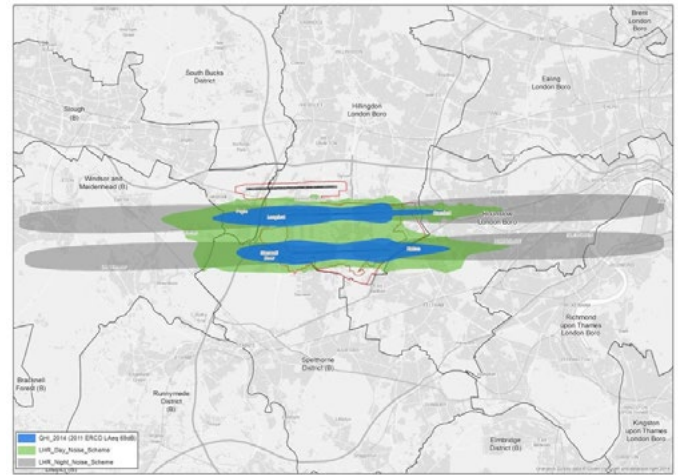
¹ intrusion on a person's territory, rights, etc.

Noise insulations scheme boundaries

Heathrow has several noise insulation schemes for existing properties. The three areas of noise insulation schemes are:

- quieter homes scheme (blue)
- daytime scheme (green)
- night-time scheme (grey)

There is a proposal for a new and more extensive noise insulation programme under Heathrow's expansion plans including a new third runway.



Hounslow local plan

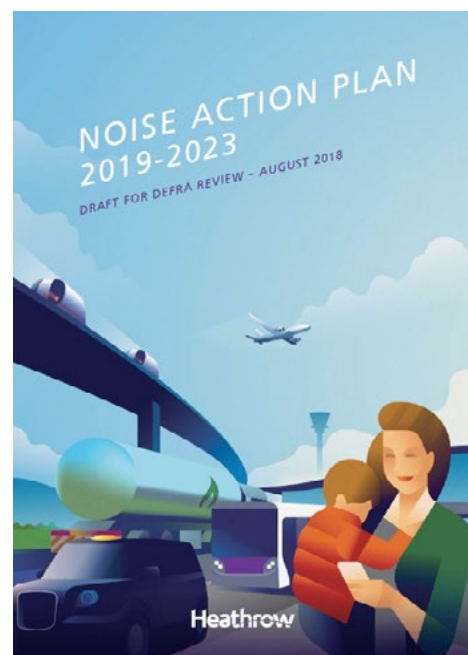
The London Borough of Hounslow lies immediately to the east of Heathrow. It recently held a public consultation on its draft Local Plan and Heathrow made a detailed submission. The council's decision acknowledged 'the council has a role in ensuring noise nuisance is not exacerbated, by placing sensitive uses outside of the higher noise contours'. Accordingly, the Local Plan included the following limitations on developments:

- no new noise sensitive developments in areas with more than 69 dB LAeq for 16 hours;
- only one bed or studio dwellings in areas between 63-69 dB LAeq for 16 hours;
- requirements for adequate noise insulation and ventilation in areas with more than 57 dB LAeq for 16 hours.



Heathrow Noise Action Plan 2019-2023

In 2019 Heathrow published its new Noise Action Plan as required by the EU Environmental Noise Directive. Of the 49 actions and commitments in the plan, there are five aimed at improving noise insulation schemes and three directly related with land use planning to develop Local Planning Principles on conditions for new sensitive developments, agreement on how to measure encroachment and a common position on encroachment was stated.





John Stewart, Chair Of Heathrow Association For The Control Of Aircraft Noise (HACAN)

Heathrow Case Study

The dilemma

Currently, 470.000 households are shared with other families, thus London needs to build more houses. It has been calculated that London needs to build 66.000 houses a year. At the same time, Heathrow Airport wants to impact fewer people, avoiding more dwellings inside the noise contours, but not under the rest of the flight path. Aircrafts are becoming less noisy while reducing noise contours and operational practices are improving all leading to reduced noise contours. Yet, given the current housing crisis, the inevitable truth is that there will be new properties built under the flight path.

Dealing with the inevitable

It is essential to bring the airport, local authorities, developers and local communities together – compromises from all parties will be required. Communities' representatives must be involved at a strategic level, so they could understand the problems and contribute to solution-finding. Additionally, people who are moving into properties under a flight path should be told beforehand. The developers must make sure that the properties built under flight paths have top-class mitigation measures installed.

A future that works

Only an overall strategy will deliver the expected outcomes. The local authorities need to know where they can permit house building. The airport needs to be able to plan future noise contours. The developers need to know what mitigation will be required. The community needs to know the noise impact.



Dipl. Ing. Wolfgang Hesina, Managing Director, Vienna Airport Dialogue Forum Association



Vienna Airport Dialogue Forum Association

The new situation in the regional discussion

The Vienna airport company is facing the challenge of not being responsible for all ground-based traffic noise in the airport region coming from different sources as well as for all environmental impacts and its changes in the quality of life.

Vienna Airport Region Project - this project includes new business settlements and land use planning activities for a reduced circle of stakeholders, mainly the mayors of the neighbouring communities. Vienna airport has a leading role in the project and is acting in some cases like a regional development agency.

Introduction to Dialogforum Flughafen Wien

Dialogforum Flughafen Wien is a non-profit organisation functioning as an information and communication platform for continuing the dialogue which started during the mediation process with more than 130 communities, the provinces of Vienna, Lower Austria and Burgenland, and citizens' action groups. Its members represent around two million residents (25% of the Austrian population).

Based on the acceptance of mediation agreements, commitment to dialogue and negotiations, 20 citizens' initiatives have been resolved.

Conclusion

Vienna Airport is at the beginning of a journey, discussing noise mitigation measures – airside and landside – taking into account that regional noise level and environmental impacts from varied sources are more than ever in the focus of the citizen initiatives and the mayors of neighbouring communities.

Vienna airport needs citizens' involvement for further land use planning and regional development. The new role as an intermodal traffic hub is a challenge for airport companies but also a chance for more acceptance of air traffic.



Franz Joechlinger, Environmental and Sustainability Management, Vienna Airport

Development of the Third Runway in Vienna: A Key Approach to Reduce Airport Noise Annoyance

Airport of Vienna

In 2018, Vienna Airport served 241,004 annual aircraft movements, carrying more than 27 million passengers and almost 300,000 tones of air cargo. The airport employs 24,000 people and provides 36,000 more indirect jobs for the region. Currently, its two cross runways are not enough to cover the demand expectations. In 2005 the mediation agreement for the new runway came into force.



Land use planning based on Mediation contract between airport and communities (2005)

Runway length

- Parallel distance 11R/29L to 11L/29R 2,400 m; landing on 11R only possible in curved approach

Noise limit: 54 dB

- Agreed major dimension of noise zone > 55 dB(A) and new "living areas" only outside
- Increase in MOV requires reduction in average noise values for individual aircraft

Night flight rule

- 07:00 to 21:00 – no limitations
- 21:00 – 22:30 and 06:00 – 07:00 – 2-runway operations
- 22:30 – 06:00 – single runway operations
- 23:30 – 05:30 – limit to average of 8 MOV / night (transition rule, currently 12 MOV)

Technical noise protection

- Noise protection measures for properties in 54 dB zone (day) and 45 dB zone (night)

Environmental fund

- 20 cents / PAX 06:00 – 22:00; 60 cents / PAX 22:00 – 06:00 incl. noise factor

DIALOGUE FORUM – lasting communication structure

- Platform also permanently available to deal with potential conflicts inherent to the system

Stakeholders of the Airport City

The stakeholders of the Airport City are regions of Lower Austria, Vienna and Eastern Region, shareholders of Flughafen Wien AG, passengers, airlines, shipping companies, firms and employees on-site, landowners, authorities and legislators, etc.

Strategic approaches

Strategic approaches for the development of the airport city include hotels, office spaces, cargo, offers of new services and businesses' location projects. These services will be expanded accordingly to the increasing number of passengers using the airport facilities.



One step further: 'Aerotropolis' – objectives and cooperation

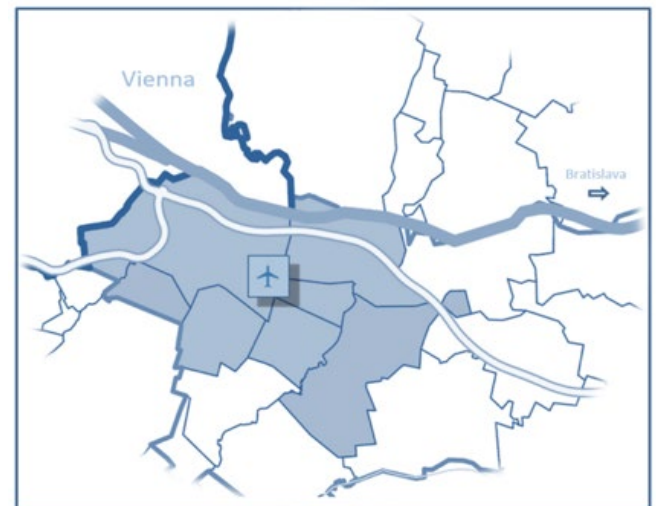
The objectives of 'Aerotropolis' region are to (1) further joint development and presentation of the region as a sustainable business and residential location, (2) intensify regional and international location marketing as well as (3) leverage the airport as an international advertising vehicle, (4) improve reachability and mobility and (5) integrate nature and ecology.

Vienna Airport region works in cooperation with seven communities – Enzersdorf an der Fischa, Fischamend, Klein-Neusiedl, Raasdorf, Schwadorf, Schwechat and Zörfeld. The Association of the Vienna Region includes Association's board as well as expanded board (City of Vienna, local enterprises, development agency, unemployment office, etc.)

Conclusion

Vienna Airport Region is a developing sustainable residential and business location. The quality of life in the region is improved by implementing specific projects, such as bypass roads, safeguarding of key green areas and landscape corridors, generation of renewable energy and development of recreational areas and biodiversity.

Vienna Airport aims to be a fair partner in the region and contribute to developing win-win situations for the airport, communities and the residents to stabilize the social peace in the region.



Quelle: Darstellung der Wallenberger & Linhard Regionalberatung KG



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