ANIMA

Aviation Noise Impact Management through Novel Approaches

D2.5 – Critical review of Balanced Approach Implementation across EU Member States

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[1] Use one of the following codes: R=Document, report (excluding the periodic and final reports)
DEM=Demonstrator, pilot, prototype, plan designs
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1. Executive Summary

This report presents an assessment of Balanced-Approach implementation by airports across European Member States. The main aim is to identify the range of operational improvements, land-use planning interventions and operational restrictions introduced by airports to address specific noise management challenges.

The research was conducted via in-depth case studies across 12 airports and one community organisation, using publicly available documentation and stakeholder interviews at each organisation. The result is 13 thorough case studies on the adoption of Balanced Approach at each airport, and specifically the implementation of a noise abatement intervention relating to the three Balanced Approach pillars of Land-Use Planning, Operational Procedures, and Operating Restrictions.

The case studies address the processes through which interventions are implemented, namely:

- Identification of the need for change.
- Design of intervention options.
- Selection of implemented intervention.
- Implementation of the intervention.
- Post-Implementation Evaluation.

By focusing on these processes, it has be possible to identify Best Practice elements that lead to successful implementation of an intervention, which may be transposable to other airports, and thus inform on the Best Practice Portal being developed in ANIMA Task 5.5. Moreover, this approach allows for tools, metrics, monitoring and modelling, and communication strategies used in each case to be identified and to inform on ANIMA Sub-Tasks 2.3.2 and 2.3.3.

The work has found that communication and engagement play a large and significant role in the implementation of noise abatement interventions across different Balanced Approach interventions, and throughout the entire process of implementation. Communication and engagement should therefore be made a more integral component of the Balanced Approach.

Land-Use Planning was found to be of particular importance to rapidly growing airports, for which pro-active engagement in the Balanced Approach can lead to avoidance of operating restrictions as the airport grows. Integration of different Balanced Approach elements in the same instance was found to be lacking in the case studies – with interventions typically being implemented as one-off actions independent. Considering interdependencies was found to be relatively lacking in intervention – noise being the primary driver behind the majority of case studies. A range of modelling and monitoring protocols were identified, disseminated through a range of metrics.

2. Introduction

This report presents an assessment of Balanced-Approach implementation by a group of airports drawn from across European Member States. The main aim is to identify elements of best/effective practice drawn from examples of operational improvements, land-use planning interventions and operating restrictions introduced by airports to address specific noise management challenges.

The main body of the report and the key messages on the Balanced Approach are been based on a selection range of airport case studies, as examples of balanced approach interventions they have proved useful in establishing the specific contribution to noise impact reduction from the perspective of airports, local/national authorities and local communities. The case studies, identified with the help of ARC and ACI Environment Committee originally included, Schiphol, Heathrow, Iasi, Kiev and Ljubljana airports, but were extended to include a further 8 case studies, making a total of 13 case studies capitalising on the partnership with local teams (partners in ANIMA) and contacts.

The case studies constructed from published information, internal documentation and corroborative interviews with key actors were designed to shed light on motivations, issues and barriers but especially to capture the processes that lead to the successful (or less successful) implementation of Balanced Approach interventions at airports, from the initial idea (conception), through to the design of options, selection, implementation and post-implementation evaluation. The focus on the processes and motivations is driven mainly by the fact that the specific circumstances of each airport can be radically different, making advocating one intervention over another difficult. However, the process and motivations that underpin their implementation can offer opportunities for shared learning and best practice approaches, as well as classify the case study under specific requirements that different airports may have in common.

The data collected was designed to capture for each case study:

- the tools used to model the potential consequences of the interventions;
- the range and effectiveness of metrics and tools used to communicate potential deployment scenarios to key stakeholders;
- whether stakeholder engagement and decision-making processes were able to establish socially optimal deployment regimes; and
- the extent to which outcomes resulted in measurable and perceived airport and community benefits.

The case studies were built through several phases, first through a review of publicly available documentation produced by airports, then supplemented by interviews with intervention stakeholders, to provide rich and detailed contextual information on each specific case, finally review of written material by relevant stakeholders from each case study provided a further validation step.

In Section 3 the concept of the ICAO Balanced Approach is introduced, and each of the elements studied in this report are presented in turn, including the addition of communication and engagement as a supplementary element. In Section 4 the methodology underpinning the research is presented, before Section 5 lays out the key research findings. Section 6 presents core messages from the work, with concluding remarks made in Section 7. Full and detailed case studies for each of the case airports are provided in the Annex.

3. Introduction to Balanced Approach

Regulatory responses to aircraft noise are influenced at the global level by the UN International Civil Aviation Organisation (ICAO), and specifically its 'Balanced Approach' to noise management, adopted at the ICAO 33rd Assembly on Aircraft noise in 2001[3]. The rationale for the Balanced Approach was built on the concept that airports face their own specific circumstances in terms of levels of traffic, the amount of night flying, proximity of the airport to built-up areas, and attitudes of local residents to noise. By providing a simple framework focusing on the core aspects of noise management, airports would therefore be able to have the flexibility to adopt their own approaches as appropriate to their own situation. This also recognises that Member States may already have their own noise regulations and policies in place.

The Balanced Approach provides a flexible way to identify and transparently address specific noise problems. It comprises four principal elements:

1. Reduction of noise at source – by encouraging the development and use of quieter aircraft;
2. Land-use planning and management – to prevent noise sensitive developments close to airports and flight paths, and to mitigate noise impacts (i.e. through sound insulation);
3. Noise abatement via alternative operational procedures that separate aircraft from noise sensitive areas or reduce thrust settings and therefore the noise generated by aircraft; and,
4. Operating restrictions on aircraft at sensitive times (e.g. at night) or in terms of absolute numbers of movements.

As well as these guiding principles, a supporting guidance document 'Guidance on the Balanced Approach to Aircraft Noise Management'[4] has been produced to support airports in implementing interventions within these core elements. Key to note is that this document states that operating restrictions should only be applied as a last resort, after the other elements have been considered and applied where appropriate. This acknowledges the key role played by aviation in the global socio-economic system, and that reductions in noise can be achieved at a lower economic cost when a stronger focus is placed on the other Balanced Approach elements.

The ICAO Balanced Approach is transposed into European Law through EU Directive 2002/30/EC, later replaced by Regulation (EU) No 598/2014. In the EU, legislation is set centrally, however implementation into local law, occurs at the Member State level. This ensures that the exact implementation of the four Balanced Approach elements is at the behest of the contracting states, which can also choose to delegate their powers to a competent authority. Below this

[3] https://www.icao.int/environmental-protection/Pages/noise.aspx
[4] ICAO (2008) Guidance on the Balanced Approach to Aircraft Noise Management, Doc 9829. AN/451. https://store.icao.int/index.php/guidance-on-the-balanced-approach-to-aircraft-noise-management-2nd-edition-2008-doc-9829-english-printed.html

level, airports are generally empowered to implement their own specific interventions designed to reduce impact, although this is commonly supported by external stakeholders, particularly national airspace providers. Doing so ensures that aircraft noise problems at individual airports can be managed in both an environmentally and economically responsible way - achieving maximum environmental benefit in a cost-effective manner.

As well as the four Balanced Approach elements, guidance on noise management at airports often refers to the central role of communication and engagement with stakeholders. Indeed, ICAO ranks communication and engagement as part of "proper land-use planning and management" and "the key link between environmental stewardship and mitigating environmental constraints to aviation operation and growth"[5]. A 2016 ICAO Circular undertaken by CAEP highlighted lessons learned and good practices on community engagement to assist and encourage States and the aviation industry, in particular airports, airlines, and Air Navigation Service Providers, to engage local communities early in airport development projects to address environmental matters. Although not defined as a genuine pillar of the Balanced Approach, community engagement and communication is considered highly important and can be seen as running through, and being a central component of, all other Balanced Approach elements. For more information on the role and value of communication, see Section 3.4.

Noise at source is not considered in this report due to the fact that it can typically only be indirectly be influenced by airports through mechanisms such as aircraft restrictions. Moreover, other EU funded research programmes (such as ARTEM, Aircraft noise Reduction Technologies and related Environmental) already exist to address this Balanced Approach Element.

3.1 Land use planning

Land Use Planning (LUP) creates significant barriers to airport expansion, generating conflict between aviation stakeholders, often leading to complaints.

There are many demands on land use - natural, agricultural, highways and railways, recreation, municipal utilities, commercial, industrial, residential and institutional. The challenge for responsible authorities to ensure a balance of uses that optimises social, environmental and economic benefits.

Land Use Planning, or land use management controls for an airport, attempts to achieve optimal utilisation of land through the use of zoning linked to noise exposure. This can be an effective method for limiting populations located near airports and potentially affected by aircraft noise. Unfortunately, however there has been very limited systematic evaluation of the use of land use planning tools to minimise noise impact over the last decade since the initiation of the ambitious ICAO/CAEP 5 work programme on Airport Planning and Land Use

[5] https://www.icao.int/environmental-protection/Pages/Community-engagement-for-aviation-environmental-management.aspx

Planning[6], during which time many airports have suffered from encouragement by noise-sensitive developments and thus the constraints to infrastructure growth has increased significantly. Thus, there remains a need for the assessment of land-use planning for noise impact mitigation if we are to **develop tools that can help policy makers and communities** (ICAO resolution A37-18).

The link between research, policy and practice

The key challenge in attempting such assessments is recognition of the range of planning interventions available and how best to tailor their selection and implementation to particular airport contexts. The range of the instruments available have been summarised by ARCP and are listed in the below Table 1. The implications from other ANIMA deliverables (e.g. D2.4), and in keeping with the priorities for communication and engagement identified in Section 3.4 below, is that such tailoring is best achieved through consultation with local decision makers, planners, local communities, and other parties affected by noise impact. This should allow for the most effective utilisation of the land use planning tools available in the design of mitigation solutions[7]. Table 1 illustrates different instruments used in assessing the LUP challenges.

Table 1: Land Use Administration / Control Systems

Planning Instruments	**Mitigating Instruments**	**Financial Instruments**
Comprehensive planning	Building codes	Capital improvements planning
Noise zoning	Noise insulation programmes	Noise-related airport charges
Subdivision regulation	Transaction assistance	Tax incentives
Transfer of development rights	Land acquisition and relocation	Other?
Easement acquisition	Real estate disclosure	

[6] https://www.icao.int/.../CAEP/CAEP-briefing_AdditionalInformation

[7] http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_027v2.pdf

	Noise barriers	

This stakeholder consultation and engagement needs to explore the use of land use planning instruments in isolation and combination to assess their potential to address challenges such as:

- Changes to population distribution around airports (density and location)
- Provision of effective protection against night noise
- How best to optimise the consequences of operational changes (e.g. optimising synergies between operational changes and land use instruments)
- How best to define and track the effectiveness of land use planning

A key achievement of effective land use planning would be the avoidance of further residential developments in areas that would endanger the reduction in noise impact previously achieved (prevention method) and the conversion of existing incompatible land-uses to ones more in keeping with the prevailing noise environment[8].

ANIMA research was focused on Land-use Planning regimes and tools, illustrating different local issues at selected airports (see Annex). Stakeholder engagement focussed on the long-term consequences of local decision making, the case of Iasi Airport being an illustrative example.

3.2 Operational procedures

Operational procedures have the potential to impact the noise around an airport, either through reducing it, or by changing the distribution of noise on the ground. In so doing these procedures have the potential to minimize noise disturbance by optimizing how aircraft use airport facilities (in the air and on the ground). Operational procedures enable the full potential of aircraft capabilities to be utilised. Possibilities include:

Noise abatement flight procedures

- Continuous Descent Operations (CDO), referred to in the past as Continuous Descent Arrival or Approach (CDA);
- Noise Abatement Departure Procedures (NADP);
- Modified approach angles, staggered, or displaced landing thresholds;

[8] https://aci.aero/Media/542d5151-7cc2-4827-b67c-bdff869e8fc3/frtfPg/Environment/3rd%20ACI%20Airport%20Environment%

- Low power/low drag approach profiles;
- Minimum use of reverse thrust after landing.

Spatial management

- Noise preferred arrival and departure routes;
- Flight track dispersion or concentration;
- Noise preferred runways.

Ground management

- Dedicated buildings for suppressing noise from, for example, engine testing and engine run up management (location/aircraft orientation, time of day, maximum thrust level);
- Auxiliary power-unit (APU) management;
- Taxi and queue management;
- Towing;
- Taxi power control (taxi with fewer than all engines operating).

What is clear from this list of examples is that there are many options available to airport managers that could potentially be implemented. However, what is less clear is what may be appropriate at a given airport. For example, the decision to concentrate or disperse flight tracks is related to local characteristics, such as the distribution of urban developments near the airport, and even cultural issues such as local attitudes towards whether the noise burden should be shared between many people, or concentrated on as small a population as possible. Other factors that may influence the appropriateness of a given intervention include: weather, topography, runway length, and the presence of tall buildings. Insulation can also play a role as an authority may choose to concentrate flights in a certain area, insulate existing houses, and ban noise sensitive development as a way to manage noise exposure. Importantly, any operational change designed to reduce noise must be compliant with safety regulations – the highest priority underpinning airport operations around the globe.

It is also important to note that although noise abatement procedures have the potential to deliver quantifiable environmental benefits, their effective implementation is beset with a range of challenges. Beyond the aforementioned safety, these can include unintended environmental consequences (interdependencies), the requirement for modelling, and trialling of procedures, stakeholder engagement (to understand aircraft and pilot capabilities and interests), monitoring and evaluation, and the approval from Air Navigation Service Providers. Importantly, as stated under the Balanced Approach, and in industry guidance, airports should engage with their local communities to give notice about changes to airport operations, and ideally should go through a period of consultation to ascertain which specific interventions may be appropriate, and how they should be implemented.

That operational procedures depend so heavily on local circumstances highlights the difficulty in airports sharing best practice via the implementation of specific noise abatement interventions. The processes that underpin the selection, design, implementation and evaluation of these interventions is however an area where shared learning may be able to take place. The case studies outlined in this paper of London Heathrow, Vienna, Schiphol, and Helsinki and Cluj-Napoca have particular relevance here.

3.3 Operating Restrictions

Operational restrictions are noise-related actions that limits or reduces the movements of the noisiest aircraft to an airport, enabling the airport to contain or shrink the noise contours around the airport. The aim is to address aircraft noise problems at individual airports in an economically, objective and environmentally responsible away.

Operating restrictions may have an impact on airlines, airports, passengers and local economies that must be assessed before its implementation in a particular airport. The range of operational restrictions includes:

- Global restrictions. Apply to all traffic at an airport based on total fleet noise performance. For example, 'Noise quotas' like in Heathrow airport.
- Aircraft-specific restrictions. Apply to a specific aircraft or a group of aircraft based on individual noise performance, like in the Barcelona case study. This kind of restriction usually starts with period of non-addition rule followed by a period of progressive restrictions before the full ban. Directive 2002/30/EC established these periods for EU members.
- Partial restrictions – these can apply:
    - at an identified time period during the day, like night curfews (Frankfurt) or night time restrictions established in many airports (for instance Madrid, Schiphol or Charles de Gaulle),
    - on specific days of the week, usually weekends,
    - for certain runways at the airport like in Madrid Barajas some specific SIDs are banned for the noisiest aircrafts.
- Progressive restrictions. Provide for a gradual decrease in the maximum level of traffic or noise energy used to define a limit over a period of time. This period is typically defined as a number of years before reaching a final level. This restriction is usually implemented before an 'Aircraft-specific restriction based on noise performances' like in Barcelona case study. EU directive established a minimum period of 5 years before the full ban.

ICAO Assembly in 2001 urged States not to introduce any operating restrictions at any airport before fully assessing available measures to address the noise problem at the airport concerned in accordance with the Balance Approach. Any restriction should be based on the noise performance of the aircraft and should be tailored to the noise problem of the airport concerned, and the special circumstances of operators from developing countries should be taken into account.

The ICAO Balance Approach was deployed into European legislation and established the rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports.

Nevertheless, many airports had already implemented Operating restrictions to try to minimize noise problems, and the Directive was not interpreted in the same way by several airports, the procedure was too long, and the airports preferred to avoid the noisiest aircrafts increasing its charges instead to apply the procedure with similar results. In other cases, like night flights that are in particular related to cargo and express air traffic, the night curfews affected the delivery of time-sensitive products and the airlines capacity schedules.

The report from the Commission of 15 February 2008 entitled 'Noise Operating Restrictions at EU Airports' pointed to the need to clarify in the text of Directive 2002/30/EC the allocation of responsibilities and the precise rights and obligations of interested parties during the noise assessment process so as to guarantee that cost-effective measures are taken to achieve the noise abatement objectives for each airport

After 12 years, an update to the operating restriction measures was necessary in order to enable authorities to deal with the current noisiest aircraft and to improve the noise environment around Union airports within the international framework of the Balance Approach. Thus, EU Parliament approved a new Regulation (EU) Nº 598/2014 of the European Parliament and of the Council of 16 April 2014 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balance Approach and repealing Directive 2002/30/EC.

The Regulation only applies to airports with more than 50 000 civil aircraft movements per year. The noise assessments should be carried out on a regular basis in accordance with Directive 2002/49/EC, requiring additional noise abatement measures if the current combination of noise mitigating measures does not achieve the noise abatement objectives (these in turn should be tailored to each airport), taking into account expected airport development. Noise-related operating restrictions should be introduced only when other Balanced Approach measures are not enough to attain the specific noise abatement objectives.

The noise exposure of areas around airports can be limited by applying operational restrictions. However, there are also negative effects such as capacity constraints, inconvenience and reduced connectivity for travellers, increasing levels of noise at other airports, higher operating costs and potentially also additional gaseous emissions.

Noise assessments should be based on objective and measurable criteria and the competent authority responsible for adopting noise-related operating restrictions should be independent of any organisation involved in the airport's operation, air transport or air navigation service provision, or representing the interests thereof and of the residents living in the vicinity of the airport. All the operating restriction assessment process defined in the Regulation, must be public and transparent.

ANIMA research was focused on some operating restriction examples based on the Directive 2002. ANIMA has not found any case that applies the new Regulation for the moment.

3.4 Communication and Engagement

There is a requirement within ICAO's Balanced Approach (ICAO, 2008, p. I-1-2) that Contracting States adopt a flexible way of identifying specific noise problems and remedies that are targeted and tailored to the local situation through a transparent process. ICAO emphasises that the process of implementing the Balanced Approach should "typically consist of an assessment of the noise situation at an individual airport, definition of the objective, provision for consultation, identification of measures available to reduce the noise impact, evaluation of the likely costs and benefits of the various measures available in order to identify the relative implementation of measures, and a provision for dispute resolution available to stakeholders." ICAO states that there should be consultation with, amongst other stakeholders, members of the public whose quality of life may be affected. It indicates that such consultation should be collaborative and enable participants to be fully informed about noise issues and proposed solutions at the airport, which ICAO suggests may lead to more acceptable outcomes. It indicates that the principles of such engagement include public education and awareness programmes, information dissemination and information exchange.

As ANIMA deliverable D2.4 highlighted, it is important that the stakeholder engagement advocated by ICAO moves beyond obligatory and, arguably, tokenistic release of information to a more participatory, inclusive dialogue that taps into community experience and local concerns if a more comprehensive approach to noise impact mitigation is to be achieved. D2.4 also concluded that this comprehensive approach is needed to directly address non-acoustic aspects known to exacerbate the annoyance response to aircraft noise.

Given the nature of modifiable non-acoustic factors it is hardly surprising that many aviation actors have identified communication and engagement as key elements in the management of noise impact (see for example: FAA, 2011; ACRP, 2009; CAC, 2015; EESC, 2015; Eurocontrol, 2018; Sustainable Aviation, 2014; and CANSO, 2013 & 2015). Illustrative of this shift in focus to more proactive communication and engagement is ICAO's Circular 351 – Community Engagement for Aviation Environmental Management (ICAO, 2017).

This Circular 351 states that "the most common form of community engagement consists of the aviation industry providing information to community groups and individuals on aviation operations and development plans, and communicating the current and future environmental, social and economic benefits and impacts. Community members may provide feedback and express their views by means such as mail, telephone, email, websites and meetings" (ICAO, 2017, p.vi)

However, the degree to which airports carry out such participatory communication and the success (or not) of their endeavours to consult engagingly is not easy to determine. There is a lack of attention in the literature to evaluation and learning from the engagement techniques airports deploy. This gap is exacerbated by the general paucity of efforts to track attitudes and the impact on annoyance.

In Chapter 7 of Deliverable D2.4, there is a more detailed discussion of communication and engagement in aviation and the theoretical and practical aspects of such participatory approaches. Examples of specific communication and engagement practices are also summarised in D3.3. Together these emphasise the importance of utilising tools and noise metrics that are comprehensible to communities if wider understanding of issues is to be achieved, which in turn can facilitate genuine participation by communities in decisions that affect their noise environment. Such meaningful engagement could create the opportunity to positively influence non-acoustic factors and thus optimise the social benefits to be derived from Balanced Approach interventions.

The case studies detailed in this report include examples of how airports have engaged with communities, highlighting the tools and metrics used to describe the noise environment and changes to it arising from management interventions. The aim is to distil learning from these examples that can inform the development of best practice principles for communication and engagement to be incorporated into the ANIMA Best Practice portal.

4. Methodology

4.1 Case study structure and intention

ANIMA Sub-Task 2.1 gave us a Pan-European overview of Existing Knowledge and Implementation of Noise Reduction Strategies. This was conducted at a high-level to provide a review of the current state-of-the-art at the European level. The intention of ST 2.3.1, as outlined in this deliverable, is to develop rich and detailed case studies that will explore examples of Balanced Approach interventions, and the processes used in their selection, design, implementation, and post-implementation evaluation. In so doing the case studies will act as valuable indicators as the processes that underpin best practice noise management regarding the implementation of Balanced Approach interventions.

As this research is rooted in a specific industry, comprising many organisations, and with many different actors, several different methodological approaches could have been appropriate. Based on the work of Yin (1994; 2011), Eisenhardt (1989), Darke et al. (1998) and Walsham (1995), a decision was made to pursue a case study approach as the primary research methodology.

According to Yin (2003), case study research is particularly useful in instances where a researcher is looking to "investigate a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (ibid., p13). Case study research is an accepted and valid method within the field of organisational research (Farquhar, 2012), due to it being able to facilitate the building of theories, the development of concepts, the drawing of specific implications, and to contribute rich insights to support, or counter, existing material within the literature (Walsham, 1995). Additionally, the approach empowers the researcher to use a combination of several different data collection methods, both quantitative and qualitative in nature (Eisenhardt, 1989). In the case of this specific research, the use of case study research as the main research method enabled rich, detailed and contextual case studies to be developed that will help to develop a picture of not just what airports are doing, but why and how they are doing those things.

It is important to emphasise here that the aim of this deliverable was to identify and build case studies with sufficient depth for us to reveal core elements of the process that make for more effective Balanced Approach interventions. It is for this reason that we focused on a narrow set of 'exemplar' case studies, based on rich qualitative data, rather than a quantitative analysis. In terms of non-acoustic factors, a key concern were those elements identified as significant influences over annoyance and that are also potentially modifiable (e.g. attitudes to airports, perceived control, etc.). These can lead to a focus on the extent of public engagement in the above process - how this was achieved, whether there was genuine input to decision-making, impact on the acceptability of outcomes, influence over post implementation monitoring and so on. This is important, because, as described in Deliverable 2.1, ANIMA has identified that all airports have different political, economic, environmental and cultural contexts that can influence which Balanced Approach interventions may be most appropriate in a given setting. This makes the dissemination of best practice interventions difficult, however dissemination of the processes that underpin the identification, selection, design, implementation and evaluation of those interventions is possible. The case studies will also be able to provide detail on:

- Data and models used to predict impact of interventions
- Outputs from scenarios (i.e. metrics) and use to inform decision-making
- Role of interdependencies in decision-making
- Extent and nature of community engagement in selecting between deployment options
- The use of trials
- Deployment processes – extent of collaboration between airport partners required to ensure effective implementation.

In collecting the above information, the deliverable should be able to help inform on ANIMA ST 2.3.2 – Noise Footprints, (where metrics used in the case study intervention and the rationale for their use could be understood), 2.3.3. - Interdependencies (to establish the means of assessing interdependencies and the extent to which these concerns influenced options and their deployment) and 3.1.2 - Evaluations of previous interventions in improving quality of life (with case studies providing the basis for more detailed analysis of effectiveness of previous interventions on quality of life).

4.2 Airport Case Studies

The selection of airport case studies was based on ANIMA airport partners, to ensure access to rich data. Additionally, from a review of Deliverable 2.1 combined with the expertise of ANIMA researchers, we identified other airports for investigation as case studies. Only one case ACNUSA although it is not representing a specific single airport, has been chosen as a best practice of authority across multiple airport fostering and coordinating dialogue between stakeholders. The full list of case studies is listed below:

<u>ACNUSA (France)</u>

ACNUSA (Autorité de contrôle des nuisances aéroportuaires / Airport Pollution Control authority) was founded in 1999 at a time of sharp growth in air traffic and yet a standstill in dialogue between stakeholders. It is a public body, without formal regulatory powers, but it carries considerable moral ascendant as it is allowed to undertake studies, provide opinions, and contribute to debates. Last, but not least ACNUSA also manages the system of administrative sanctions (ie, fines) in the cases where existing environmental regulations are being breached. The mandate of ACNUSA encompasses noise pollution and was more recently (2010) expanded to air quality. ACNUSA covers some of the busiest airports in the country.

Actions and activities undertaken by ACNUSA are based on four main pillars:

1. Enabling debate through knowledge and information

2. Supporting a better management of airport related pollution
3. Preventing and repairing
4. Administering penalties

Barcelona El Prat (Spain)

Barcelona Airport case study focuses mainly in the operational procedure. Specifically, it was related to the switching role of each runway during the day (the ones that would be used for take offs, should be used for landings and vice versa), and new flight configuration during the night. Another interesting aspect of this case study relates to the institution of the Commission for Environmental Monitoring of the Airport Expansion Works (CSAAB) which aims to monitor and control the compliance of the preventive, corrective and off-setting measures, developed during the construction and operation phase of Barcelona Airport's expansion, as well as to approve the studies and previous investigations indicated in the of the environmental statement.

Catania (Italy)

Catania Airport is the 6th largest airport in Italy for passenger movements, with over 9 million in 2017 and 6700t of goods, and 68000 flights (http://www.assaeroporti.com/statistiche_201712/). The Airport has only one runway with orientation east-west and it is located very close to the sea and approximately 5km south to the City of Catania.

As a land use focused case study, the legislation includes a noise zoning system approach and Catania has implemented both noise maps approved in 2005 and land use planning acoustic classification plan by Catania Council, based on noise maps and airport inputs, approved in 2013.

Cluj-Napoca Avram Iancu (Romania)

Cluj-Napoca is the largest urban centre of Transylvania. Cluj Avram Iancu airport is a rapidly growing airport located in the North West of Romania, with over 2.5m air passengers in 2017. The airport is currently undergoing major development in anticipation of future growth, with a new runway being built in phases to handle larger aircraft.

This case study looks at the use of preferential runways and night restrictions at the airport to avoid over flying Cluj city centre, and therefore avoiding a highly populated area. It therefore acts as a useful case study to inform both on the implementation of operating restriction and operational procedure noise abatement.

Frankfurt (Germany)

Frankfurt Airport (FRA) served more than 69.5 million passengers in 2018, thus posting a new record high in the airport's history. Compared to 2017, traffic at Germany's largest airport grew by some 5 million passengers or 7.8 percent. It also increased by 5.1 percent to some 31.6 million metric tons.

The Frankfurt Case study discusses the interventions and measures taken by the Frankfurt airport with respect to the Balanced Approach of Land use planning. Frankfurt airport had an expansion process between 1997-2011 and provides a good example of how the German system operates for the construction or expansion of airports, how it relates to spatial planning, and how environmental concerns (especially noise) are taken into consideration.

London Heathrow (UK)

In 2018 London Heathrow Airport (LHR) served over 480,000 annual aircraft movements, carrying over 80 million passengers. The airport is one of the largest in the world and has due to its vicinity to a highly populated and dense population, has been engaging in noise management for many decades.

This case study describes the implementation of a steeper departure profile on the 'Detling' DET09 departure route, with the intention of reducing noise impact over the community at Teddington. This initiative was initially raised by community members, and acted upon by the airport, therefore acting as a useful case study to understand the implementation of new operational procedures, and the role of community engagement.

Helsinki (Finland)

Helsinki airport was originally built for the Summer Olympics in 1952. About 90% of Finland's international air traffic passes through Helsinki Airport, with the airport serving approximately 21 million passengers in 2018.

This case study describes the implementation of a new operational procedure (NADP1) at the airport to reduce expected increases in noise exposure to residents from increasing capacity at RWT-22L. As well as changes to flight paths, the case also required changes to airspace - thus representing a useful case through which operational procedures can be investigated.

Iasi(Romania)

Iasi has an International airport, which is located at 8km from the city centre. Iasi Airport is the fourth busiest airport in Romania. By 2017 the airport had 11 800 aircraft movements and about 1.146 million passengers transiting through the airport.

The airport is well connected to all the major European cities. The case study of Iasi airport is to understand the impact of noise from the airport on its surrounding communities and also to engage with the stakeholders to analyse the steps taken or proposed to mitigate the noise issues arising from the airport. The case study is bounded within the analysis of land use and zoning around airports

Kiev (Ukraine)

More than 90% of overall Ukrainian air traffic is managed by five strategic airports: Boryspil, Dnipropetrovsk, Odessa, Lviv Kharkiv and Kiev (Zhuliany Airport). Statistic data collected since 2011 pinpointed Boryspil International Airport as the manager of over 60% of the overall passengers and over 70% of the total air cargo.

This case study provides an overview of the previous, current and proposed practices of Boryspil International Airport (Kiev), as a part of their Noise Management Strategies.

Ljubljana (Sloevenia)

Fraport Slovenija is the operator of Ljubljana (Joze Pucnik) Airport, having as its core business the airport management and operation, airport infrastructure development, provision of ground handling services and other commercial activities. This is the central Slovenian international airport, managing approximately 97% of the total passenger air traffic in Slovenia.

This case study provides an overview of the previous, current and proposed practices of Ljubljana Airport, as a part of their Noise Management Strategies.

Amsterdam Schiphol (The Netherlands)

Amsterdam Schiphol Airport is the main international airport of the Netherlands and located 9 kilometres southwest of Amsterdam. With 71 million passengers in 2018 travelled from, to or via Amsterdam Airport Schiphol it is the third busiest airport of Europe in terms of passenger volume, and has almost half a million air transport movements per year.

This case study looks at the implementation of a noise abatement operational procedure (NADP2) provide noise relief to communities around Schiphol from both arriving and departing aircraft. At the same time it was anticipated that this change would deliver fuel savings for airlines.

Stockholm-Arlanda (Sweden)

Stockholm Arlanda Airport located in the Sigtuna Municipality of Sweden approximately 37 kilometers north of Stockholm and nearly 40 kilometers south-east of Uppsala. It is the largest airport in Sweden and the third-largest airport in Scandinavia. Most of the international air traffic within Sweden was in 2017 carried out by approximately 27 million passengers, including 21.2 million international and 5.5 million domestic travellers.

The case study discusses the implications of a proposed curved approach to reduce noise impact in response to opening of an additional runway at Stockholm Arlanda international airport. The case study also discusses the impact of community engagement by airport authorities.

Vienna (Austria)

Vienna Airport is the largest airport in Austria. Serving a total of approximately 27m people in 2018 (representing annual growth of 10.84%), and over 240,000 aircraft movements. The airport is located 17km west of Vienna City and surrounded by mostly rural areas but including several large urban conurbations.

This case study describes the implementation of a curved approach to Vienna Airport, with the aim of reducing noise exposure in a highly populated region. It also describes the key role of the Vienna Dialogue Forum in finding optimal solutions for stakeholders. The case study thus acts as a useful lens through which the implementation of operational procedures, and the role of communication and engagement can be assessed.

4.3 Data Collection Methods

The case studies were built through two primary research phases:

- Initial airport overview: Backgrounds to each case study airport were developed via a review of airport noise action plans, plus any other relevant published documentation. As well as an initial background to the airport, this enabled existing approaches to noise management to be identified for instance, current Balanced Approach interventions implemented, the extent of existing community engagement programmes, the use of modelling and monitoring tools and so on. The main intention here was to understand what airports are doing, and to provide some initial context as to how they may be doing things. Importantly, this review helped to identify specific interventions that are illustrative of best practice and, importantly, helped to inform the questions that were included in the interview protocols used in each case study.
- Detailed airport context: In-depth interviews with key airport stakeholders were carried out to corroborate the findings from the initial review and to provide more detailed appreciation for the motivation for the range of Balanced Approach interventions deployed (or in development). Importantly this phase enabled the underpinning processes behind intervention implementation and evaluation to be understood, in terms of how and why airports are undertaking specific Balanced Approach interventions. These interviews provided an opportunity to develop a rich understanding of the processes involved in airport decision making,

planning and implementation, the role of consultation, and the methods used to evaluate the success of different interventions.

4.4 Stakeholder Interviews and Scope

The aim of the case studies was to investigate interventions embracing different elements of the ICAO Balanced Approach (operational procedures, land-use planning, operating restrictions). That different elements were being investigated meant that the use of a single interview protocol across cases was deemed to be inappropriate. For instance, the questions asked around the implementation of a new departure profile were different to those relating to the implementation of an insulation programme. As such researchers working on each case study were afforded the autonomy to develop their own interview protocols as appropriate to each case, and based on the information they had been able to obtain from the reviews of publicly available airport documentation (i.e. noise action plans). That said, all researchers were briefed of the intention of the interviews to understand the processes that underpinned implementation of noise management intervention, as outlined in the previous sub-section. Below, the interview protocol used to investigate the London Heathrow case study is provided as an illustration of one of these protocols for intervention on steeper departures.

- Identification of design options:
  - This intervention appears to be a community initiated one, with local communities contacting the airport with their concerns via the Operations and Procedures Working Group. How does this dynamic function? Is escalating community concerns to trialling new operational procedures typical?
  - Did communities present any other suggestions other than steeper departures? Where any alternatives proposed to them?
  - How has noise along this departure route been communicated to communities? Do you think that such communication played a role in community groups requesting steeper departures?
  - Why was a departure gradient of 5% chosen for the trials?
  - Which other stakeholders were consulted before deciding to go ahead with this intervention?
  - Was any resistance to a steeper climb gradient encountered internally, or from other airport stakeholders? How was this overcome?

- Option Selection:
  - Were communities presented with a suit of options regarding the nature of the steeper departure trials?

  - What were the key issues in debate during this process? For instance, the balance between sharing of noise exposure, or concentrating noise to a specific population?
  - Are some people expected to be worse off as a result of these trials?
  - Were interdependencies taken into consideration in designing this intervention? For instance, what are the expected carbon or safety implications associated with steeper departures and how did these influence the design or selection of this intervention?
  - What were the airport ambitions or expected outcomes from this intervention? What were your priorities?

- Implementation:
  - The steeper departures were trialled over a one-year period. Why was this period advocated, over say 6 months?
  - What challenges did you face in implementing steeper departures? What processes or procedures helped these to be overcome?
  - Did any communication about the trials take place prior to their go ahead? Did you experience any negative responses? If so, how were these dealt with?

- Post-Implementation monitoring and evaluation:
  - What assessment of impact/benefits of the intervention will take place? What is the nature of any assessment processes (e.g. noise monitoring, community surveys etc)?
  - You will soon publish your interim trials report, have the results been as you would have expected? Has the trial been worth the allocated resources? Have there been any unexpected outcomes?
  - Following the trials, do you plan on developing a suite of options to be presented to community, or other stakeholder groups, for their consideration?
  - An additional 11 noise monitoring terminals where installed under the departure route. How was this number arrived at? How was the location of these terminals decided on, for instance, were community groups consulted?
  - What lessons have you learned from this intervention that you can carry forward into future changes to operational procedures? Where they any particular success stories or things you would do differently?
  - Are you taking into consideration any non-acoustic elements in your monitoring?

Interviews were conducted on a face-to-face basis, via telephone or in some instances though written responses. For face-to-face or telephone interviews, the process lasted between 1 and 3 hours.

4.5 Stakeholder groups identified

Various stakeholder groups were identified in the beginning of this subtask. Having the purpose to develop detailed and comprehensive case studies, the process started with considering all aviation relevant organisations, together with the National Institutions (Governmental Institutions, Ministries, Regional and Local Authorities and others) that are involved in or related to aviation noise, according to the National legislative framework of each state. In this respect, a review of the ANIMA Task T2.1 Pan-European overview of Existing Knowledge and Implementation of Noise Reduction Strategies was necessary in order to establish the designated Competent Authorities for aviation noise. Furthermore, any available data (airport website/reports/others) was reviewed, in pursuit of understanding the relationship and cooperation level with other relevant organisations. Finding showed that one airport (Ljubljana) considers the media to be a very important stakeholder, to ensure a trustful and transparent mean of communication with the wider public, on all their efforts to manage environmental impacts.

Further developments included the development of interview protocols and questionnaires for all identified stakeholders for each particular airport involved in the development of case studies. All questions and statements were personalised for each category of stakeholder, according to their general activity and operations, e.g. focus on noise exposure alleviation procedures for ANSPs (Air Navigation Service Providers), on land-use planning for Ministries in charge of Urban Development etc.

Interview results revealed that, in the case of some airports having less than 50,000 movements per year (Iasi, Cluj Airports), an unclear legislative framework to reflect the designation of responsibilities among authorities to manage aviation noise led to difficulties in establishing the extent of involvement of all interested parties. As a result, noise management was undertaken only by airports and regional/local authorities, as the owners of the airports, with the Ministry of Environment. Together, they did their best for ensuring the compliance with the Environmental Noise Directive transposition in the National legislation, which includes, in the case of Romania, several other airports designated as "urban airports". Even if they have not reached 50,000 movements per year, the "urban airports" have to comply with the Environmental Noise Directive (END), i.e. ensure noise mapping and the development of Strategic Noise Maps and Action Plans, as a preventive and preparatory measure for fast growing airports. Therefore, the number of formal stakeholders and their level of involvement was limited. Further organisations (Civil Aviation Authority, Air Navigation Service Provider, other Ministries) do involved, on a voluntary basis, to support the airports during the development of all necessary documentation to ensure compliance with the Environmental Noise Directive.

Further interviews revealed that the community is considered as a relevant stakeholder in aviation noise. In several cases, the description of the community as a stakeholder is divided in two separate categories, formed by persons working at or near the airport within an aviation related organisation (‘direct beneficiaries of airport operations’) and residents not connected to the aviation field (‘indirect beneficiaries of airport operations’).

5. Results and Key Findings

Rather than provide a case-by-case description of the case studies, this section presents the key findings and core messages identified through their analysis. Full, detailed, case studies for each airport can be found in the Annexes in Section 7.

To perform the analysis, researchers focused on the underpinning processes behind the specific interventions, namely: recognition of the need for an intervention; the design of different implementation options; the selection of a specific intervention option; its implementation; and any subsequent post-implementation evaluation.

Researchers took this approach as transposition of such processes across different airports is both feasible, and can lead to best practice for individual airports considering their own specific circumstances. Doing so also enabled the different case studies to be analysed against each other, despite the case studies often differing significantly in nature (i.e. across different Balanced Approach elements). This approach also enabled contributions to be made to ANIMA Sub-Task 2.3.2, 2.3.3 and particularly to the Best Practice Portal being developed in Task 5.5 "Task 5.5 Measures supporting the Exploitation of the ANIMA results". These outputs include:

- Identifying the tools used to model the potential consequences of the interventions;
- Establishing the range and effectiveness of metrics and tools used to communicate potential deployment scenarios to key stakeholders;
- Evaluating whether stakeholder engagement and decision-making processes were able to establish socially optimal deployment regimes; and
- Highlighting the extent to which outcomes resulted in measurable and perceived airport and community benefits.

Core findings of the research are presented below.

5.1 Different categories of airports

ANIMA Deliverable 2.1 "Scoping the challenges – Pan-European overview of Existing Knowledge and Implementation of Noise Reduction Strategies", identified three broad categories of airport in terms of their experience of noise management:

- **Starting the journey:** airports with little to no experience in the application of Balanced Approach principles and/or community engagement. Starting the journey airports often lack the expertise and resources required for best practice, and may face a lack of legislative drivers to encourage the implementation effective noise abatement interventions. Such airports may require guidance in how to progress towards best practice for their own specific circumstances, rather than copying the approaches of airports with more 'advanced' noise management strategies.

- **Experienced travellers:** airports experienced in applying Balanced Approach principles and interventions. Experienced travellers will require support to further advance and add value to their noise management programmes, considering that they may already be engaging with stakeholders.
- **Pathfinders:** airports at the lead-edge of Balanced Approach implementation. Pathfinders are the experienced airports known to be innovative in exploring novel approaches to noise annoyance, through leading-edge interventions involving a wide range of stakeholders and Balanced Approach elements. Pathfinders require help to further advance their efforts using the latest available research, particularly in the enhancement of community communication and engagement programmes designed to improve quality of life outcomes for local citizens.

The intention of these categories is not to designate a status to a given airport – and this report makes no attempt to do so. Rather, the intention is use them as a lens through which the requirements of different airports can be inferred.

The case studies developed in this Sub-Task support the work of Task 2.1, by finding that larger airports had more developed Balanced Approach portfolios, and more rigorous processes behind interventions. Community Engagement was in particular found to be more advanced. Smaller but rapidly growing airports however, were found to be increasingly developing their own approaches to noise abatement, either due to regulatory and legislative requirements, or due the desire to address emerging land-use planning issues, to ensure that growth is achieved with the least possible noise impact.

Although the specific cases selected in this Sub-Task may not be indicative of the wider approach to noise management taken by the case airports (or others), it is noticeable that case studies from airports regarded as being at the cutting edge of noise management demonstrated a high degree of learning with regard to community engagement. **Both Vienna and Heathrow for example where responding to community suggestions and requests for new flight paths, rather than acting with the specific intention of reducing complaints, as per the case of Barcelona.** Smaller airports 'starting the journey' showed a strong commitment to noise management, but it was noticeable that most of them referred to issues of land-use planning, suggesting that this is a pressing concern for rapidly growing airports. The rapid growth at such airports (i.e. 43% increase in passengers at Iasi since 2016) suggests that citizens may be coming newly aware of the impacts of airport noise on their quality of life, and that such concerns are only just beginning to reach airport managers and regional municipalities, local authorities and developers. Likewise, growth in aircraft movements will inevitably lead to requirements for land-use based changes, for example through new or extended runways. The Kiev case study is indicative of a forward-thinking airport that is looking to meet regulative compliance, and is an example of where European policy is acting to guide airports outside of the European Union in their move towards reducing noise impact and exposure.

In terms of the motivations behind the interventions at each case study, six categories of motivation where identified, which may act as a useful structure for presenting information in the Best Practice Portal. These are summarised in Box 1.

Box 1: The motivations that drove the interventions studied in each airport case study.

- **Two-way dialogue.** Interventions implemented as a result of the airport listening to community suggestions for changes to operations. This is a pro-active approach, led by the communities, and acted upon by the airports.
- **Communities complaining.** Where interventions have been implemented due to local communities and groups complaining. This is an airport driven response to reduce complaints.
- **Predicted growth, not land use driven.** Changes made when the airport is not yet at capacity and the same number of runway/s can be used, without any footprint expansion.
- **Predicted growth, land use driven.** Changes made when the airport needs to expand capacity through extension of the existing runway or expansion through an additional runway, requiring footprint expansion of the aerodrome.
- **Reducing impacts.** The key driver for the intervention is a combination of the need to reduce noise, fuel, and emissions.
- **Strengthening Community engagement.** A situation where there is a need to strengthen the relationship with local communities, typically at new or fast-growing airports who want to avoid making mistakes or to simply to learn from experience of others.
- **Regulatory.** Airports that need to deal with new regulation implementation (e.g. END) or how regulatory frameworks can help in making sure some element of BA such as land use can be highly effective in reducing noise exposure and complaints.

Most of the case studies identified noise abatement as the primary reason for the intervention, whether the original motivation was airport growth, meeting community aspirations, or reducing complaints. In some instances, however, noise was not the primary driver behind the intervention. At Schiphol, the primary goal of the intervention was to reduce fuel burn on a departure route, with a reduction in noise identified as part of a win-win outcome. In this sense noise could almost be seen as an interdependency of a fuel reduction campaign. Similarly, in Helsinki, the primary objective was for airport growth but with the acknowledgement that mitigating noise impact would be an essential part of obtaining a licence to operate the desired changes. In all cases, no matter what the original driver, noise played a secondary role compared to the requirements for safe and logistically feasible airport operations.

5.2 Underpinning intervention processes.

As previously stated throughout this report, successfully implementing a noise abatement intervention is underpinned by five broad steps from identification through to post-implementation evaluation. Although airports were found to be, in effect, taking considered approaches throughout the process of implementation – for example via the use of stakeholder engagement, trials, modelling and monitoring, there was no evidence of any clear prescribed and systematic processes being used by any airport. Rather, ad hoc approaches were taken in each specific case. The variable nature of different Balanced Approach elements, or even between specific interventions, suggests that there may be some validity taking such an approach, however identifying core principles that underpin each implementation phase could have value for airports. This could for example take the form of a series of questions that airports should answer at each stage of the process to ensure the level of transparency and procedural fairness advocated in ANIMA Deliverable D2.4. For instance, for an operational procedure change this might look like the example below:

Identification of the need for an intervention:

- Do you have multi-stakeholder, and independently led stakeholder engagement forums (including community representatives) through which the requirement for an operational change could be communicated and discussed?
- Are all communities represented in such engagement activity, so that any re-distributive effectives on noise exposure can be systematically addressed and consensus built as to the most socially optimal outcome(s)?
- Are such stakeholders and community groups engaged with openly and transparently to establish trust? Is noise data made available on-line for those not able to attend such forums?
- Do stakeholders have the ability (via independent sources) to challenge noise and interdependency data at the request of members, i.e. to respond to a particular concern potentially through the generation of their own data?
- Is the stakeholder group driven by an agreed singular vision of what it is trying to achieve?
- Are there other avenues through which communities or other stakeholders can raise concerns with noise managers and/or make complaints?
- Are the concerns of those contacting an airport acknowledged? Are individuals provided with tailored responses relevant to their specific concern, rather than via template responses?

Design of options:

- Are all stakeholders given the possibility of designing their own solutions to the required change?
- Do stakeholders have the opportunity to work in collaboration with each other in identifying potential noise mitigation solutions?
- Are designs pre-informed by a set of criteria and objectives, for example by framing them within what is logistically feasible, safe, and regulatory compliant?

Selection of intervention option:

- Has modelling been carried out (ideally by an independent entity) to assess the impacts of the potential design options? Does this modelling include interdependencies?
- Are these results communicated to stakeholder forums for discussion?
- Have all stakeholders been included in the discussion, even if they appear to be removed from the designed option (to help identify unintended consequences and trade-offs between communities).?
- Have the reasons why some options may not be feasible been communicated effectively?
- Have the results of any modelling, analysis and discussions been effectively disseminated to the public so that there is a clear and transparent pathway that shows how the requirement for change was first raised, which options where considered, and why one in particular has been advocated.
- Have other complementary interventions been considered? For example, could an operational change be couple with a change in land-use planning to enhance the predicted benefits?
- Have trial been carried out to verify modelling outcomes, and to perform analysis on the impacts on communities and other stakeholders?
- Do communities understand and value the metrics and dissemination tools used? Do you need to consider a different approach to communication?

Implementation:

- Have all stakeholders been made aware of the intervention in advance?
- In order to demonstrate outcomes have you considered if you need to move noise monitoring terminals, purchase new terminals, or make use of mobile terminals?
- Is regular feedback of the progress of the implementation made available to stakeholders?

- Have contingency plans been designed should the new procedure change and you need to fall back to the previous procedure?
- Do you have plans for on-going evaluation of the procedure, and plans for regular dissemination?

Post-Evaluation:

- Have you committed to long term monitoring and evaluation and reporting to stakeholders?
- Do you communicate the procedure at engagement events?
- Do you have a long-term plan for the evaluation of the outcome of the intervention on non-acoustic factors, general acceptability of the decision and quality of life implications for local residents?

In terms of monitoring and modelling, it is important to speak to stakeholders early to identify what data is pertinent to them and where noise monitoring terminals should be located. Dialogue in this way can also help to identify how this data should be reported back to them, and via what metrics. Interdependencies should be considered in the modelling and monitoring process, and this data made available to stakeholders. All modelled data should be ratified through trials to ascertain their validity, but also to identify unintended consequences i.e. for safety. The length of trials can differ depending on the specific case, but should be of sufficient duration to capture enough data to cover all possible operating conditions (i.e. a year-long trial may be required to capture seasonal differences in weather and aircraft movements).

5.3 The role of communication and engagement

What is clear from the questions posed in the above example process, is that communication and engagement runs throughout all parts of the process.

Constant two-way dialogue between all stakeholders (particularly communities) for example is an important element throughout the entire implementation process, seeing as it helps to identify the wants and needs of local citizens, what information might be most appropriate for them (and thus what data needs to be collected) and the impacts of a given intervention can be best assessed. The use of independently-led dialogue and community forums is likely to help with fostering trust.

It seems essential that airports have fully integrated communication and engagement in the delivery of a Balanced Approach intervention from the identification of the need for a change, through to Post-Implementation evaluation. **Although none of the airports studied here went as far as considering impacts on quality of life and annoyance in their evaluations, the literature studied in D2.4 suggests that this is indeed best practice.** For effective noise management, communications and engagement appear to be integral and should be therefore more fully integrated into the ICAO Balanced Approach. **Rather than being considered as an ancillary measure, or even a 5th pillar, communication and engagement should run across, and be fully integrated into all existing Balanced Approach interventions, and through all the processes that underpin the implementation of a given intervention.** In so doing airports will be able to optimise the how interventions are implemented, build trust, avoid mistakes (that can break trust), and to better ensure that there is integration across this different balanced approach elements, as illustrated in Figure 1 below.

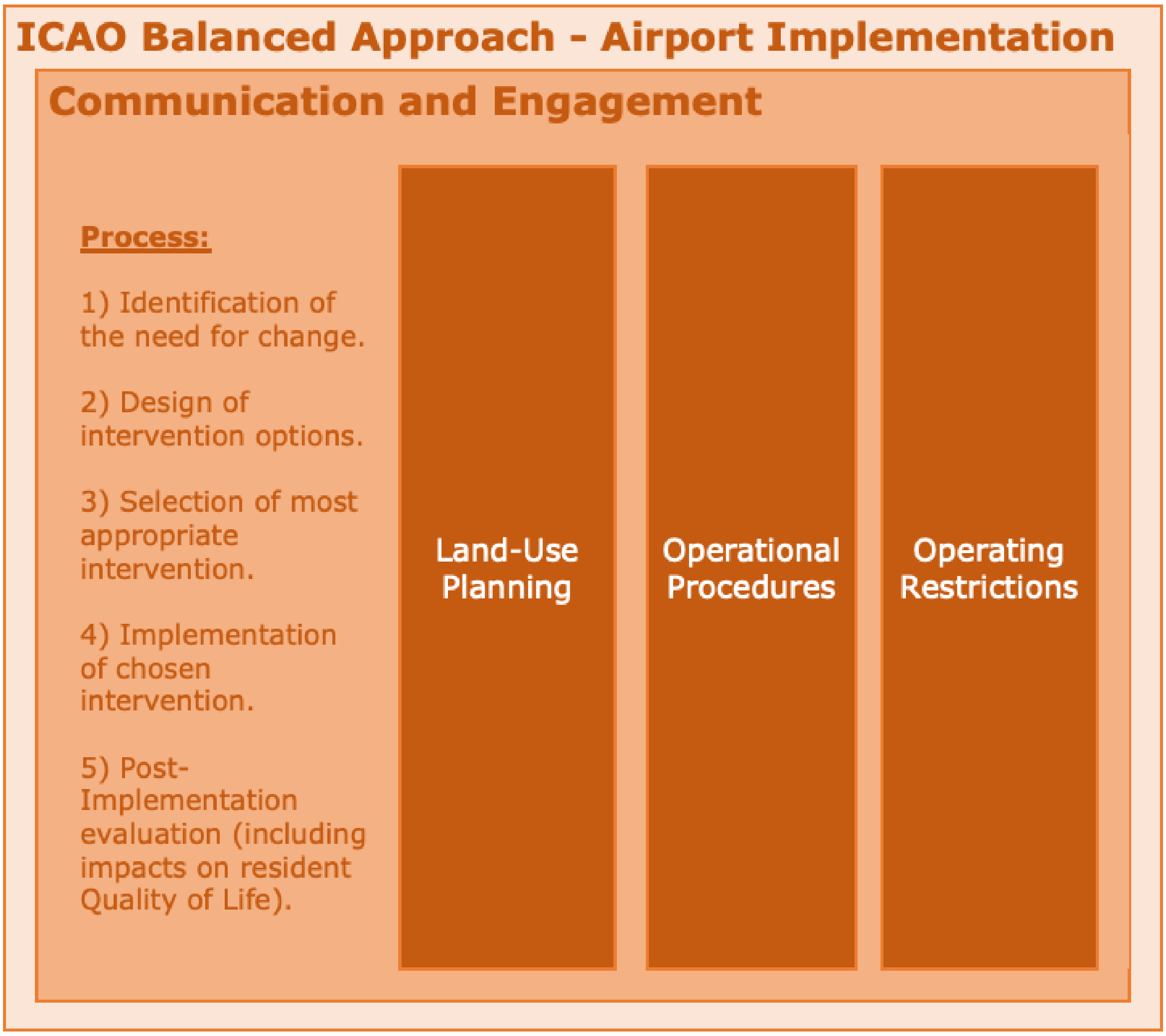

Figure 1: illustrating the role of communication and engagement in the effective implementation of Balanced Approach interventions.[9]

As well as spanning across the process of Balanced Approach implementation, it is also essential that such communications address the full range of stakeholders who have the potential to impact the production of, or to be impacted by, aviation noise. Engaging with communities ensures that their specific concerns

[9] Reduction of noise at source has been excluded from this diagram to reflect the fact that this is difficult for airports to influence other than indirect measures such as noise charges.

can be responded to – and importantly to be understood. By understanding these concerns, the requirements for dissemination can be determined. For instance, one community may be concerned with the number of over flights per day, whilst another may only be interested in the number of departures of a given aircraft per day. This was demonstrated by Heathrow and Vienna airports, both of which implemented their case study interventions in response to community requests, and took the effort to communicate effectively with their stakeholders, by providing a breadth of data. In the case of Heathrow, the changes to the departure profile were communicated through detailed reports relevant to that specific flight path, and at community noise events. At Vienna, the role of AustroControl as an independent member of the Dialogue Forum meant that citizen concerns could be listened to, responded to and relevant data provided. This included some bespoke monitoring of noise from aircraft flying the new curved approach. Both of these airports also demonstrated engagement with industry stakeholders to find out what was technically and operational feasible in terms of the interventions, to ensure that commitments made to communities could be achieved. In the case of Heathrow, it meant that the specific calls by the community for a 6% departure gradient could not be achieved on the grounds of safety – as subsequently communicated by the airport. This differs from the case of Helsinki where promises were made to the community that could not be fulfilled, leading to a great distrust in the airport. The importance of fulfilling commitments is perhaps best summarised by a statement from the representative of AustroControl during the interview process "Once you have lost trust, it is almost impossible to win it back".

5.4 Land Use Planning

Land use planning across the different case studies has highlighted as being highly important, with significant implications for the community perception of noise, and for community engagement. For those airports where land use planning was the key implementation element, it was demonstrated that there is a lack of national legislation that can empower airports to have a role in the land use planning decision process. Two case studies, namely Kiev and Catania airports, provided very good examples of best practices of land use planning, in particular how the national legislation helps that process and ensures that zones surrounding the airports are subjected to as little as possible uncontrolled or business driven development. Both case studies have drawn the attention at the key role on collaboration and communication between airport and related local authorities. In so doing the needs of each party can be understood, and the long-term implications of developments of noise sensitive buildings close to airports can be disseminated to regional decision makers. Thereby the long-term health and economic future of the region can be safeguarded – the airport is better able to grow, whilst the health impacts of living near an airport can be mitigated. How best to establish appropriate and novel land-use planning techniques around airports should be an area for increased attention by the research community. This is particularly the case for small but rapidly growing airports that have the opportunity to stop local developments near an airport before they occur. For airport suffering from encouragement by noise sensitive developments, such as Heathrow, the challenge is distinctly different and requires its own unique solutions.

5.5 Rapidly growing airports should consider Balanced Approach to avoid future restrictions

By considering the adoption of Balanced Approach interventions before noise becomes a constraint (i.e. via complaints and objections to developments) airports will be better placed to manage their future. When being reactive to such pressures, such airports will be forced to act quickly, potentially at higher cost, and potentially with the issue taken out of their hands (i.e. by national policy makers), leading to sub-optimal outcomes. Through being pro-active and developing long-term noise management strategies, these rapidly growing airports will be able to better control their on-going development on their own terms and help to shape future policy rather than being at the behest of policy decisions made by others. Land-Use Planning is perhaps the best way through which this can be done. For instance, if rapidly growing airports are able to develop long-term noise maps based on future growth, they will be able to stop the encroachment of noise sensitive buildings such as public residences, thus leading to fewer complaints in the longer term.

5.6 Integration of Balanced Approach Elements

The case studies showed little consideration of interventions across the different Balanced Approach elements. They are typically considered in isolation; however a more cohesive approach may be able to find more optimal solutions. For instance, operational changes to flight paths, coupled with effective land-use planning could have significant benefits for noise management and the numbers of people exposed to noise, and the impact thereof. As above, this may be more difficult when airports have already been encroached by noise sensitive developments, but for more rural and rapidly growing airports the potential could be significant.

5.7 Interdependencies

Analysis of the case studies shows that interdependencies were only considered in a small number of cases, and usually only as an ancillary factor to noise. The primary exception is Amsterdam Schiphol where fuel reduction was the primary motivator for the studied intervention – with reductions in noise also achieved. Although this represents a win-win situation, one could argue that in this specific case, noise was the interdependency to fuel reductions. In general, larger airports considered interdependencies compared to smaller airports. Interviews supported those carried out in Task 2.1 of ANIMA where the general opinion of local communities is that noise is by some distance the most important issue. Air quality has some importance, and Greenhouse Gas Emissions associated with climate change are the least important factor. For those living further away from the airport, climate change rises in importance. Pressure for fuel savings typically comes from industry stakeholders such as airlines.

None of the studied airports demonstrated a comprehensive collection of data associated with interdependencies in the specific case studies, however many do publicly report on interdependencies. Heathrow Airport for example publishes a significant amount of air quality data on-line[10]. No metrics were mentioned in the case studies other than fuel burn.

5.8 Modelling tools and metrics

This section focuses on the tools used to model the potential consequences of the noise reduction interventions and the range and effectiveness of metrics and tools used to communicate potential deployment scenarios to key stakeholders.

The case studies presented in this Deliverable relate to specific airport Balanced Approach (BA) interventions, aiming to provide insights into the tools to generate as well as the purpose and nature of noise information provision to support the design, decision-making, implementation and evaluation of measures designed to reduce noise exposure.

The case studies demonstrated a range of purposes for which noise information was prepared and disseminated by the case study airports:

- Communicating aircraft noise issues to different stakeholder groups.
- Setting criteria and targets for regulatory purposes (and monitoring compliance).
- Comparing alternative what-if scenarios (i.e. between one intervention and another).

Setting criteria and targets for regulatory purposes was conducted in the Frankfurt case study where examples are provided of how acoustic metrics have informed a complex set of operating restrictions and compensation plans designed to manage the impact of airport expansion. Similarly, the Barcelona case study highlights the challenges of managing the impact of airport expansion, whilst the Catania case study used aggregate metrics generated by a mix of models and monitoring tools to justify zoning for land-use planning and compensation.

Comparing alternative what-if scenarios was a common purpose for noise data collection and dissemination. At Helsinki for example data was used to ascertain the impacts of different operating procedures (alternative departure procedures). At Arlanda data was used to investigate the impacts of

[10] http://www.heathrowairwatch.org.uk/data/

implementing steeper arrival glide slopes). In Vienna and Schiphol, a curved approach and amendments to NADPs used investigated respectively.

The Heathrow and Vienna cases represent cases where data was not only used to investigate the potential impacts of different operating procedures, but also to drive significant community engagement with local community action groups, thus leading to better citizen engagement.

Tools for Noise Management

From the review of existing literature and the case studies identified and studied in this task, a set of tools have been identified according to four main categories namely Noise Modelling/ Mapping, Noise Monitoring/Management, Noise Forums and Noise Publications. Starting from trajectory visualisation tools and continuing with online real time depictions of noise contours, there is a great variety of tools used by different airports that bring an important contribution to the application of ICAO Balanced Approach principles. Table 2 summarises the different tools encountered during state of art research and fieldwork for the development of case studies, followed by a description of some. Annex 8.14 provides additional information for each of the tools listed.

Table 2: Noise tools used by Airport and case studies

Category of Tools	Tool	Reference to Case Studies
Noise Modelling/ Mapping	BaseOPS software pack (including NoiseMap suite)	*(Cluj Airport Case Study, Iasi Airport Case Study)*
	IMMI	-
	IsoBella Model	*(Boryspil Airport Case Study)*
	Predictor-LimA	-
	SoundPLAN	-
Noise Monitoring/Management	ANOMS	*(Heathrow Airport Case Study)*
	CadnaA	*(Iasi Airport Case Study)*
	NoiseDesk	-
	Virtual Community Noise Simulator (VCNS)	*(Stockholm Arlanda Airport Case Study)*
	WebTrak	*(Barcelona Airport Case Study, Heathrow Airport Case Study)*
	WebTrak	*(Heathrow Airport*

	MyNeighbourhood	Case Study)
	xPlane	(Heathrow Airport Case Study)
Noise Forums	Airport and Region Forum (Forum Flughafel und Region, FFR)	(Frankfurt Airport Case Study)
	Heathrow Community Noise Forum (HCNF)	(Heathrow Airport Case Study)
	Vienna Dialogue Forum	(Vienna Airport Case Study)
Noise Publications	A Quieter Heathrow	(Heathrow Airport Case Study)
	Heathrow 2.0	(Heathrow Airport Case Study)
	Noise Management Plan (NMP)	(Stockholm Arlanda Airport Case Study)
	Noise Exposure Plan (PEB)	(ACNUSA Case Study)
	Noise Disturbance Plan (PGS)	(ACNUSA Case Study)
	Sustainability Reports	(Ljubljana Airport Case Study)
	Teddington Community Noise Information Report	(Heathrow Airport Case Study)

Metrics for Noise Management

Considering the wide range of case studies investigated in this Deliverable, it is understandable that a breadth of noise indicators where used to describe noise to different stakeholder groups. Table 3 presents a summary of the types of noise data provided. In the case of Heathrow, the airport objective was to respond to concerns about lower and noisier aircraft on a particular departure route over a specific community. The use of flight track vertical profiles and gate analysis presented extensively in a public report demonstrated that all departures were compliant with the original 4 degree climb-out trajectory, however a very small number of aircraft (0.72%) failed to achieve a 5 degree trajectory. However, those that did fail were usually A380s, which being the largest aircraft operating at Heathrow, appear to have had a disproportionate impact on perceptions. Thus, the airport set a new minimum trajectory of 5 degrees and has been able to monitor performance against this using the same illustrate operational data. Interim results show an improvement in compliance with the new 5 degrees threshold with only 0.52% of aircraft departures failing to achieve the performance standard.

Table 3: Noise information matrix – airport case study use of different noise indicators by type

Airport Case Study	**Operational Indicators**			**Acoustic Metrics**		
	Lists of operations	Cross-sectional charts	Flight tracks	Single Event (at defined receiver points)	Time Averaged (at defined receiver points)	Spatial Averaging and Aggregation
ACNUSA	On request	On request	On-line flight track visualisation tools	LAmax – Number above event profiles over time periods and by aircraft groups	Laeq, Lden, Lday, evening, night. For arrival, departures and total movements	Lden contours for noise exposure plan
Arlanda	None listed	None Listed	None listed	None listed	Lden/Lnight	Lden noise contour maps
Barcelona	Per use of each runway and overall number of movements	Only on request	Number of infringements per track under 6000 ft	Lmax events from noise monitoring stations in 5dB bands for town councils	Lday, evening, night. Plus averaged indicators for monitoring stations	Lday, evening, night noise contours
Catania	% movements by different aircraft on different flight tracks	None listed	Flight tracks	None listed	Lden /Lnight	Lden and Lnight contours
Cluj	Lists of operations	NADP1 and NADP2 published information (AIP)	Flight paths and online tools (e.g. flightradar24)	$L_{E,A}$ sound exposure level; $L_{p,AS,max}$ or $L_{p,A,eq,1s,max}$ maximum sound pressure levels	Lden / Lnight	Lden and Lnight contours
Frankfurt	On request	On request	On-line flight track visualisation tools Environmental/neighbourhood Agency: INAA,	Continuous SPL, $L_{Amax\ events}$ from noise monitoring stations	Measured data for every : $Leq_{Aircraft}$,Leq_{total}, $L_{DEN\ Aircraft}$,	Contour maps calculation Leq_{Day}, Leq_{Day}, $Leq_{Night50}$+6x68

			FRAPORT: FRANOM German Air Traffic Control: Stanley track		L_{DEN} total, L_{DEN}, Maximum level distribution, L_{night}	
Heathrow	% movements by operational mode Proportion of departing aircraft by type	Deviation from centre of gate chart	For particular departure routes	Single event noise profile	Leq for specific location	LAeq dB noise contours
Helsinki	On request	None listed	Departure profile comparisons to show NADP1 and NADP2 altitudes on climb	LAmax used to identify changes to the routes	None listed	None listed
Iasi	Lists of operations	NADP1 and NADP2 published information (AIP)	Flight paths and online tools (e.g. flightradar24)	$L_{E,A}$ sound exposure level; $L_{p,AS,max}$ or $L_{p,A,eq,1s,max}$ maximum sound pressure levels	Lden / Lnight	Lden and Lnight contours
Kiev	None listed	None listed	None listed	LAmax	LAeq day, evening and night	LAeq day, evening and night contours
Ljubljana	None listed	None listed	None listed	EPNL for loudest aircraft	Lday, Levening, Lnight and Lden	Lden and Lnight contours
Schiphol	Lists of trial and reference flights	NAPD 1 and 2 profiles compared	Flight paths highlighting runway usage	Lmax used to record measurements from monitoring stations	Lden	Grid analysis of contours
Vienna	Flugspuren.at has specific data relating to all routes from all runways at	Flight profiles	Full information of flight tracks provided on flugspuren.at	LAmax profiles	Leq	N65 contours (As per mediation contract).

	any point in time.					

6. Conclusions and Further Work

6.1 Conclusions

The case studies carried out in this Deliverable illustrate a wide range of different practices and procedures regarding the implementation of different Balanced Approach interventions at 13 European Airports.

These case studies demonstrate the significant efforts that the aviation industry is going to in order to help mitigate its noise impact. Efforts span the entire range of Balanced Approach elements, and there is evidence of a maturing landscape in which airports are acting based on well thought out – if not systematic, processes, driven by rich stakeholder communication and engagement. The shift towards a pro-active approach to pre-emptively ensure that noise impact is reduced, rather than reactive responses once people have already been exposed to noise is becoming a more common problem. This is the case across the full range of airports studied, from pathfinders, to those starting the journey. The later in particular are beginning to recognise, **partly through engagement with the ANIMA research project** and as a response to European legislation, that developing an appropriate noise management strategy early on is more effective than when complaints have started to arise. This is clearly demonstrated by the cases of small but rapidly growing airports, which demonstrate a desire to mitigate noise impact through effective land-use planning, operational improvement and operating restrictions. How such airports can further develop their approaches, and move towards best practice is an important area of future research. Unlike large airports that have had to develop noise management strategies at the same time as best practice and management theory has emerged, these airports have the potential to scope unique approaches, tailored to their specific circumstances. In this sense, these airports have the potential to act as the best practice airports of the future – representing a showcase of how airports can evolve with optimal noise management systems and processes in place. The research community and wider aviation industry should be acting to provide guidance to such airports to help them achieve this objective.

A trend that is clear from the case studies is that stakeholder communication and engagement is more evident at larger airports. How this situation evolved is perhaps understandable – large airports already have active and vocal community groups, whilst at smaller airports noise-based opposition is less common. What is clear is that effective communication underpins Balanced Approach best practice. This is highlighted in the cases of Heathrow and Vienna where airports operate extensive communication and engagement programmes, but also at Stockholm Arlanda. Here the airport had issues with the community as a result of promising something that they ultimately could not deliver (poor industry stakeholder communication), but have taken extensive steps to try to rectify the situation through community engagement, and via the novel use of a virtual reality headset. **It was observed that even in the best-case examples, there is a lack of consideration of non-acoustic factors and impact on the wider quality of life of local residents.** Considering the importance of these issues as raised in Deliverable 2.4, this can be considered an important area of future research. Deliverable 3.3 also highlighted the relevance of Arnstein's Ladder of Participation (see Figure 2Figure 1) in identifying effective community engagement, however few of the case airports were found to be engaging at the higher levels of this ladder. Whether this is feasible in this sector, and how it can be achieved should be an area of future focus.

8	Citizen Control	Citizen Power
7	Delegated Power	
6	Partnership	
5	Consulting	Tokenism
4	Informing	
3	Placation	
2	Therapy	Non-participation
1	Manipulation	

Figure 2: Arnsetin's (1969) Ladder of Participation

Following the research conducted in ST2.3.1, a pertinent question would be: *is the BA the right tool for airports?*

ANIMA researchers, being concerned with noise impact and community engagement, have demonstrated that the topics illustrated below are not well covered by BA:

- Complaints management
- Community relations
- Communications strategy
- Community Outreach initiatives

As a result, implementing BA can lead to sub-optimal outcomes as communities do not understand the rationale behind specific interventions and how they will be affected (whether positively or negatively). This in turn can reduce the acceptance of the changes, potentially leading to complaints and confrontation with residents who do not value the efforts being made to reduce noise impact.

Consequently, the Task 2.5 Airport Exemplification Case Studies will need to explore further the gaps in implementing Balanced Approach at the European airports.

6.2 Further work

The development of comprehensive case studies on various airports, together with active engagement with relevant stakeholders and interested parties during fieldwork concluded that research is still needed on such a sensitive topic as noise, due to its multidisciplinarity. As ICAO Balanced Approach offers guidance for any type of airport, many improvements on currently available tools are needed in this area by all airports, irrespective of their number of movements, i.e. over or below 50,000 movements per year (according to the requirements for Environmental Noise Directive compliance).

When dealing with such a wide range of relevant stakeholders, a common approach for both expert and non-expert representatives is required. From improving the quality of processed data from noise measurement systems to the development of a noise management tool to a support for noise decision-making, which includes the working principles of the coordination bodies (i.e. relevant noise stakeholders), several support tools are yet to be developed to respond to all needs and requirements of all partners (communities, industry, policy-makers etc.).

Despite the variety of the tools identified and described here, either extracted from case studies or from state-of-the-art research, there appears to be an **absence of a comprehensive toolset** addressing the different types of stakeholders. Most tools can be operated or can produce information for a specific category of stakeholders, i.e. either expert or non-expert and the integration of many to respond to all requirements could result in higher costs for airports. Insights into the opportunities that could increase the efficiency of communication and understanding of noise come from various other tool options, including Social Media (e.g. Heathrow Airport, Helsinki Airport), where the communities are particularly active on this issue. Even so, the lack of sufficient information on such initiatives inhibits full evaluation of the potential challenges that could arise from trying to establish and maintain a trustful and efficient collaborative environment through the use of such tools. That is why ANIMA will develop from the conclusions of this Deliverable a portal for informing on Best Practices and on how to implement them (T2.5).

In-depth research for the development of the case studies concluded that many airports put a lot of effort in trying to use many of the aforementioned tools in order to be able to communicate in an adequate and transparent manner with all relevant stakeholder and facilitate efficient collaboration, yet a more extensive tool to support discovering and understanding of opportunities for noise impact mitigation through collaboration between all relevant stakeholders, based on common understanding, is still needed.

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8. Annexes:

8.1 Case Study 1 - Schiphol Airport

Introduction to the airport

Amsterdam Schiphol Airport is the main international airport of the Netherlands and located 9 kilometres southwest of Amsterdam. With 71 million passengers in 2018 travelled from, to or via Amsterdam Airport Schiphol it is the third busiest airport of Europe in terms of passenger volume. There are 326 direct destinations reachable from Schiphol, resulting in 499.446 air transport movements. The air transport movements consist of 36.9% transfer passengers and 1.7 million tonnes of cargo are transported [2]. Schiphol Airport ranks as the world's fifth busiest airport in terms of international passenger traffic and the world's sixteenth busiest for cargo tonnage. The Schiphol Airport passengers increased by 4% in 2018 as a result of an increased number of aircraft movements. The economic impact in 2016 was estimated $27.3 billion US dollar. The terminal infrastructure consists of one-terminal concept that includes three large departure halls serving local airlines and as a European hub. Schiphol Airport has six runways, covering a total area of 2.79 ha land. The runway use at Schiphol Airport is shown in figure 1. The red coloured flight tracks indicate departures while the blue coloured flight tracks indicate take-offs. Schiphol is mainly approached from the North Sea and Flevoland, which is an artificial, low populated island.

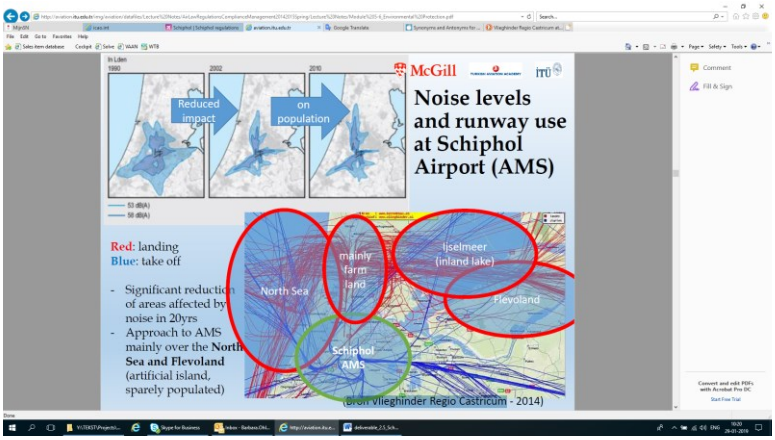

Figure 1.1: Runway use at Schiphol Airport indicating flight tracks for departures (red color) and landings (blue color).

The applicable noise regulations include regulations and limitations about handling the air traffic and noise regulations that relate to the "maximum amount of noise". The limitations of the runway system are stated in the Dutch airport traffic order [9]. Anoverview of all runways is shown Figure 1.2. The current noise regulations at Schiphol work on the basis of enforcement points such as the 24-hour period and the night period. A maximum Lden or Lnight value applies to each of these points.

Approach to the Balanced Approach

In the Aeronautical Information Publication (AIP) Netherlands are details of regulations, procedures and other information pertinent to flying aircraft described [10]. Currently applied noise and emissions restrictions at Amsterdam Schiphol Airport (AMS) are included in EHAM AD 2.21 under noise abatement procedures. The AIP Netherlands includes departure and arrival procedures that have proved to be highly efficient in respect of noise abatement in the vicinity of Schiphol Airport. Deviations from the procedures are permitted for safety reasons. The noise *abatement procedures* are included in the below table.

Noise abatement procedures applied in the vicinity of Schiphol

Procedure	Explanation
Take-off and climb procedure	National abatement take-off and climb procedure NADP2 recommended for all jet aircrafts departures. If for operational reasons compliance with the recommended procedure is not possible, NADP1 may be used.
Minimum noise routing	Standard instrument departure routes aiming avoid residential areas as much as possible.
Reduced flaps	Reduced flaps landing procedure is recommanded
ILS available	Minimum flaps setting with landing gear retracted
Non precision approach and visual approach	Following descent path using a minimum flap setting with landing gear retracted not lower than 5.2% (3.0 degrees), selecting gear down after passing 2000 ft AMSL and postponing minimum certified landing flap setting until passing 1200 ft AMSL.
Use of runways	a) As landing runway: 06, 18R, 36R, 18C, 36C, 27. b) As departure runway: 36L, 24, 36C, 18L, 18C, 09

Further noise restrictions include engine run-up, controlled APU (ground power units), operating quota in effect and a preferential runway system [10]. The runways at Schiphol Airport are selected by the Air Traffic Control (ATC) according to a preferential runway system. Principles accounted for in the runway system are prevailed traffic safety, departure and landing take place on separate runways, the influence of noise influence and traffic handling, wind and visibility criteria which are in accordance with the guidance material laid down in Annex 16-ICAO (Aircraft noise). The basic rule for the use of a runway combination is that Dutch ATC must handle the most preferred combination of available and usable runways from the runway preference table [10]. During the day basically all runways may be used depending on weather and safety conditions (see Figure 1.2). The primarily preferred runway during daytime is the Polderbaan (36L, 18R). In case of capacity restrictions the second preferred runway during daytime, the Kaagbaan (06, 24) or the Aalsmeerbaan (36R, 18L) are used. During the night time between 23:00 and 06:00 CET the Kaagbaan (06), the Polderbaan (18R) and the Zwanenburgbaan (36C) may be used for landings. For starts are the Polderbaan (36L), the Kaagbaan (24) and the Zwaanenburgbaan (18C) allowed.

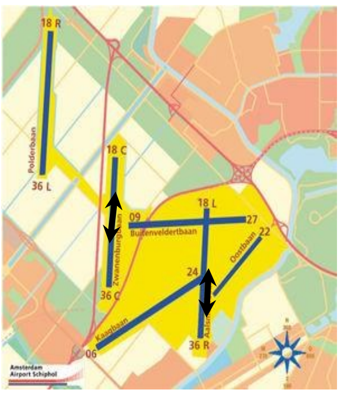

Figure 1.2: Runways at Schiphol Airport

Noise mitigation strategies and land-use planning have been applied in terms of sound insulation of residential and public buildings or by destructing houses and buildings.

1. **Introduction to the case study optimization of start procedures**

Noise abatement operational procedures are applied to provide noise relief to communities around airports from both arriving and departing aircraft. Two specific noise abatement departure procedures (NADP's) were developed to mitigate air traffic noise. The NADP-1 departure procedure is most effective in confining the noise impact within a small area around the airport [1]. NADP-2 has a distant cross-over point to become quieter than NADP-1 and is most effective to reduce fuel consumption.
The differences between NADP1 and NADP2 with respect to the ground and flight speed and the lateral noise exposure is illustrated in Figure 1.3. The noise exposure is shorter due to a higher ground speed when NADP2 is used compared to NADP1 (see point 1 in Figure 1.2). For the NADP2 departure procedure the flight altitude is lower, which results in a reduction of the lateral noise exposure (see point 2 in Figure 1.3).

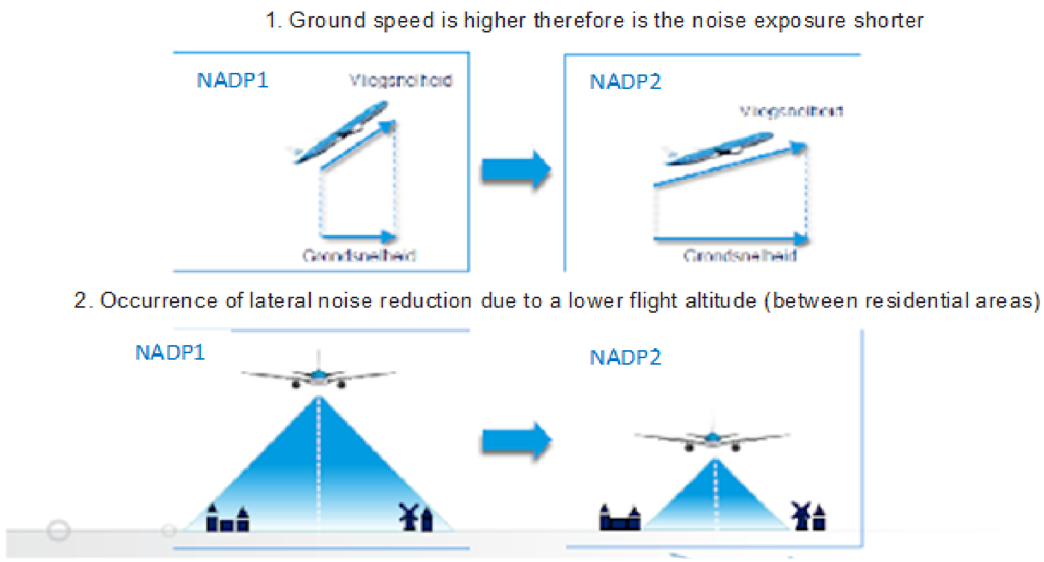

Figure 1.3: Comparison of the ground speed and the lateral noise exposure between NADP1 and NADP2. The NADP2 departure procedure leads to a reduction in noise exposure due to a shorter fly over event and a smaller lateral area of exposure, compared to NADP1.

The NADP describes the procedure in which the aircraft transits from the high take-off power having extended flaps and slats settings towards a climb phase using climb power and all flaps and slats retracted [5,6]. Overall, the thrust cutback is performed similarly between NADP1 and NADP2. The main difference is that the altitude at which the aircraft starts accelerating is reduced from 3000 ft (NADP1) to 1500 ft (NADP2) (see Figure 3). In other words, the noise abatement departure procedure included a choice between thrust cutback altitude and acceleration altitude.

For the NADP1, the application of thrust cutback is done before the flaps and slats retraction. The climb thrust is selected at reaching 1500 ft altitude. At 3000 ft, the pitch angle is reduced such that the aircraft will climb and accelerate simultaneously. The flaps

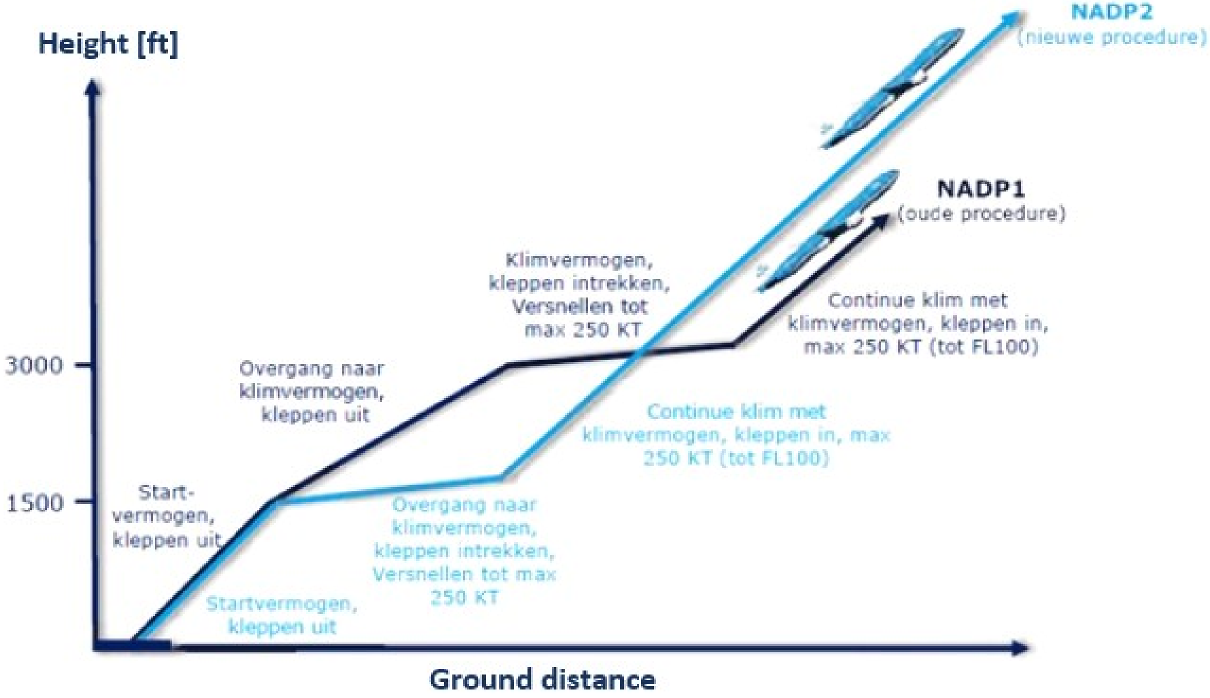

Figure 1.4: Illustration of the climb heights between NADP1 and NADP2. The NADP2 procedure starts with a steeper climb where the acceleration required for flaps and slats retraction starts at 1500 ft.

Delve into the processes behind the case

a. Identification of the 'need'.
Reducing the amount of fuel used during a flight has a direct beneficial impact on the airline. Financial benefits can be achieved related to fuel costs and related to the EU Emission Trading Scheme (ETS). Fuel reduction has additionally a positive impact on the climate. Applying the NADP2 departure procedure was expected to save approximately 20-60 kg of fuel per departure [7]. Along with fuel reduction the number of highly-annoyed people was expected to reduce.

b. The design of options.
There was no knowledge of another approach that would result in comparable benefits.

c. The selection of the intervention.
Operations based results, meaning fuel savings, were used for decision making. The effect within the noise contours was beneficial too. Hence, both were overall positive and therefore the decision was to recommend this procedure to all airlines. The noise effects were assessed based on the legal criteria for Lden and the locally established dose response relationship. Adopting the departure procedures from NADP1 to NADP2 was for Schiphol more a change in an operational procedure than a decision. That is the reason why the communities were informed ahead of time before the departure procedures were changed but they were not directly involved in the decision making process.

d. Implementation
First calculations were carried out to estimate possible fuel saving and noise benefits. The noise related calculations were based on models using the so called "Grid analysis". This analysis takes the number of houses within noise contours, highly annoyed people and

people with sleep disturbance into account. The calculations were based on different traffic scenarios including only ArceFly flights or the full aircraft fleet at Schiphol Airport.
Flight simulator sessions were carried out to validate the calculated fuel savings and noise benefits. The calculations could be confirmed by the flight simulator sessions. Experiments with actual flight procedures were carried out during a three month trial using live traffic observations. The data collection included in-flight data, flight information such as flight tracks and flight plans and noise measurements via the NOMOS monitoring stations.
Actual noise and fuel measurements were carried out to test whether the assumption based on calculations and simulations were true. Finally, the usage of the NADP2 departure procedure was expanded and applied for other airlines. Currently, 80% of all departures at Schiphol use the NADP2 procedure.

e. Post-Implementation evaluation.
The essence of the optimization was defined by improving the overall noise conditions for the area. This means that fuel consumption and noise exposure were used as performance indicators for the overall outcome. Schiphol Airport is also legally bound to look at the overall noise contours. Not applying such an operational procedure could actually be problematic as it stops or limits innovation within the flight sector. Changing the departure procedure from NADP1 to NADP2 is beneficial for the climate, for the airlines and for the overall noise exposure. It comes, however, at the expense of those who live directly underneath the path where the differences are noticeable.

f. The use of metrics, trials, modelling, monitoring, interdependencies etc. will be discussed throughout these sub-sections.
Experiment with actual flight procedures
Several factors were analyzed to test the calculated fuel consumption and noise levels. Those factors are summed up in the below Table.

Overview of test conditions for measuring fuel consumption and noise levels on actual flight procedures

	Procedure	Operator	Period
Experimental	NADP2	ArceFly, KLM	3 weeks
Reference	NADP1	Other airlines	Real life

Actual noise and fuel consumption measurements
The noise monitoring system (NOMOS) of the Amsterdam Airport Schiphol was used to determine real, measured sound levels of the alternative NADP2 departure procedure. NOMOS consists of a network with more than 25 noise monitoring terminals located in residential areas around Schiphol Airport [8]. Not all 25 measurement terminals were required. The tested runway and route combination together with the relevant NOMOS measurement stations are shown in Figure 1.5.

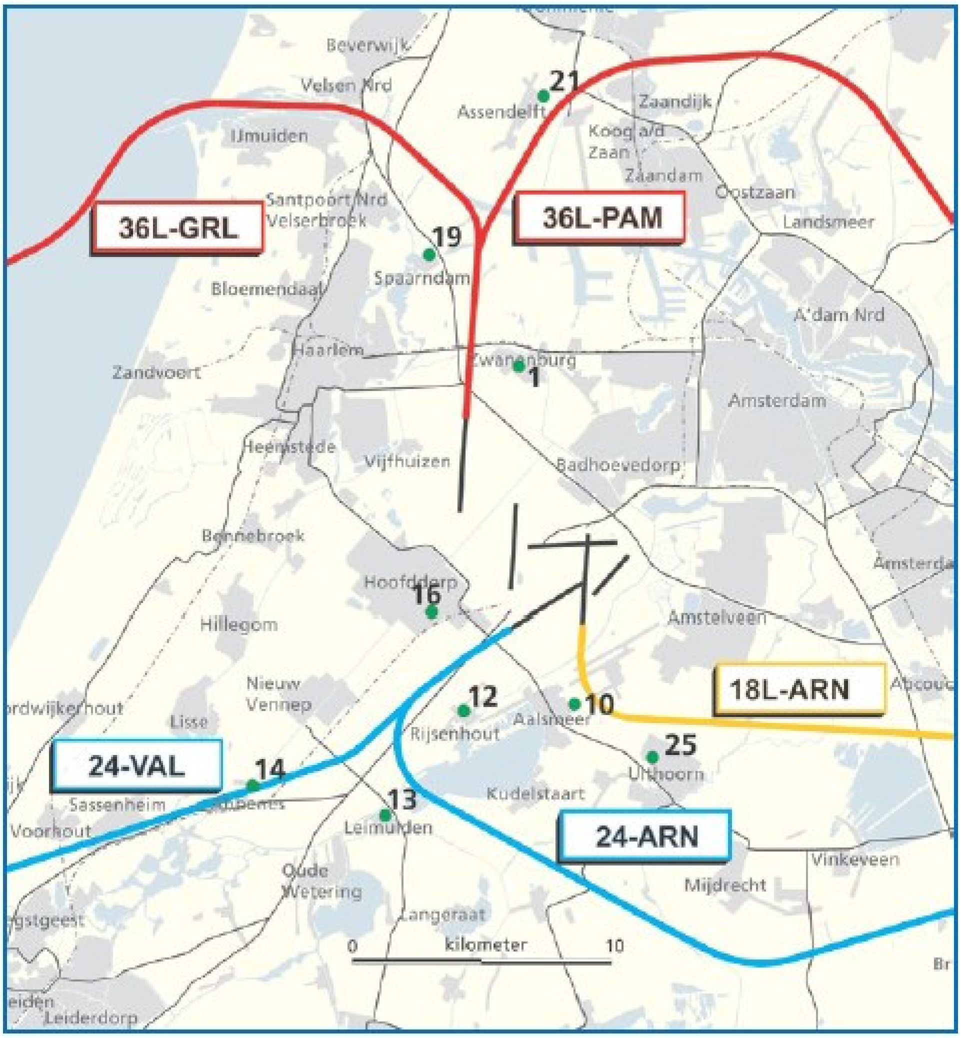

Figure 1.5: Schematic setup of the experimental comparison between reference and control aircraft groups.

In practice is it very difficult to test two departure procedures under the exact same conditions. An experiment was carried out to determine the isolated effect of the NADP2 departure procedure. A number of pairwise comparisons of acoustic measurements between an experimental group of airplanes and multiple test groups were applied (see Figure 5).

- The experimental group of airplanes consisted of flights carried out by the experimental operator (ArceFly or KLM) using the NADP2 procedure. Acoustic and fuel consumption measurements were only carried out during the experimental period.
- The first control group (*Control group 1)* consists of flights carried out by different operators that are usually flying in daily life. This is the only difference between the experimental group and the first control group. All other conditions, including the same aircraft type, the same engine type, the same ICAO type designation and the same runway combination were consistent.
- The second control group (*Control group 2)* included flights that by different operators that are usually flying in daily life. The NADP1 departure procedure was tested during the experimental period of 3 weeks.
- The third control group (*Control group 3)* covered flight conducted by the experimental operator during daily life using NADP1 departures.

The likelihood of any difference in noise levels between the experimental group and the control groups was tested using hypothesis testing. The scheme of the experimental design is shown in Figure 1.6. The relevant comparisons between the experimental and the control group are indicated by green and yellow arrows.

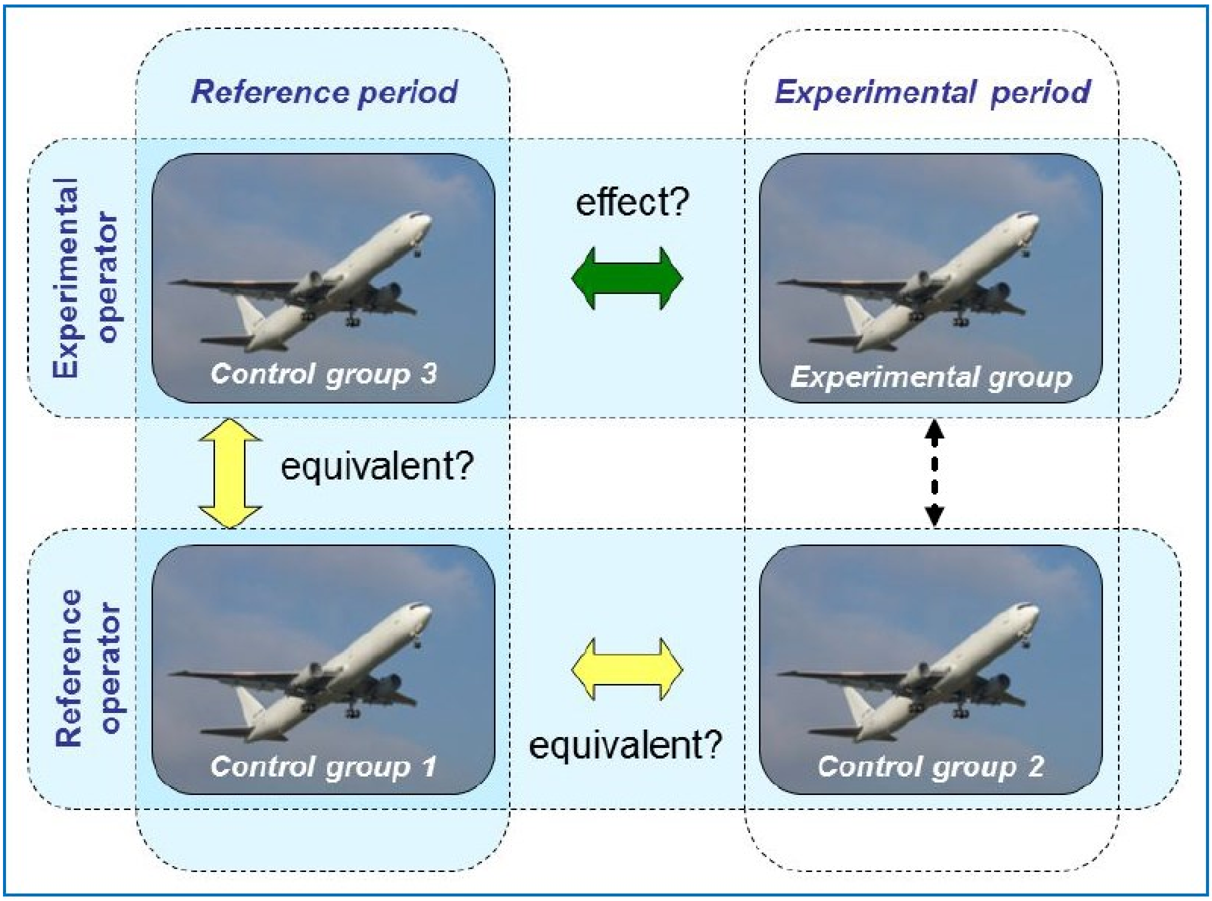

Figure 1.6: Schematic presentation of the experimental design. The measurements from the experimental group were compared with three control groups.

The influence of external and airline dependent disturbances in the acoustic measurements can not be completely determined. The applied pairwise comparisons can provide a qualitative judgment about the likelihood of the effects of the alternative NADP2 departure procedure. However, the influence from external and airline dependent factors cannot completely be eliminated. To minimize the bias qualification levels such as, likely impact, probable effect, possible effect and non significant effect was applied.

<u>Interdependencies</u>
In terms of operational procedures the priority was fuel consumption. If changing the departure procedure would have been framed as noise mitigation measure the whole project would have been treated differently and we would have been less independent. The question is at what point is it smart and necessary to involve the local community? Are interdependencies really a matter that the local communities should decide about? It is due to the high amount of critics very important to be careful about how a message is presented and who it is presented to. Schiphol Airport tries to balance everybody's interests in the best possible way, which also applies to for this project.

<u>Summary (of the whole airport case)</u>
The benefits assessments for NADP's procedures are complex and may require detailed modelling in order to be well understood. The results confirmed the expected fuel reduction for the NADP2 procedure. The measured noise levels in residential areas show

positive effects. Based on the dose-response relationship, the number of highly annoyed people living in the vicinity of Schiphol Airport decreased. However, drawing an overall conclusion with respect to air traffic noise is complex. The benefit for the community depends on the location of the residential area.

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8.2 Case Study 2 - London Heathrow

Introduction to the airport

In 2017 London Heathrow Airport (LHR) served just under 476,000 annual aircraft movements, carrying approximately 78m passengers. Located 21km west of central London, the airport employs over 76,000 people - half of whom live in the surrounding five London Boroughs. The airport is operated by Heathrow Airport Holdings Ltd (HAHL) a consortium comprising 7 organisations. In July 2015, the airport was recommended by the Airports Commission that the airport be granted a third runway, so as to improve its operating capacity, and in June 2018 the UK cabinet signed off plans that had been approved by the Government's economic sub-committee. This highly contentious runway has the potential to add an additional 222,000 aircraft movements to the airport.

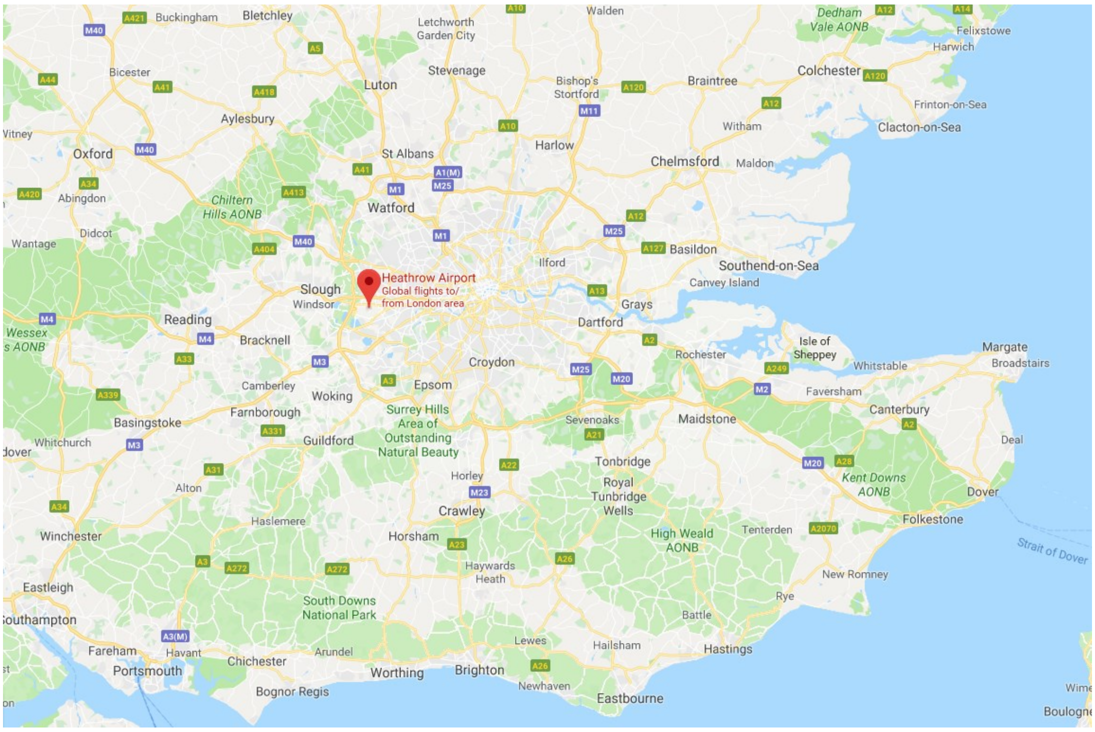

Figure 2.1: Heathrow Airport geographical position.

Heathrow is one of three airports designated under section 80 of the Civil Aviation Act 1982, which stipulates that relevant authorities may "specify the maximum number of occasions on which aircraft of descriptions so specified may be permitted to take off or land". For Heathrow this responsibility is held by the Secretary of State. Noise management at the airport is broadly influenced by two primary legislative acts.

Noise has been the primary constraint in Heathrow obtaining permission to develop their third runway. In response they have developed a lead-edge noise management team and today can be considered at the forefront of international efforts to tackle noise, taking a pro-active stance to the issue by accepting that noise is an important issue for local communities, and by demonstrating a long history of noise management interventions, and involvement in research programmes.

Heathrow's strategy towards noise management has been on a continuously evolving journey since the 1950s, beginning with developing an understanding of their noise impact is (i.e. through the development of noise monitoring), through to working in partnership with industry to reduce noise and comply with emerging regulation, towards its modern approach in which building trust and tolerance with its noise effected communities through varied community engagement programmes is key.

The first noise implications for Heathrow can be traced back to the 1952 Cranford Agreement, which prevented aircraft from taking off over the village of Cranford except in exceptional circumstances and applied when Heathrow was on easterly operations. Subsequently the airport began monitoring noise in the 1960's which represented its early attempts to understand it's noise impact. This has evolved to the point where today there are over 50 noise monitoring terminals around the airport, and noise data reported through a number of mechanisms, including in real-time via the website WebTrak[11].

The continued development of Heathrow's approach to noise is visualised in Figure 2.2 below, taken from the airports 2018 document "Our Approach to Noise[12]".

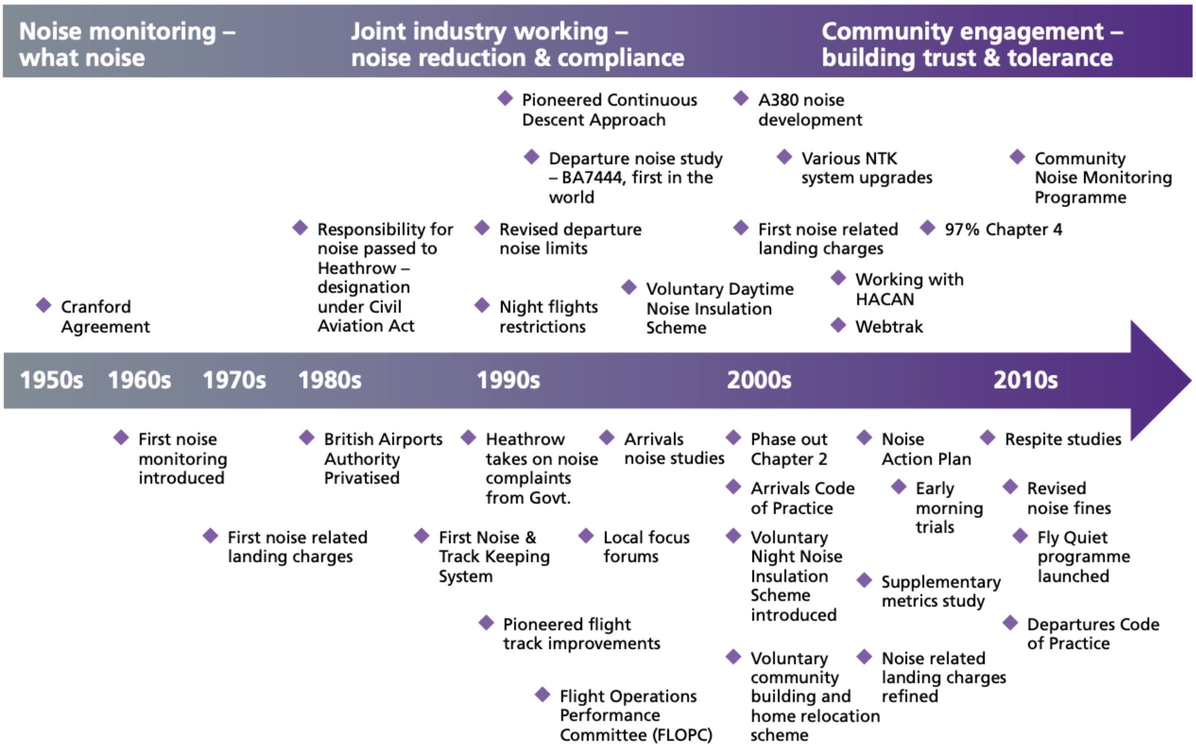

Figure 2.2: The evolving journey of Heathrow Airport's approach to noise.

Here it can be seen how over time the airport moved from noise monitoring to working to actively reduce noise impact, first through the implementation of noise related landing charges in the 1970s, but by the turn of the century including night flight restrictions, revised departure noise limits, voluntary daytime noise insulation schemes, flight track

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11 https://webtrak.emsbk.com/lhr4

12 https://www.heathrowconsultation.com/wp-content/uploads/2018/01/6746-Expansion-Noise-v11-KL.pdf

improvements, and the 'pioneering' of the continuous descent approach. The 1990's also saw the airport develop its first local focus forums through which noise could be discussed. This lead to the Heathrow Community Noise Forum (HNCF) being established in 2015, set up in response to local concerns regarding future changes to airspace as a result of the Governments airspace modernisation strategy which aimed to bring airspace management into the modern era, by utilising technology to improve efficiencies, reduce carbon emissions and reduce nose. The forum brings together representatives from local authorities around Heathrow, NATS, BA, DfT, CAA and Heathrow in the same room on a bi-monthly basis to discuss noise and to listen to community concerns resulting from airspace changes.

Hence, the airport had been effectively engaging in the 4 balanced approach elements prior to its official implementation into EU legislation in 2002, as well as working closely with communities for many years. This demonstrates an increasing focus on non-acoustic factors in recent years, evidence of the airports commitment to being at the forefront of effective noise management and impact mitigation. Indeed, the airport makes explicit reference to non-acoustic factors in the two iterations of its Noise Action Plan. Both Noise Action Plans also refer to the concept of interdependencies, which refer to carbon emissions and air quality implications of the airport's operations. The reports state that operational controls need to be balanced. For example, they give the example of reducing thrust to lessen NOx emissions has the impact of increasing noise lightly for those under the same flightpath. The airport has also been in a number of studies to help investigate interdependencies in detail, and to quantify the most appropriate balance of these issues in specific situations.

Approach to the Balanced Approach

The ICAO Balanced Approach and it's four underpinning principles, as enshrined in European Law under directive 2002/30/EC was implemented in UK law by the Aerodromes (Noise Restrictions) (rules and Procedures) Regulations 2003 (SI 2003/1742). The Environmental Noise Directive was brought into UK law through the Environmental Noise (England) Regulations 2006, with government guidance for airports on creating their noise action plans published by the Government in 2013 (DEFRA, 2013). This guidance stated that plans must be designed to manage noise issues and effects, including noise reduction if necessary and aim to preserve quiet areas in agglomerations.

Prior to the transposition of the END into EU Member State legislation, most large airports in England were already routinely undertaking their own Strategic noise mapping, and had also implemented a range of local noise management measures specifically tailored to the size and impact of their operations. It was therefore decided that the relevant Airport Operator should be responsible for producing strategic noise maps (SNMs) and for noise action planning (in consultation with relevant stakeholders) – the exception being Heathrow, Gatwick and Stanstead, for whom the CAA are responsible for strategic noise maps, and who are regulated by the Secretary of State. These airports have consultative committees and any changes to noise control are discussed with them. The Government advises that Noise Action Plans and any other noise measures that are agreed locally should be proportionate to actual noise impacts.

Heathrow operates in line with the Government's overall policy on aviation noise, that is "to limit and, where possible, reduce the number of people in the UK significantly affected by aircraft noise as part of a policy of sharing benefits of noise reduction with industry in support of sustainable development". The overall noise strategy is however, structured around the ICAO Balanced Approach, which is used as a framework through which good practice can be identified and implemented.

In 2013 the airport produced its 'A Quieter Heathrow' report which established a commitment to operating under the guidance established in the ICAO Balanced approach. This commitment was further established in their 2017 the airport 'Heathrow 2.0' in which the airport set out a high-level approach to noise management, further detailed in the 2013-2018 Noise action plan, produced under the END. In 2018 an updated Noise Action Plan was produced, in line with the requirements of END, with a period of consultation regarding the report closing in July 2018. Throughout all of these documents the airport has placed considerable effort in addressing all of the Balanced Approach elements, supplemented with a strong focus on communication and engagement with local communities.

Heathrow 2.0 set out a clear vision with three primary goals driving noise management at the airport (balanced approach elements have been highlighted):

1. To encourage the use of the quietest aircraft available ***(reducing noise at source),*** operated with the least noise impact practicable, within an agreed noise envelope ***(operational procedures and operating restrictions)***.
2. To influence national and international policy and engage with local planning authorities to ensure more effective land planning processes in noise affected areas, and to improve our noise mitigation ***(land-use planning)***.
3. To continue to improve the relationship with our local community by working more transparently and collaboratively to develop noise action plans, by improving our communications, monitoring, measuring and research capability ***(community engagement).***

Of note here is that three of the balanced approach elements are clearly outlined as important strategic goals for the airport, including reducing noise at source – something which the airport can only influence indirectly, by encouraging airlines to operate (and hence purchase quieter aircraft). Operating restrictions are lacking from explicit reference in these goals, however operating aircraft within an agreed noise envelope has clear implications in terms of restrictions. Moreover, lack of clear reference to operating restrictions is merely in-line with Balanced Approach guidance, which states that restrictions should not be sought as a first option. That community engagement is listed as part of these goals, is evidence that the airport has a high-level understanding of noise management issues, and the importance of maintaining regular, two-way, transparent dialogues with its different stakeholders.

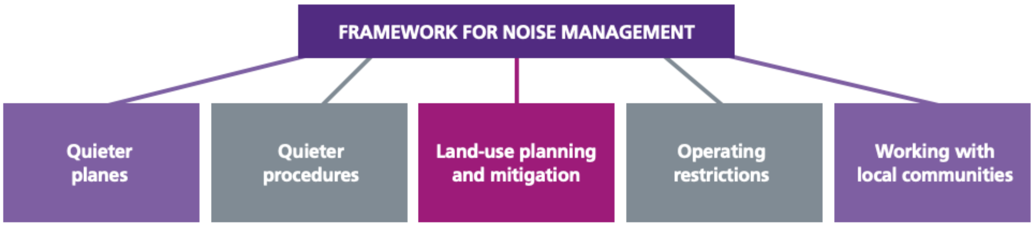
In goal two the airport can also be seen to be engaging with national and international noise policy – as evidenced by their involvement with ANIMA, and in other research programmes, for example on noise respite[13].

A commitment to engage with local planning authorities is evidence of the Heathrow's desire to drive better land-use planning around the airport. Heathrow's 'A Quieter Heathrow' report, reports that there were 16% more homes in the 57 decibel Leq noise contour in 2013 compared to 1991. Responsibility for land-use planning in the UK lies with local authorities, with guidance previously outlined by Planning Policy Guidance 24 – although this was not always enforced. More recently this guidance was replaced by the National Planning Policy Framework (NPPF) which is less explicit about where developments can be built. The airport has committed to pushing the Government for improved guidance and is working with local authorities to focus on the development of businesses and industrial parks around the airport, rather than noise sensitive

[13] https://www.heathrow.com/noise/making-heathrow-quieter/respite-research

developments such as housing. The airport's commitment to engage with local authorities shows an eagerness to remain involved with such stakeholders and to find effective solutions to the construction of noise-sensitive building developments around the airport. Goal three demonstrates a high level of commitment to tackling the noise problem, by going beyond balanced approach compliance by contributing to research.

Heathrow's current approach to managing noise can be illustrated through its 'Framework for Noise Management', as illustrated in Figure 2.3[14]. Beyond the high-level strategy to noise management, the airports Noise Action Plan clearly outlines a number of specific interventions through which this framework will be delivered – doing so not just by listing actions, but enhancing them with deadlines, Key Performance Indicators, targeted outcomes and impacts, and detail of those who will be affected.



Approach	General commitment
Quieter planes	As aircraft and technology improves and planes become quieter, we will continue to work to ensure that residents share in the benefits. We are committed to continuing to provide a strong financial incentive for airlines to use the quietest planes currently available, including in the early morning period, through the use of variable landing charges.
Quieter procedures	We are committed to take full advantage of opportunities to manage airspace differently, working with local communities to identify changes that could benefit them. This will include trialling new airspace management procedure to test the concept of providing predictable periods of respite from early morning arrivals and for some of our departure routes.
Land-use planning and mitigation	We are committed to continuing to help with noise insulation and mitigation through a range of schemes. We will also continue to press the Government to provide more detailed guidance on planning around airports, and to restrict noise sensitive development in high noise areas.
Operating restrictions	In line with principles of the ICAO Balanced Approach we do not see restrictions as a first resort and are committed to developing collaborative approaches which are often quicker to implement and more effective. For example the voluntary agreement with airlines not to schedule marginally compliant aircraft. Where restrictions are in place we are focused on ensuring that they are adhered to fully, for example in our administration of the night flying restrictions.
Working with local communities	Underpinning all of our work to tackle aircraft noise, we are committed to engaging openly and constructively with local communities to understand their concerns and to provide accessible information and an on-going dialogue.

Figure 2.3: Heathrow Airport's Framework for Noise Management

In total 55 noise impact interventions were listed in Heathrow's recent draft Noise Action Plan[15] which was published for public consultation. These interventions are spread across all the Balanced Approach (and community engagement), with 8 focusing on noise at source, 18 focusing on operational procedures, 8 addressing land-use planning, 4 related to operating restrictions, and 17 to help the airport work better with local communities. That the airport has gone to the effort of including community engagement as a separate pillar suggest a strong level of commitment to tackling the noise challenge, and a high-level of awareness of the issues at play in terms of influencing noise impact. Some of the

14 https://www.heathrowconsultation.com/wp-content/uploads/2018/01/6746-Expansion-Noise-v11-KL.pdf

15 https://www.heathrowconsultation.com/wp-content/uploads/2018/05/FINAL-DRAFT-NAP-2019-2023.pdf

interventions across the Balanced Approach elements are described below. The Noise Action Plan can be broadly summarised through Figure 2.4.

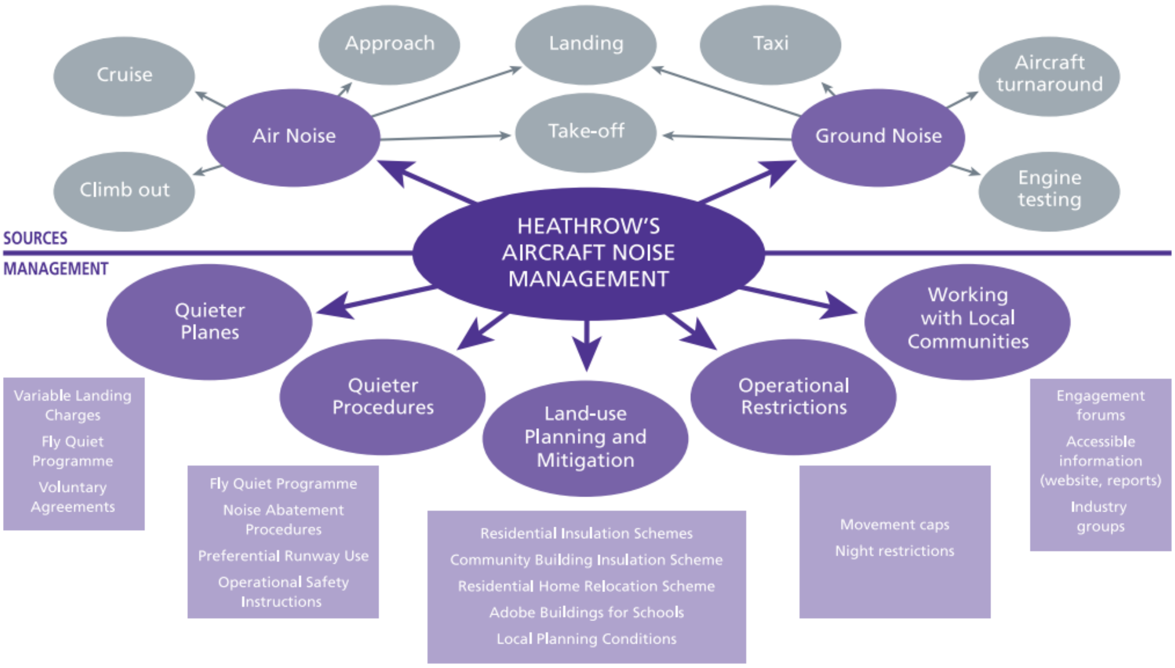


Figure 2.4: Heathrow Airport's approach to noise management

Reducing noise at source

Heathrow have a long-established system of charging more for older, noisier variants of aircraft than their newer quieter counterparts. This is based on ICAO noise certification standards and the margin by which a specific aircraft exceeds that standard. Differential landing charges are reviewed annually and the percentage of the aircraft fleet meeting or exceeding this standard is tracked. The airport was the first in UK to introduce charges in relation to Chapter 14 compliance. Charges for compliance are made publicly available on the airport website. In 2017, over 55% of take-offs and landings were met by aircraft that met or exceeded the Chapter 14 standard. Only 1% of aircraft met the oldest standard (Chapter 3). Such variable landing charges promote the use of 'best in class' aircraft using the airport.

The airport also operates a 'Fly Quiet and Green Programme' which benchmarks aircraft in terms of noisiness. Results are published quarterly in a league table that enables good performing airlines and those who have been improved to be identified. For noise, airlines are ranked against 'noise quota per seat', Chapter certification, early or late movements (between 23:30 and 04:30), continuous descent approach violations, and compliance of flying 'noise preferential routes'.

Operational Procedures

Heathrow airspace is managed with the aim of reducing noise impact (considering interdependencies such as safety, carbon emissions and air quality), doing so by working with local communities to identify potential changes and their impacts. This includes a focus on providing respite to communities from early morning arrivals and on some departure routes. Heathrow defines three broad categories that aim to make operations 'quieter':

- Making individual aircraft quieter (i.e. by changing thrust settings during take-off and approach).
- Making aircraft higher (i.e. when flying over communities).
- Managing aircraft routes differently (to avoid populated areas).

The airport works with the UK Civil Aviation Authority, NATS and airlines to explore and employ smarter operating procedures that fulfil these objectives, with measures reported by the airport including:

- Aircraft are required to be at a height of not less than 1000 ft aal (above aerodrome level) at 6.5 km from the start of roll, as measured along the departure track of that aircraft.
- There are noise limits applied at fixed noise monitors for departing aircraft and fines are enforced for breaches.
- Aircraft departing from Heathrow are required to follow specific paths called noise preferential routes (NPRs) up to an altitude of 4000 ft.
- 4% minimum climb gradient between 1000 and 4000 ft.
- Westerly preference on departures to reduce the number of aircraft flying over London.
- Continuous Descent Approaches to reduce noise for communities under arriving aircraft en-route to the final approach.
- Limiting use of reverse thrust at night by arrivals.
- Runway alternation/rotation: During westerly operations, wherever practicable the arrival runway is alternated according to a published schedule.
- Joining point rules: Between given times for aircraft approaching specific runways and using the Instrument Landing System (ILS) the aircraft shall not descend on the glide path below a given altitude before being established on the localiser, nor thereafter fly below the glide path.
- Slightly steeper approaches of 3.2 degrees compared to the standard 3 degrees.

Land-use planning

A range of schemes are listed in relation to land-use planning, however of particular note is the airport's commitment to challenging the Government to provide better guidance on planning around airports, so as to restrict noise sensitive developments being built in high-noise areas. Without such guidance the airport can see their efforts to reduce noise exposure limited as more people move to live within the noise contours that they have been working to reduce.

Interviews conducted as part of ANIMA DELIVERABLE D2.1 highlighted that the airport believes there is an absence of clear national policy on land-use planning. They have therefore committed to press the Government to provide guidance on planning around airports and to engage with local authorities on local planning strategy, to ensure a more coherent and consistent approach which adheres to the guidance set out in the Noise Policy Statement for England (NPSE) and National Planning Policy Framework (NPPF). This will be tracked together with annual population statistics published with their noise contours. Subject to the definition of Quiet Areas by the government, the airport also works with local authorities, government and local community groups to develop a plan to protect these areas in line with the Aviation Policy Framework (APF), Noise Policy Statement for England (NPSE) and National Planning Policy Framework (NPPF).

The airport engages with local authorities to ensure that aircraft operations are considered in planning applications for noise sensitive developments such as hospitals and schools, who are also offered acoustic insulation if they are exposed to levels of noise of 63dB Leq 16h or more. Other interventions detailed in the Noise Action Plan (2018) include:

- Conducting a review of noise insulation and mitigation schemes.
- Deliver the Quieter Homes Scheme; providing acoustic insulation to resident buildings. This includes full secondary glazing, double glazing, loft insulation and ceiling over-boarding in bedrooms. It is based on the 16 hour 2011 69 Leq contour.
- Expanding a school insulation programme to include ventilation.
- Undertaking a research programme to determine the overall satisfaction of insulation schemes from those who have been in receipt of such programmes.
- Working with local authorities to agree new local planning guidance, consistent with NPSE and NPPF.
- Identify new ways of monitoring population growth and encroachment to better understand impacts on noise contours and metrics. This will include working with local authorities to monitor new building developments annually and tracking this with noise population statistics.
- Work with community stakeholders to identify a common position on encroachment and development near the airport and set out this position for the Government.
- A home relocation assistance scheme providing eligible home-owners with financial assistance with the costs of moving away from areas of high levels of airport noise. For properties that fall within the 2002 69dB ALeq noise contour at Heathrow.
- A community buildings noise insulation scheme offers acoustic insulation to noise-sensitive buildings in the community – hospitals, schools and colleges, nurseries attached to schools and hospices, nursing homes, registered nurseries, libraries and community halls. The scheme provides noise mitigation to the buildings which can extend to window replacement, mechanical ventilation or any other activity related to provision of noise insulation. Eligible community buildings are those that fall within the 2002 63dB ALeq noise contour.
- There is a night noise insulation scheme - based on the noise 'footprint' of the noisiest aircraft regularly operating between 11.30pm–6.00am in 2004/05 90dBA SEL contours. Since the scheme is intended to mitigate the impact of night flights, rooms eligible for insulation are bedrooms or bedsitting rooms only (which are used as bedrooms on most days of the year).
- Residential day noise insulation scheme provides acoustic insulation to residential buildings in the community. This includes free secondary glazing or half price double glazing plus loft insulation to external windows and doors only. It is restricted to the 18 hour 1994 69dB ALeq 18h noise contour, enhanced to take account of early morning arrival noise.
- Vortex Protection Scheme designed to protect and repair homes around the airport. Includes fixing and maintaining properties near the airport that are susceptible to vortex damage.
- Home Relocation Assistance Scheme which sees Eligible homeowners receive a lump sum of £5,000, plus 1.5% of the sale price of the property (up to a maximum of £12,500) when moving to a quieter area. The scheme applies to residential properties around Heathrow within the 2002 69 decibel Leq noise contour.

Operating restrictions

The airport acknowledges the ICAO Balanced Approach principle of focusing on other elements of noise management before considering restrictions. That said, there is an air traffic movement cap in place of 480,000 movements per year, and night flight restrictions enforce d at the airport. The latter has seen the airport work with airlines to not schedule aircraft arriving before 4:30 – this is a voluntary measure and has only been breached in the case of one emergency. A further voluntary measure is no to schedule cargo flights between 23:30 and 06:00. There are no scheduled flights between 11pm[16] and 4:30am. Between 11:30pm and 6am Heathrow is restricted by the Government to 5,800 night-time take-offs and landings a year. There is also a night quota limit, which caps the amount of noise the airport can make at night. As a noise designated airport, the Government is responsible for setting restrictions on night-time flying at Heathrow. Night-time take-offs and landings are currently restricted to 5,800 per year between 11.30pm and 6am. Further restrictions apply to the chapter certification of aircraft than can operate – known as a Quota Count. From October 2017, all aircraft movements count towards the movement limit. From October 2018 noise quota limits were be reduced to 2,415 in winter (currently 4,080) and 2,735 in summer (currently 5,100)., with the aim of securing the benefits of newer quieter aircraft.

Community Engagement

Supported by the Governments Aviation Policy Framework call to focus on collaboration and transparency, Heathrow has long operated a thorough portfolio of engagement activities with its local communities and other stakeholders. One such group is the Heathrow Community Noise Forum (HCNF), which aims to establish a common level of understanding of Heathrow's operations amongst communities and stakeholders, not least NATS, British Airways, Virgin, the Department for Transport, and the Civil Aviation Authority. The HCNF meets every two months and there are also two working groups which feed into the main

Forum – one on 'Monitoring, Research and Policy' and the other focused on 'Operating Procedures'. Community groups and local authorities are also represented on bodies like the Heathrow Strategic Noise Advisory Group (HSNAG) and we engage directly with some community groups such as the Richings Park Residents Association.

Communication outside of these forums is driven by the airports dedicated noise website which hosts (or links to) numerous tools made available to the public. These include:

- Information on Heathrow's operations (arrivals/departures, wind, night flights).
- Monthly and daily statistics.
- WebTrak – an on-line facility which show aircraft type, flight number, speed, altitude and noise levels at over 40 noise monitors.
- xPlane – a web-based tool for residents to access flight data based on their specifications.
- WebTrak My Neighbourhood, which provides a broader view of how often particular flight paths are generally used on a monthly, quarterly or yearly basis.
- Reports, HCNF meeting notes and presentations, annual and quarterly performance reports.

The airport also operates a dedicated Twitter service to provide real-time runway updates for those in noise affected areas. The airport runs a Community Trust Fund which is funded from noise track infringements (http://www.heathrowcommunityfund.com/). The fund generates approximately £80,000 - £90,000 per year, with awards for individual projects being between £500 and £2,500. Projects typically include youth programmes (e.g. funding a scout troop to go hiking), biodiversity programmes (e.g. Transforming an unused area into a wilderness garden), and community neighbourhood activities (e.g. an art work trail produced by people with emotional difficulties, hampered by isolation, social deprivation and exclusion).

[16] There is one flight at 2310.

Regarding complaints, the airport has a dedicated noise complaints website form, email address and free-phone number. Complaints handling is supported by a 3 page complaints handling policy document . Complaint information regarding noise is easily found on the airport website in a dedicated section. The Operational Data website is also linked here where complaints data can be viewed. A key performance indicator of the airports noise action plan is to respond to all noise complaints within 5 working days. All complaints are reported daily on the Heathrow Operational Data website, in the airport's quarterly Flight Performance Reports and to the Heathrow Airport Consultative Committee (HACC). Complaints are monitored for trends to inform the airports noise management priorities but flight paths are not changed purely on the basis of the number of complaints received from a particular area.

Future priorities

Based on an analysis of its noise contours ad affected populations, Heathrow have highlighted a number of areas that are central to noise management during the period of its soon to be announced noise action plan (2019-2023). These are:

- Continuing to encourage ever-quieter aircraft using Heathrow;
- Greater consistency in implementing noise abatement procedures and working on new opportunities when possible.
- Delivering the quiet night charter to support predictable operations, fewer off-schedule movements, greater transparency and quieter operations;
- Continue working with local authorities to avoid encroachment and reduce the number of dwellings and people living in the highest noise areas;
- Reviewing and delivering sound insulation whilst working to ensure that new homes are built with appropriate insulation ratings; and
- Improving the management of noise from ground-based sources, including monitoring and mitigation.

Case Study (Operational Procedures): Heathrow DET09 Steeper Departure Trial

The intention of introducing this case study is to investigate the processes that underpin best practice at London Heathrow. In so doing providing context surrounding the actions undertaken, and decisions made in reducing noise impact. To recap the process described in the methodology, this process takes the airport from an initial awareness of a noise problem or requirement for change, through to the design of interventions, the selection of an appropriate intervention option, and its subsequent implementation, and post-implementation evaluation.

Aircraft leaving Heathrow are required to be at an altitude of at least 1000ft, 6.5Km after the start of their take-off roll (UK AIP EGLL AD 2.21). From this point, they are required to maintain a gradient of at least 4% until reaching 4000ft AAL. This is not part of the standard Instrument Flight Procedure (IFD), rather it is something implemented by the airport for noise abatement purposes to ensure that noise is progressively reduced along the ground (see Figure 2.5).

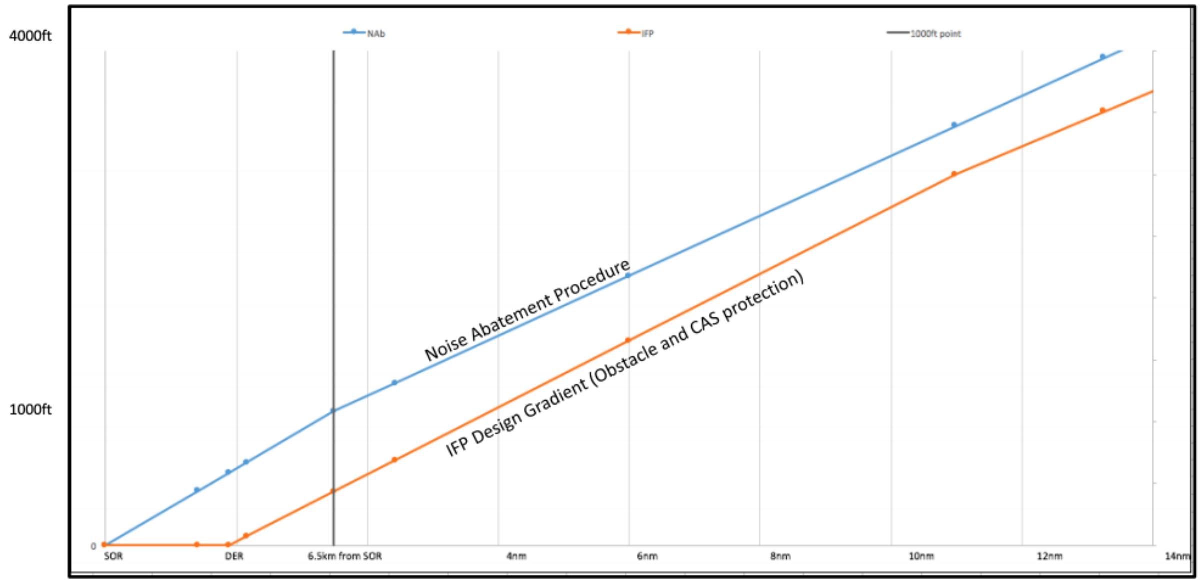


Figure 2.5 Illustrating how the airport's noise abatement procedure results in aircraft being higher than they would be following the IFP design gradient.

Although this gradient has existed for many decades, technology to monitor compliance has only recently existed, with Heathrow only collecting and reporting data since January 2017, as part of the airports regular flight performance reporting. The overall compliance rate in 2017 was 99.8%, with the majority of compliance failures being due to A380 operations.

The roots of this intervention can be traced to when the community of Teddington (approximately 9km South East of Heathrow) raised concerns with Heathrow Community Noise Forum. The community group 'Teddington Action Group' (TAG) believed that a gradual decrease in climb performance on the DET 09R departures route had occurred over previous years which had led to aircraft flying lower over their community. Moreover, the group had noted that the minimum departure gradient at Heathrow of 4% was somewhat lower than that found at other large airports. In response they requested that this minimum departure gradient for DET 09R departures be increased to reduce noise exposure over the Teddington Community. The location of Teddington in relation to Heathrow, can be seen in Figure 2.6.

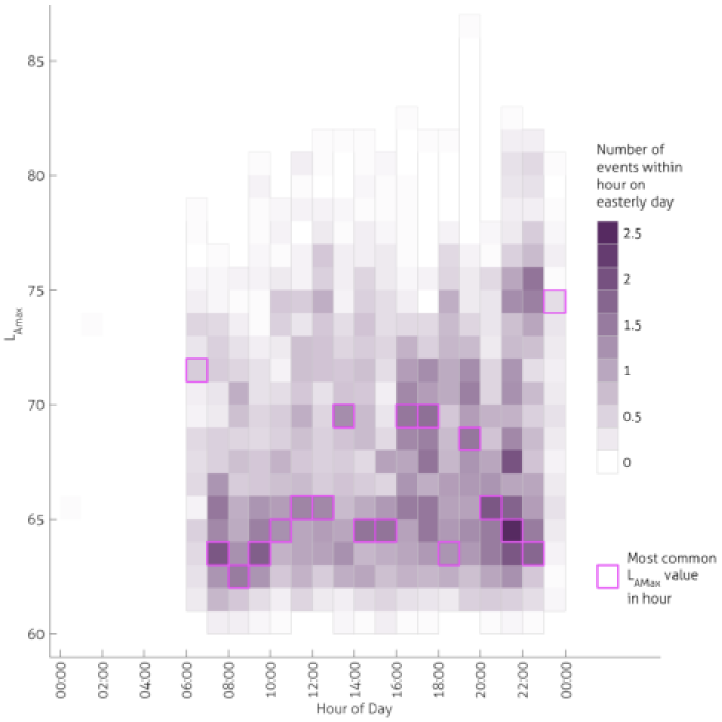
Figure 2.6. Location of Teddington in relation to London Heathrow, including the flight paths overflying the community

Heathrow have a long-standing commitment to developing its capacity to effectively communicate noise to its stakeholders, and have demonstrated an awareness that different stakeholders want to know different things and hence require different types of information (explained to them through a variety of different ways – as appropriate to their comprehension of aviation noise). The report published for the Teddington community about noise in their area[17] is a useful example to help demonstrate this commitment. For instance it describes:

- How wind direction affects aircraft operations (describing the rationale behind Westerly and Easterly operations).
- Flight path analysis (over which areas aircraft are flying).
- Operational and gate analysis data.
- Measured noise data and levels in the community.
- Overview of flight track data and changes over time.
- Changes to the concentration of flights (location on the ground and altitude).
- Changes to the fleet mix.
- Overview of noise monitoring data:
    - loudness and duration of aircraft events,
    - types of aircraft responsible, average maximum noise levels (LAmax) for different aircraft,
    - average Sound Event Levels (SELs),
    - numbers of noise events over different levels (N60,N65,N70),

17 https://www.heathrow.com/file_source/HeathrowNoise/Static/CIR_NPL_Teddington_0815_0316.pdf

- average minutes an hour where monitoring thresholds were exceeded,
- contribution to ambient noise levels,
- Longer-term average daytime (LAeq, 16hr/N65) and Night-time (LAeh, 8hr, N60) noise levels.



This case provides an interesting example where already established engagement platforms helped the airport to recognise community concerns regarding the DET09R flight path. The community was able to raise its concerns about aircraft departure profiles by approaching the HCNF directly and making these concerns clear to airport representatives and industry stakeholders. This is a clear example of the importance of airports establishing such community engagement platforms, and importantly, to ensure that they provide for a two-way dialogue, as to merely speaking to communities in an attempt to raise their awareness of airport activities.

The airport took a pragmatic approach to these concerns, first by listening to the community groups, and second by looking to validate their concerns through extensive testing and analysis of flight track data. Multiple studies were conducted and were found to broadly support the views of the HCNF members. Aircraft were outperforming the Instrument Flight Procedure (IFP) climb gradient. Approximately 99.7% of departures adhere to the current 1000ft Noise Abatement requirement, with 99% then adhering to the 4% to 4000ft requirement. However, the analysis also showed that whilst all heavy departures climbed in excess of the minimum departure gradient at some point between 1000ft and 4000ft, approximately 17% were, at some point, climbing at shallower gradients. This is thought to be largely down to the differing Noise Abatement Departure Procedures being executed by a mix of airlines and aircraft types. Other findings included that:

- An increase in A380 departures from Heathrow.
- There had been approx. 30 more DET09 departures per day.
- There was a small increase in concentration along SID centrelines.

- There was a small decrease in climb performance (210ft).
- The claimed noise benefits of the A380 were not being realised by overflown communities.
- Departures significantly outperform Instrument Flight Procedure (IFP) climb gradient of the standard instrument departure (SID).
- Aircraft were now concentrated in two distinct swathes rather than one.
- Daytime average aircraft noise levels had not changed substantially between 2011 and 2015, but that there was up to 7 additional noise everts per day (where L_{AMAX} was greater than 65dB).
- There had been approximately 1dB (LAeq, 8hr 23:00 to 07:00) increase in night noise, with no significant increase in the number of individual events.

4% NAB v IFP v Actual v Proposed 5% NAB

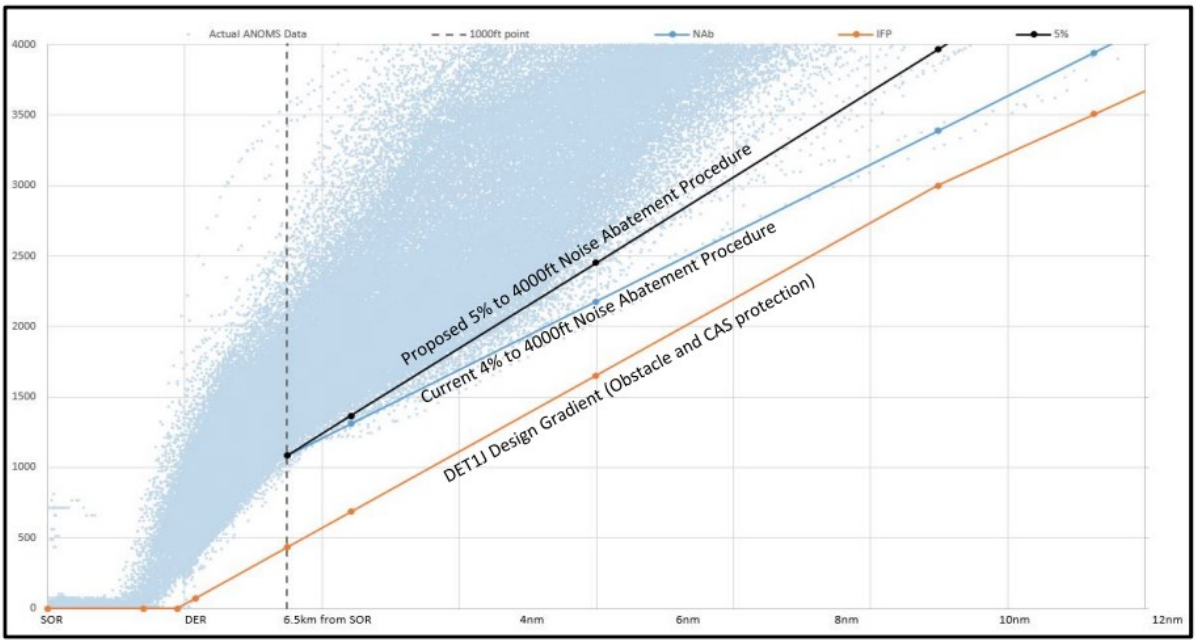


Figure 2.7. Illustrating the results of the analysis, showing how the vast majority of flights were well in exceedance of the 4% and 5% departure gradients.

The conclusions of this testing were made publicly available through a number of publications, including the Teddington Community Noise Information Report[18]. This document is an excellent example of lead-edge noise data communication. It clearly states its objectives, methodologies and key findings, and displays its findings through a wide range of novel metrics. This document is clear evidence that the concerns raised by the community group had been taken seriously by the airport, and that the airport had made the effort to communicate noise data clearly and transparently.

The report was based data collected from noise monitoring terminals in the area, and for the wider geographical area, on the Heathrow INM model. The airport uses the INM model as its primary tool for noise modelling, however, they acknowledged that modelling is complementary to monitoring and should not be used exclusively. For this reason, data was also assessed from the airports existing noise monitors in the area.

18 https://www.heathrow.com/file_source/HeathrowNoise/Static/CIR_NPL_Teddington_0815_0316.pdf

This analysis showed that community concerns were to extent valid, but that these concerns were only in association with a limited number of aircraft, namely 'heavy' and 'super-heavy' aircraft such as the A380.

Following analysis of the monitoring and modelling data the decision was made to increase the minimum departure gradient for aircraft following the Detling departure route from 4% to 5%. Increasing the departure profile in this way was seen as an optimal solution in that it would demonstrate positive action to the local community, address the small number of non-compliant and underperforming heavy aircraft, but have relatively minimal impact to the majority of flights who were operating well in exceedance of the both the 4% and 5% gradients. The local communities had desired an even steeper departure gradient, however operational factors (technical feasibility and trade-offs with changes to noise exposure and interdependencies) meant that this request would not be possible. Increasing the gradient from 4% to 5% would however ensure that larger aircraft would be encouraged to fly higher. Impacts in terms of extra fuel burn, engine wear and emissions were all considered when selecting the 5% gradient. Negative implications for noise were also considered as steeper departure profiles result in greater noise near the start of roll and to the side of departure route centrelines. noise data was communicated to residents via a number of reports, made publicly available on the www.Heathrow.com/noise website.

In terms of interdependencies, the CAA made it clear that any changes made to the departure profile would not be allowed to result in an increase in emissions below 1000ft (hence another reason why the 5% departure profile was selected – steeper profiles would not have been in compliance with this). Safety was also a concern as it is the main priority underpinning all operations at Heathrow. A joint risk assessment was held with airlines and NATS to determine any other operational impacts. This determined that a steeper departure would have affected the flow of aircraft leaving the airport as steeper climbing results in slower speeds. Moreover, aircraft that would not be able to meet steeper profiles would need accounting for and would also cause significant logistical issues. Steeper climbs also meant that aircraft would reach 600ft more quickly (the restriction altitude for Heathrow SIDs). The airport had to consider how this would interact with other airports' routes and how that is affecting continuous climb operations.

Rather than go immediately ahead with implementing the new departure gradient as part of their SID, Heathrow decided to first trial the new procedure. This decision was made based on an awareness that changes to a flight path would have implications in terms of interdependencies – namely, fuel burn, emissions, safety, and changes to the distribution of noise along the ground based on the fact that changes to operational procedures do not reduce noise, but rather move it into different places. The suspicion here would be that whilst a steeper departure profile would reduce noise exposure in the Teddington community, it would increase noise closer to the runway, and along the side lines of the flight path. This is clear evidence of a high-level of knowledge about noise distribution and the consideration of interdependencies in the noise management process.

The trial allowed Heathrow to analyse the variance in noise profiles associated with different airline Noise Abatement Departure Procedures which are Standard Operating Procedures (SOPs) not within the control of the airport. At the same time, it enabled a detailed comparison and comprehensive environmental and operational analysis of aircraft operating on the DET 1J (09R) SID before and after the introduction of a steeper IFP design gradient. For comparison, data was collected during a pre-trial (January-December 2017) and in-trial (January-December 2018) period, with an interim report compiled in July 2018. An annual period was selected for the trial in recognition of the fact that prevailing meteorological conditions at Heathrow mean that Easterly operations occur approximately 30% of the time – however this can vary. For reliability in the study, it was decided that if by 30th September 2018, the number of easterly days of operation was not at least 70% of the size of the number of easterly days over the same period in 2017, the trial would be extended beyond 5th January 2019. This was not required take place. Safety implications of the trials were taken into consideration via a Hazard Analysis forum held at NATS (Swanwick) on 31st March 2017.

Two years before the trials began, the airport commenced its standard stakeholder liaison process. This process a robust communications plan, particularly considering that over 90 airlines fly from Heathrow. Along with the airlines, Heathrow consulted the UK CAA and the DfT (their regulatory authorities). As a study that had not previously been undertaken, they also consulted with the UK Flight Safety Committee and other safety related forums. Regarding local communities, communication were held between the airports deafferent Consultative Committees – i.e. the Heathrow Community Noise Forum, and other working groups (such as the Teddington Noise Action Group). In planning the procedure the airport also collaborated with NATS, who played a key role in its development. Results from the trials will be fed to all the above parties and the Sustainable Aviation Operations Improvement Group. Information will also be fed to Eurocontrol.

Engaged communities resisted the 1% increase in departure gradient (demanding more), stating that they believed it was unambitious. As a result the airport embarked on a campaign to explain the reasons why steeper gradients were not achievable. In response communities highlighted that steeper gradients had been achieved at other airports, however this demonstrated a lack of understanding of where those gradients were measured from compared to Heathrow. For instance, Paris is often cited as having a 6.5% departure gradient, however Paris measures its gradient from a different point on the ground, nor do they monitor airline adherence to the profile. Heathrow believe that on a like to like basis their gradient is actually higher than that of Paris.

Communities where not presented with a suite of different options regarding the intervention because of the specific circumstances (interdependencies) surrounding the intervention (and the fact that the airport was responding directly to a community request by increasing the departure profile as requested. Increasing to steeper departure profiles would have required changes to NADP procedures which the airport did not see as viable, hence this increasing to a 5% profile was seen as the only possible option.

An additional 11 noise monitoring terminals were deployed in the region to help capture data with a high level of granularity, bringing the total number of terminals in the area to 20. The purpose of increasing the number of NMTs is to enable the gathering of pre-trial and trial datasets which are large and diverse enough to fully understand the distribution and density of noise energy underneath and to the side of the DET departure route. This was important as a report from the CAA suggested claimed that steeper departure profiles would increase noise at the side lines of the flight path, and increase the duration of the noise event for everybody[19].

Data collection began on 1st January 2017 and took place by gathering Airport Noise Monitoring and Management (ANOMS) data of aircraft using the extant DET 1J SID as well as from the existing Noise Monitoring Terminals (NMTs) and the additional NMTs deployed to the area.

19
https://publicapps.caa.co.uk/docs/33/20180719%20CAP1691a%20Departure%20Noise%20Mitigation%20Summary%20Report.pdf

The trial aims to gather aircraft performance and noise data for a pre-trial period and an in-trial period so that changes to noise distribution, and its interdependencies could be evaluated, by enabling a detailed comparison and comprehensive environmental and operational analysis of aircraft operating on the DET 1J (09R) SID before and after the introduction of a steeper IFP design gradient. This detailed analysis of the operation of a vertical departure profile will be the first of its kind within the United Kingdom.

Aircraft crews were engaged with (via the airlines) before the trials began to understand their capacities to deal with the new departure profile and to help shape the trials and what would be expected of the crews.

The objectives of the trail are outlined in the below table, with success criteria outlined in the following table. A reversion process put in place to ensure that if the trial went wrong in attempting to accomplish these objectives (i.e. massive noise increase or safety concerns) that the airport could revert back to the old SID quickly.

Objectives of the Detling Departure Trials

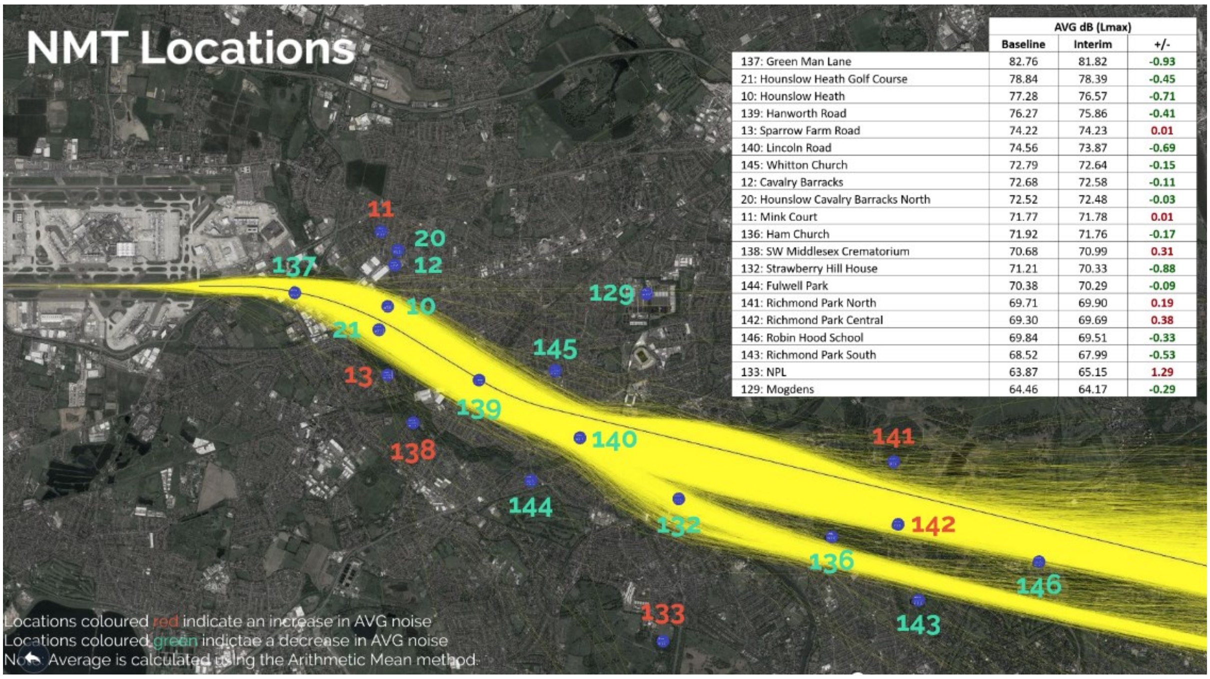
Objectives	**Method of Verification**
Understand the change in noise distribution associated with aircraft climb gradients.	NMT measurements, ANOMS data
Validate the modelled variation in noise distribution attributed to differing airline NADP procedures	NMT measurements to validate industry theory of how aircraft noise is distributed as a result of aircraft climb gradients. ANOMS data
Gather sufficient data against which to compare baseline and trial findings across a wide-range of meteorological and aircraft operating conditions and aircraft types	Total number of DET 2Z departures in 2018 is at least 70% of the total number of DET 1J departures in 2017 Total number of Heavy/Super Heavy DET 2Z departures is at least 80% of the number of Heavy/Super Heavy DET 1J departures in 2017
Ensure the trial gradient results in an actual change in aircraft climb performance	Pre-trial analysis and 12-month baseline/trial periods
Enable a steeper SID trial without dictating a change in airline NADP procedure(s)	The trial does not dictate a change in NADP procedure Qualitative unless airlines willing to share quantitative data. Airline workshops
Understand the impact of a steeper SID gradient on airline operations (engine wear/fuel burn/SOPs)	Qualitative unless airlines willing to share quantitative data. Airline workshops
Understand any impacts on Local Air Quality as a result of the steeper SID	Should airlines report a change in thrust settings below 1000ft, Heathrow will perform a Local Air Quality assessment

Understand all the consequences of increasing the height of aircraft on departure over specific communities. (Similar requests have been made of Heathrow by other industry members for airspace design purposes)	Final report detailing changes in noise distribution and operational consequences
Support the establishment of future airspace design principles for Heathrow Airport, shared with industry via FASIIG	Final Report

Success criteria for the Detling Departure Trials

Criteria	Method of Verification
The trial has not had any direct impact on the safety of aircraft and/or Heathrow operations	No MORs filed with resultant investigation finding DET 2Z a contributory factor
Total number of DET 2Z departures in 2018 is at least 70% of the total number of DET 1J departures in 2017	Data collection – Trial extension procedure
Total number of Heavy/Super Heavy DET 2Z departures is at least 80% of the number of Heavy/Super Heavy DET 1J departures in 2017	Data collection – Trial extension procedure
Sufficient good quality data has been collected for aircraft operations as well as from the noise monitors so as to allow for understanding changes in noise distribution as a direct result of an increased climb gradient	Final Report findings
The trial has not had a detrimental effect on local air quality	If an airline reports an increase in thrust settings on departure as a result of DET 2Z it will trigger a Local Air Quality assessment.

Initial results from the trials (January-July 2018) found that Heathrow's aircraft movements grew by 5.7% and cargo by 2.2%, with a 10% increase in Easterly departures (45% from 35%) and departures increasing from 9,816 to 13,773. Heavy departures (i.e. those previously underperforming over the Delting flight path) increased from 3,999 to 5,393 movements. Only 0.52% of aircraft did not maintain the desired 5% climb gradient – down from 0.72% in the same period in the previous year. Findings from the trials have broadly demonstrated a success, with the majority of aircraft flying at higher altitudes than during the baseline period. Moreover, as illustrated in Figure 4, 14 of the 20 NMTs showed a reduction in average dB(max) – albeit the benefits were mostly marginal. Of the 6 NMTS to experience an increase in average dB(max), all but one was located on the side lines of aircraft noise exposure cones (i.e. the extremes of noise exposure). Essentially, the noise contours along the Detling departure route became shorter and fatter. This outcome was predicted by the airports.



	AVG dB (Lmax)		
	Baseline	Interim	+/-
137: Green Man Lane	82.76	81.82	-0.93
21: Hounslow Heath Golf Course	78.84	78.39	-0.45
10: Hounslow Heath	77.28	76.57	-0.71
139: Hanworth Road	76.27	75.86	-0.41
13: Sparrow Farm Road	74.22	74.23	0.01
140: Lincoln Road	74.56	73.87	-0.69
145: Whitton Church	72.79	72.64	-0.15
12: Cavalry Barracks	72.68	72.58	-0.11
20: Hounslow Cavalry Barracks North	72.52	72.48	-0.03
11: Mink Court	71.77	71.78	0.01
136: Ham Church	71.92	71.76	-0.17
138: SW Middlesex Crematorium	70.68	70.99	0.31
132: Strawberry Hill House	71.21	70.33	-0.88
144: Fulwell Park	70.38	70.29	-0.09
141: Richmond Park North	69.71	69.90	0.19
142: Richmond Park Central	69.30	69.69	0.38
146: Robin Hood School	69.84	69.51	-0.33
143: Richmond Park South	68.52	67.99	-0.53
133: NPL	63.87	65.15	1.29
129: Mogdens	64.46	64.17	-0.29

Figure 7: Location of Noise Monitoring Terminals and differences in AVG dB (max) between the baseline period and interim trial results.

One aspect of the trials was to understand the implications of slower speed associated with steeper climbing (impacting the 'flow' of aircraft departing the airport. The impacts of this are currently under analysis. During the trials it also became apparent that some aircraft gave crews an indication of whether the aircraft could successfully make the departure profile whereas some aircraft did not give an indication until the aircraft became airborne. This presented a new operational challenge that had to be considered. Another impact of the intervention was that a new SID name for the trials required an Electronic Flight Progress Strip change.

Following the above described processes, modelling and regulatory procedures have ensured a safe and successful trial. Success was determined through the array of class-one microphones and monitoring stations deployed around the airport and the subsequent analysis of collected data. A final report documenting the results of the trials is in the process of being written, once full and detailed analysis of the data has been completed. The interim trial report data showed that the impacts of the new procedure were broadly in line with what was expected. The limits and tolerances of aircraft flight management systems and been learned and the airport are in the process of feeding in airline data to understand fuel flows, implications for interdependencies, and associated fuel costs.

No qualitative analysis (for instance regarding non-acoustic factors) is taking place with communities.

Summary

As the first such study of its kind in the world, the Detling Steeper Departure Trails can be seen as a leading example of an operational procedure intervention. A community concern was escalated to airport management via existing communication channels. This concern was listened to and acted upon via the airport, with such action involving a wide range of industry stakeholders, and considering a raft of interdependencies throughout. The trials were informed by initial data modelling and analysis of noise monitoring data (with results fed back to the community), which validated community concerns and calls for an increase in the steeper departure gradient. A range of novel communication method were used to help describe noise to community members. This led to a year-long trial being conducted to ascertain the full implications of implementing a steeper minimum departure gradient which involved the follow cooperation and collaboration of industry stakeholders (airlines, NATS, CAA, DfT, and Safety regulators). There currently exists no plans to assess the impact of the new departure routes in terms of impacts on quality of life of the Teddington residents, however existing communication channels will ensure that any concerns can be captured going forward.

8.3 Case Study 3 - Iasi Airport

This case study provides an overview of the previous, current and proposed practices of **Iasi Airport**, as a part of their Noise Management Strategies.

The structure of the case study is constructed such that the actions and interventions accomplished by **Iasi Airport,** are presented in a descriptive and detailed manner with the purpose of emphasizing lesson learning and good practices.

All information used for the development of this case study was gathered from the airport, interviews with relevant stakeholders and online sources. Interviews included **airport representatives, ANSPs (Air Navigation Service Providers), the CAA (Civil Aviation Authority) and relevant National Ministries (Environment, Transport)**. The interview findings were correlated with all other available information and included within the case study. Most of the topics of the interviews were formulated around the knowledge, understanding and application of ICAO Balanced Approach, together with further actions designed to reduce and mitigate noise and its effects.

The target audience of the case study includes airport operators and several other relevant stakeholders such as Air Navigation Service Providers, Civil Aviation Authorities, aircraft operators, environmental and government organisations and other interested parties.

<u>Background information</u>

<u>Overview of the Romanian air traffic on all Romanian Airports</u>

According to the latest statistics developed for the interval 01 Jan. 2017 – 30 Sept. 2018, passenger air transport increased from 15414.9 thousand of passengers to 16622.0 thousand of passengers, i.e. a 7.8% increase, in Romania. Cargo, including mail, increased by 11.5%, from 32267 tons to 35986 tones.

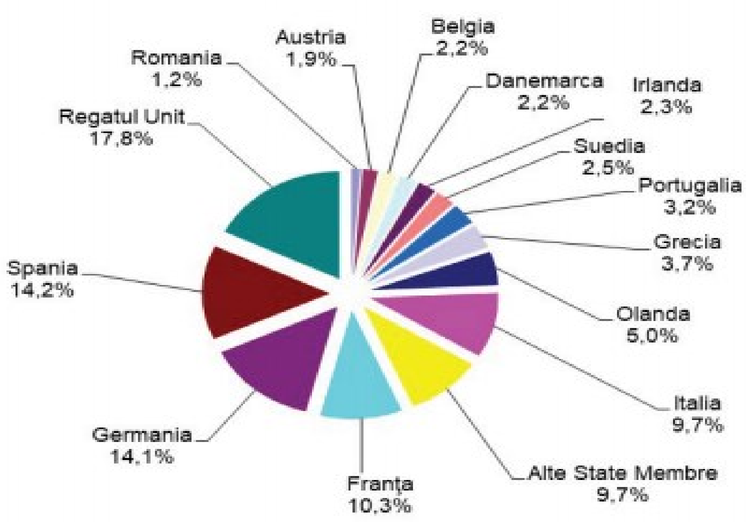


Figure 3.1 - Passenger air transport in Member States during the interval 01 Jan. 2017 – 30 Sept. 2018 [1]

Four macroregions have been developed for the analysis of air traffic on all Romanian Airports by taking into account the regions of development and the counties where the airports are located. Therefore, the following four categories have been formulated:

- The first macroregion: Bihor, Cluj, Satu Mare (North-West); Mures, Sibiu (Centre);
- The second macroregion: Bacau, Iasi, Suceava (North-East); Constanta, Tulcea (South-East);
- The third macroregion: Ilfov (Bucharest-Ilfov);
- The fourth macroregion: Dolj (South-West Oltenia); Arad, Timis (West).

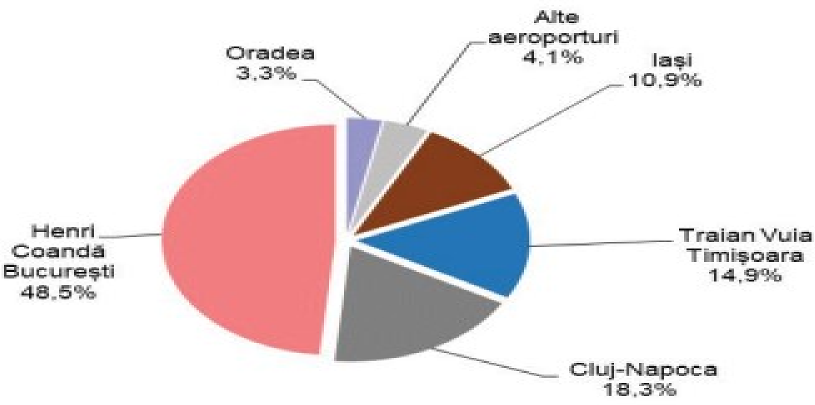


Figure 3.2 - The structure of embarked passengers within domestic transport in the interval 01 Jan. 2017 – 30 Sept. 2018 [1]

<u>Iasi Airport background information</u>

Iasi Airport is located in the NE of Romania (121m altitude), on a hill of approx. 180 metres height and at 8 km from the centre of Iasi city, on its NE side. Since 1905, the area was used for aeronautic activities, supported by the Royal House, thus it is one of the oldest certified Romanian Airports.

Immediate surroundings include the Ciric forest, together with Aroneanu, Dorobant and Valea Lunga villages. The overall North-Eastern Region, including Bacau, Botosani, Neamt, Suceava and Vaslui Counties, has an approximate number of 3.8 million residents.

Iasi Airport had the highest percentual increase from all Romanian regional airports in 2018. Air traffic growth is accelerated, as it increases from a number of approximately 200,000 passengers in 2012, to 1 million in 2017. Initial forecasts estimated 1 million passengers to be reached 5 years after the new runway was put in use, yet the number was achieved 2 year earlier. Predictions for 2019 estimate an approximate number of 150,000 passengers in each summer month, having at least 100,000 in the rest of the year.

The estimated number of passengers for 2019 is around 1.5 million passengers. In line with this forecast, terminal T1 was re-opened in order to manage some of the external traffic handled by the terminal T3. This is only a temporary solution until the new major airport development plan will be implemented. Forecasts for the next 4-5 years estimate reaching the number of 2 million passengers.

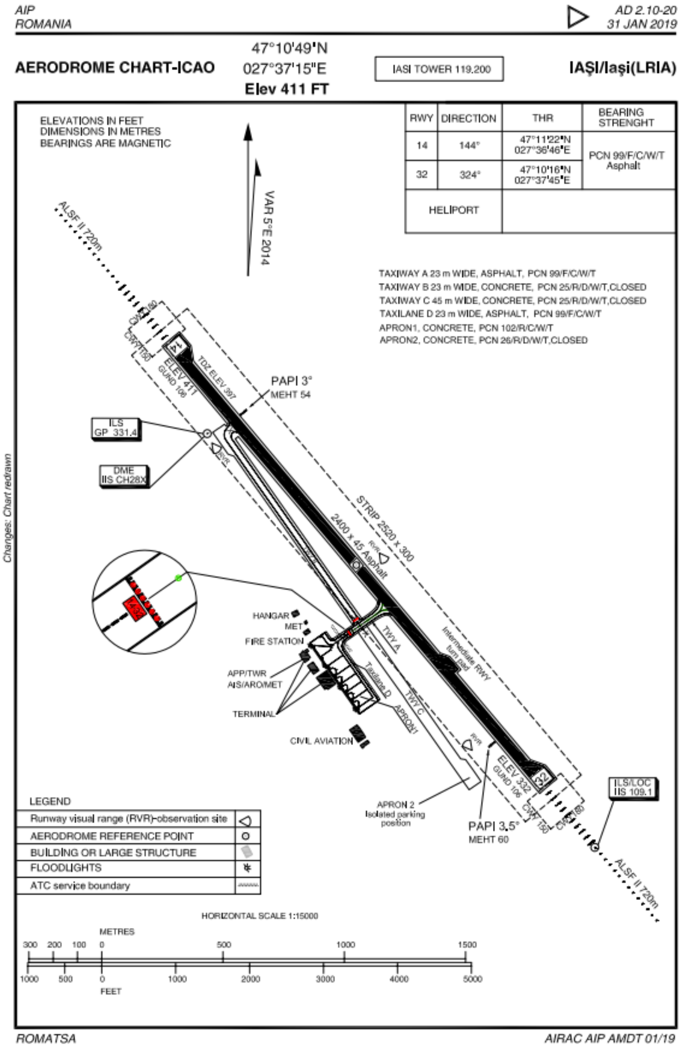


Figure 3.3 – Aerodrome Chart – ICAO [2]

Table 3.1 - General Airport Information [2]

Name of the company	R.A. AEROPORTUL IASI
Aerodrome location indicator and name	LRIA – IASI/ Iasi
Aerodrome geographical and administrative data	
Direction and distance from the city	3.48 km East from Iasi city; 8 km NE from the centre of Iasi city
Elevation	Approx. 400 FT (411 FT according to AIP)
Reference temperature	28.7° C
AD Administration	R.A. Aeroportul Iasi
Types of traffic permitted (IFR/VFR)	IFR/VFR

Passenger facilities	
Transportation	Buses, taxis and rent-a-car on the airport.
Radio navigation and landing aids	
Type	LOC 15 (ILS CAT II) GP 15, DME 15 NDB, MKR, LM

Table 3.2 – General Airport and Air Traffic Information [3]

Total number of passengers	1,256,640 in 2018 (10% increase from 2017; 43% increase from 2016)
Total number of aircraft movements	12,749 in 2018 (8% increase from 2017)
Flight connections [countries]	12 countries
Flight connections [destinations]	23 destinations

Table 3.3 – Traffic figures in the period 2012-2018 [4][19][20][24]

Year	Number of Passengers
2012	173,248
2013	231,933
2014	273,046
2015	376,858
2016	881,000
2017	1,146,086
2018	1,256,640

New routes have been introduced in 2018, including domestic direct flights to Cluj-Napoca and Timisoara and external flights to over 10 EU destinations. Further charter flights were introduced during the high season towards Antalya, Rhodos, Corfu and Heraklion. The frequency of flights to Munchen, Milano and Torino also increased.

Table 3.4 - Runway Physical Characteristics [2]

RWY Designator	Direction	RWY Dimensions [m]	THR elevation [ft]
14	144°	2400 x 45	THR 411
32	324°	2400 x 45	THR 332

2. Applicable Noise Regulations

The **Environmental Noise Directive** [5] was transposed into the National Legislation in 2005 (**H.G. 321/2005**) [6]. Further updated and modified versions were published through the years, together with the necessary framework for the implementation and evaluation of its provisions. As a main result, the development of Strategic Noise Maps and Action Plans is mandatory for major airports. Romania has only one Major Airport, that being Bucharest Henri Coanda International Airport.

Its alignment to **END** is furthered in 2007 (**H.G. no. 674/2007** [7]), 2012 (**H.G. no.1.260/2012** [8]) and 2016 (**H.G. no. 944/2016** [9]) through modifications and completions done under the provisions of the **Law no. 52/2003** [10] regarding the decisional transparency of the public administration.

A new **Noise Law** [11] was initiated in 2018, transposing the updated version of the **Environmental Noise Directive**, i.e. together with the **Annex of the EU Directive 996/2015** [12] establishing the common methods of noise evaluation at the EU level. The implementation of the **Noise Law** will repeal the previous transposition of the **Environmental Noise Directive**, together with all its subsequent legislation.

Regarding **ICAO Balanced Approach** [13], recent legislative changes include the transposition of the **Regulation (EU) no. 598/2014 of the European Parliament and Council of 16 April 2014 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC** (August, 2018) [14].

A detailed description of the Romanian Legislative Framework regarding Aviation Noise can be found in Annex (A). Responsible Authorities for aviation noise are detailed in Annex (B).

3. The approach to ICAO Balanced Approach and Noise Management

Iasi Airport does not fulfill the condition of having more than 50,000 movements per year in order to be classified as a Major Airport. Even so, according to the National legislation, it is considered an Urban Airport, thus having the responsibility of developing Strategic Noise Maps and Action Plans.

General Overview

According to the Romanian AIP [2], **Noise Abatement Procedures** have been introduced since the 31st of January, 2019 as a mandatory requirement for Iasi Airport. The provisions are formulated both on departure and on the ground. The provisions for departure have not been published yet. For the ground operations, the provisions state that: the use of GPU and APU must be limited; the use of reverse thrust should be avoided (especially in the 2300-0600 LT interval) as possible as in safe; ATC will approve engine ground operations only at idle speed; engine ground testing permitted only between 0600-2300 LT and only with ATC approval; the Safety Officer on duty decides the location and timing of engine ground testing, for safety reasons.

Land-use planning and management is currently developing within the Romanian legislative framework on noise.

Operating restrictions [14] have been transposed, compliant to a balanced approach, within the National legislation. At the moment, only Major Airports must apply these provisions [14], therefore Iasi Airport is not required to become compliant with noise operating restrictions.

Review of Noise Action Plans and previous BA interventions

R.A. AEROPORTUL IASI is the economic operator responsible for the development of noise maps, Strategic Noise Maps and Action Plans.

The development of acoustic maps and respectively the evaluation of acoustic pollution, serves, among others, to public informing. After the acoustic mapping, it is necessary to develop action plans through which problems and negative effects generated by sound pollution to be solved, and if necessary, to reduce the level of ambient noise. The strategic mapping work and the reports for the Action Plan construction are meant to support the beneficiary in fulfilling the obligations according to the national legislation (**HG 321/2005** [6]), EC requirements and public informing. Global and individual strategic acoustic maps were developed for airport activities. No previous noise reduction programmes were developed before 2014.

From the analysis of noise maps, no areas have been identified as potential quiet areas.

Methods used for calculus or measurement

The mapped area is on a calculated distance according to point 21 "Date privind suprafata care va fi cartata in vederea realizarii hartii de zgomot" (English: Data regarding the surface that will be mapped for the development of noise maps) from Chapter 3.2 of "Ghidul privind metodele interimare de calcul a indicatorilor de zgomot pentru zgomotul produs de activitatile din zonele industrial, de traficul rutier, feroviar si aerian din vecinatatea aeroporturilor" (English: the Guide regarding the interim calculus methods of the noise indicators for noise produced by activities in industrial areas, road, rail and air traffic in the vicinity of airports, approved by "**Ordinul ministrului mediului si gospodaririi apelor, al ministrului transporturilor, constructiilor si turismului, al ministrului sanatatii publice si al ministrului administratiei si internelor, nr. 678/1344/915/1397/2006**" [15] (English: the Order of the Minister of Environment and water management, of the Minister of transport, construction and tourism, of the Minister of public health and of the Minister of Administration and Internal Affairs, no. 678/1344/915/1397/2006).

Calculus Methods: According to **HG 321/2005** for the evaluation and management on ambient noise, acoustic pollution of the ambient environment has to be determined and respectively presented through acoustics maps, result of acoustic mapping. The method for calculus used is **ECAC.CEAC Doc. 29** [16] "Report on Standard Method of Computing Noise Contours around Civil Airports", 1997, regarding the calculus of noise indicators for noise produced by air traffic around civil airports. From the different approaches of modelling flight paths, it is used the technique of segmentation mentioned in the section 7.5 of **ECAC.CEAC Doc. 29** [16].

This method of computing is implemented in the program CADNA A produs de DATAKUSTIK GmbH and used by the society ACCON Environmental Consultants S.R.L. in developing Strategic Noise Maps.

According to **ECAC** [16], ground maneuvers are not taken into consideration as aircraft movements, therefore only take-offs and landings are used.

Therefore, according to [15] Cap 2.3, noise emitted by airport activities (others than the ones produced strictly by aircraft take-off and landing – aircraft movements) inside urban agglomerations and that have under 50,000 aircraft movements/year, are treated as industrial areas when the public administration authorities develop strategic noise maps and the noise emitted by all activities of take-off and landing (aircraft movements) of these airports are considered separately in the development of strategic noise maps, therefore their mapping will be done separately. Airport activities that can be considered as industrial activities are: aircraft engine testing, the use of the main and auxiliary energy generators and motor vehicles used for parking and aircraft fueling.

Measuring methods: For noise produced by aircraft, **ECAC.CEAC Doc. 29** [16] is used. From the different approaches of modelling flight paths, it is used the technique of segmentation mentioned in the section 7.5 of **ECAC.CEAC Doc. 29** [16].

The methodology used for obtaining the number of residencies and residents exposed to noise is the use of CadnaA v.4.3. („land use" module), through which the population was distributed on buildings. The mapping software and its version used is CadnaA4.0 made by DATAKUSTIK.

The distribution of residencies and residents in residential buildings

Starting from the total population of Iasi Agglomeration, it was firstly made a division of it on habitable areas. After these areas were obtained, the building with residential character were selected and the ones that are not were separated (i.e. industrial warehouse, commercial buildings, administrative buildings). Out of these, it was obtained the number of existing residential buildings in each of the defined population areas.

By using the program CadnaA v4.3 (using the object type area "land use"), the population was distributed on buildings. It was used the Instrument 2 from point no. 18 from [17].

The total population of Iasi Municipality and of Aroneanu Village was obtained from the website of the National Statistics Institute [18] and it was referring to the census from 2011.

Table 3.5

Instrument 2 [17]: There are no data regarding the number of residents having the residency inside the mapped area (or of any part of this surface) [19]

Method	Complexity	Accuracy	Cost
The number of the total people inside each building within the mapped surface is determined	x	x	x
• An estimation regarding the mean average of the number of people that have the residency within different types of buildings within the mapped zone is done • A limited research of the different types of buildings within the mapped zone and a list of them is developed, and an estimation of the people having the residency within the mapped area is developed afterwards.	x	x	x

The estimation of the number of people exposed to noise for L_{den} and L_{night}

The estimation of the number of people exposed to urban ambient noise is made through the distribution in bands of variation of the values of noise indicators according to **Annex 7 point 1.5 of HG 321/2005** [6], separated for different noise sources and cumulated.

This chapter is completed after obtaining acoustical maps and it contains the evaluations necessary to be transmitted to the Commission, in compliance with the requirements of **Annex 7, from HG 321/2005** [6].

According to the mentioned Annex, it is needed to determine the number of residents living in the interior of some bands defined by ambient noise. The width of these bands is of 5 dB(A). For the L_{den} indicator for the inferior class is 55-59 dB(A). For the indicator during the night time L_{night} inferior class, is 50-54 dB(A).

For the estimation of the height of buildings, all these data were corroborated with the indications of [17] Cap 3.2 point 22, Instruments 1 and 2, i.e. "It is used the same height for all buildings" scenario, as well as point 12 ("There exist maps or aerial photographs" scenario) Instrument 2 corroborated with method 6 metres for buildings with one or two floors, 15 metres for buildings with more than two floors, combined with the method through which the height is calculated from the number of floors multiplied by 3 metres.

Table 3.6 - Maximum allowed values and target values for the maximum allowed values for the year 2012

The exposure of the population and of residencies/ building to noise from air traffic at values of L_{den} and L_{night} [19]

Category	No. of people
No. of people (near major airports) exposed to L_{den} 50-54/ 55-59/ 60-64/ 65-69/ 70-74/ >75	0
No. of people (near major airports) exposed to L_{night} 50-54/ 55-59/ 60-64/ 65-69/ >70	0
No. of people (living in residencies with special insulation) exposed to L_{den} 55-59/ 60-64/ 65-69/ 70-74/ >75	0
No. of people (living in residencies with special insulation) exposed to L_{night} 55-59/ 60-64/ 65-69/ >70	0
No. of people (on a quiet façade) exposed to L_{den} 55-59/ 60-64/ 65-69/ 70-74/ >75	0
No. of people (on a quiet façade) exposed to L_{night} 55-59/ 60-64/ 65-69/ >70	0
No. of people (living in residencies with special insulation, noise being from major sources) exposed to L_{den} 55-59/ 60-64/ 65-69/ 70-74/ >75	0
No. of people (living in residencies with special insulation, noise being from major sources) exposed to L_{night} 55-59/ 60-64/ 65-69/ >70	0
No. of people (living in residencies with a quiet façade, noise being from major sources) exposed to L_{den} 55-59/ 60-64/ 65-69/ 70-74/ >75	0

No. of people (living in residencies with a quiet façade, noise being from major sources) exposed to L_{night} 55-59/ 60-64/ 65-69/ >70	0

Apart from the number of residents, it is requested to also determine the number of residencies exposed to noise levels in the previously mentioned bands. The estimated number of residencies affected by ambient noise results from the number of affected residents.

Table 3.7

The estimated number (approximated in hundreds) of residencies, as well as schools and hospitals exposed to ambient noise generated from airport activities. Data from 2014 [19]

Lzsn(Lden) dB(A)		Exposure to ambient noise generated by airport activities, estimated in hundreds						The total surface (in km^2) exposed to the values of the indicator	
		Residencies		Schools, Education		Hospitals, Clinics, Sanatoriums			
Above	Up to	Lzsn	Ln	Lzsn	Ln	Lzsn	Ln	Lzsn	Ln
45.0	49.0	0	0	0	0	0	0	0.9	0.33
50.0	54.0	0	0	0	0	0	0	0.39	0.08
55.0	59.0	0	0	0	0	0	0	0.12	0
60.0	64.0	0	0	0	0	0	0	0	0
65.0	69.0	0	0	0	0	0	0	0 0.1218 (2016)	0
70.0	74.0	0	0	0	0	0	0	0	0
75.0		0	0	0	0	0	0	0	0

Table 3.8 - The estimation of the number of people, residencies and surfaces exposed to values of L_{den} greater than 55, 65 and 75 dB [19]

Category	No. of people
No. of people (living in residencies and surfaces) exposed to Lzsn(Lden) 55-59	0
No. of people (living in residencies and surfaces) exposed to Lzsn(Lden) 60-64	0
No. of people (living in residencies and surfaces) exposed to Lzsn(Lden) 65-69	0
No. of people (living in residencies and surfaces) exposed to Lzsn(Lden) 70-74	0

No. of people (living in residencies and surfaces) exposed to Lzsn(Lden) >75	0

Data processing

Data used for the development of Strategic Noise Maps and Action Plans include: airport coordinates [2]; runway dimensions and physical characteristics [2]; airport plan [2]; air traffic data (airport); data regarding the flight paths and flight profiles [2]; data regarding the number of population, number of residencies and statistical distribution of population; data about the level curves; the map with cities; building types and heights. Data regarding the flight paths and flight profiles [2] include the Aerodrome Obstacle Chart, Precision Approach Terrain Chart, Standard Departure Charts and Instrument Approach Charts. All the aforementioned are further processed through the use of BaseOPS (v 7.363) software pack (calculus and prediction) for noise mapping. In addition, NoiseMap – Washmer Consulting (v 4.969) is the software pack used for editing and visualizing airport GIS data.

Table 3.9 – Air Traffic Data [20]

Year	Total No. of Movements	No. of Movements (smaller or military aircraft)
2016	10,269	346
2017	11,781	380

Additional input data regarding air traffic that was taken into account during the process of noise mapping refers to the distance between the airport reference point and the runway reference point, the distance between the landing point and the runway reference point, the distance between the take-off point and the runway reference point, the runway length and direction, the ID code for each runway (i.e. RWY14 and RWY32) and the description of the flight path, split in sections, starting with the runway reference point, separated for take-off and landing.

Data with respect to the degree of use of the flight paths was taken into account because the directions used for take-off/ landing have a direct influence on the areas affected by noise generated by airport activities.

Table 3.10 - Statistical data with respect to the degree of use of flight paths [20]

RWY	Operation type	2014	2015	2016	2017
RWY14	*Landing*	70.12%	69.34%	68.23%	73.95%
	Take-off	51.40%	53.12%	52.21%	57.37%
RWY32	*Landing*	29.88%	30.66%	31.77%	26.05%
	Take-off	48.60%	46.88%	47.79%	42.63%

Total number of aircraft movements	1.124	6.057	10.269	11.781

Information about aircraft movements was classified according to international aircraft categories defined by **ICAO** [21]. The **distribution of aircraft movements on flight paths** has been provided by the airport and will be presented in the following tables, together with the **distribution of aircraft movements on time intervals** (day, evening, night).

The description of airport traffic [19]	
Reference time interval	(366 days = 8748 hours) (the days for the beginning and end of the interval will be mentioned, with the according dates)
Day time	0700-1900 = 12 hours
Evening time	1900-2300 = 4 hours
Night time	2300-0700 = 8 hours

Emission data for aircraft movements – Local Time [19] **The number of movements according to the aircraft type**						
	RWY15			**RWY33**		
Aircraft Type	**Day 07-19**	**Evening 19-23**	**Night 23-07**	**Day 07-19**	**Evening 19-23**	**Night 23-07**
AT45	52	8	6	68	9	0
AT75	12	17	6	19	19	19
DH8D	27	0	0	23	0	0
B733	33	15	2	53	15	4
F70	1	0	0	1	0	0

These data were processed and introduced in the calculus program according to [15], Cap.2.3.

Noise Maps Description

Acoustic maps were computed with a raster, spatial grid of 10m, at a height of imission of 4m above ground. There were taken into consideration the reflections from the buildings, acoustic obstacles and the effects of the terrain on noise propagation.

For the determination of the number of citizens exposed to a certain level of noise, the computation points were placed on the facades of the buildings. For this case, it is not taken into consideration the last reflection on the façade of the building, on which the computing point is situated. Calculus regarding the affected people are done, as well for a height of 4m above ground (see **HG 321/2005** [6]).

Next, there will be presented strategic acoustic maps at a scale of 1:10000. The colour code for the representation of noise level curves are included in the Action Plans.

Table 3.13 - Aircraft Movements (2016) [20]		
Direction	Movement type	Number of aircraft movements on flight paths
RWY14	ARR	3501
	DEP	2683
RWY32	ARR	1630
	DEP	2455

Table 3.14 - Percentage distribution of aircraft movements on LRIA, according to the type of movement and time interval (2016) [20]			
Movement type	Day time (0700-1900)	Evening (1900-2300)	Night time (2300-0700)
Landing	64.40%	27.53%	8.07%
Take-off	66.29%	18.12%	15.59%

Previous programmes for noise reduction and current measures against noise

Iasi Airport has been preoccupied with noise control as an outcome of airport operations. In this line, **Strategic Noise Maps and Action Plans** were developed in 2014.

From the measures proposed in the first Action Plan (2014) [19], Solution 1 was implemented, i.e. the development and use of a new runway having a different orientation such that is avoids as much as possible overflying communities. Its orientation modified the flight paths and reduces in a significant manner overflying surrounding communities. The new runway started to be completely used since October 2014. The estimated reduction was between 3 an 18 dB(A). This solution was assessed to have high costs, with a negative impact on air traffic growth. This scenario implied overflying the Eastern part of Iasi city (mostly industrial areas) and the Western part of Aroneanu Village, leading to a decrease in the number of exposed people.

Solution 2 (2014) [19], i.e. increasing the use of the Northern direction for take-off and landing, was partially implemented to reduce the generated noise level in residential areas. Most landings during the night time (more than 90%) are from the Northern direction (RWY14 direction), while on this direction are the equipment for assisted landing in low visibility conditions. The estimated reduction of the noise level was between 3 and 14 dB(A), implying medium costs for implementation. Further implications include a higher fuel consumption and a higher noise burden in the Northern area, i.e. an increase of 10 dB in the Northern area and a decrease to no exposure in the Southern area.

Aircraft not compliant with **ICAO Annex 16 Volume I ("Aircraft Noise") Chapter 2** [22] **or FAA FAR Part 36 Chapter 2** [23] are not allowed to operate on Iasi Airport since April 2002. Moreover, a significant amount (74% from the total number of aircraft in 2017) of aircraft that operate on Iasi Airport are compliant with the noise standards from ICAO Annex 16 Volume I 3rd Edition, 7th Amendment, Chapter 4. All take-off and landing operations are made in compliance with standard flight profiles.

An additional measure is with respect to the organization of the operation program such that the number of take-offs/landings is reduced as much as possible during the night at/from this airport.

Data was obtained from either official sources or though vectorization by the method of production and the methodology used for obtaining the input data is detailed in Annex (C).

Public Consultations (according to Law no. 52/2013 [10] regarding the decisional transparency in the public administration, with further modifications and updates)

In order to ensure transparency in decision-making, suggestions, recommendations and proposals can be sent to an e-mail address, by specifying the articles from the Action Plan that are referred to, which is available on the website of the airport at the same time when the announcement is made. The announcement for the official meeting have been published on the website and also in local newspapers.

The participation to the public consultation requires an a priori registration which can be done online or at the airport.

All proposals and observations discussed during the public consultation are included in the official minute and further analysed in order to establish what can be included in the Action Plan.

The minute of the public consultation, the recorded recommendations, an updated version and the final version of the Action Plan and other relevant documents are published and available on the website of the airport, respectively at the airport.

The Agency for Environmental Protection Iasi, the Iasi County Council, the City Hall of Aroneanu Village and the City Hall of Holboca Village attended previous public consultations (2014) [19].

Long-term strategy

The long-term strategy for noise reduction takes into account the analysis of sustainable measures that are focused more on the prevention of noise. Key objectives that are taken into consideration are the promotion and support of legislative changes for land-use planning in the conflict areas such that the number of exposed people is reduced and the development of both residential and airport activities are synergetic. Additional measures include maintaining an optimal number of flights during the night time.

Estimations regarding the reduction of the number of exposed people (annoyance, sleep disturbance etc.)

It is highlighted in the Action Plan the importance of informing the population of Iasi city about the noise levels that can be beared by the human body, together with the dangers they are exposing to through long-term exposure to noise with high intensity. The effects of noise are described in detail, including annoyance, communication interferences, attention and focus problems, sleep disturbances, hearing damage and stress with further implications and consequences. In addition, socio-economic effects are communicated.

Table 3.15 - Total no. of people living outside agglomerations in residencies exposed to Lden/Lnight values, at 4 metres above the ground, for the most exposed façade [20]		
Interval (dB)	No. of exposed people to Lden	No. of exposed people to Lnight
45-49	N/A	124 (2016)
50-54	N/A	154 (2016)
55-59	159 (2016)	122 (2016)
60-64	0 (2016)	0 (2016)
65-69	0 (2016)	0 (2016)
70-74	0 (2016)	0 (2016)
>75	0 (2016)	0 (2016)

Table 3.16 - Total surface (km^2) outside agglomerations exposed to the values of Lden/Lnight greater than 55, 65 and 75 dB [20]		
Indicator value (dB)	Total surface for Lden	Total surface for Lnight
>55	N/A	2.9956 (Aroneanu Village) 92016)
>65	0.1218 (2016)	0.0049 (2016)
>75	0.00 (2016)	0 (2016)

Table 3.17 - Total surface (km^2) exposed to the values of Lden/Lnight greater than 55, 65 and 75 dB [20]		
Indicator value (dB)	Total surface for Lden	Total surface for Lnight
>55	5.4321 (2016)	N/A
>65	0.1218 (2016)	N/A
>75	0 (2016)	N/A

Table 3.18 - The number of residencies exposed to the values of Lden/Lnight greater than 55, 65 and 75 dB [20]		
Indicator value (dB)	Number of residencies for Lden	Number of residencies for Lnight
>55	92 (2016)	N/A
>65	0 (2016)	N/A
>75	0 (2016)	N/A

Table 3.19 - The number of people exposed to the values of Lden/Lnight greater than 55, 65 and 75 dB (including agglomerations) [20]		
Indicator value (dB)	Number of people for Lden	Number of people for Lnight
>55	244 (2016)	N/A
>65	0 (2016)	N/A
>75	0 (2016)	N/A

Table 3.20 – Data regarding the number of exposed people [20]			
Indicator value (dB)	Total number of exposed people	No. of people exposed, living outside agglomerations	No. of people exposed, living inside agglomerations
*The total number of people living in residencies (at 4m above the ground and for the most exposed façade) exposed to **Lden>70 dB(A)**, according to strategic noise mapping for 2016* [20]			
>70	0	0	0
*The total number of people living in residencies (at 4m above the ground and for the most exposed façade) exposed to **Lden>65 dB(A)** – **The target for the long-term target value**, according to strategic noise mapping for 2016*			
>65	0	0	0
*The total number of people living in residencies (at 4m above the ground and for the most exposed façade) exposed to **Lnight>60 dB(A)**, according to strategic noise mapping for 2016* [20]			

>60	0	0	0
The total number of people living in residencies (at 4m above the ground and for the most exposed façade) exposed to ***Lnight>50 dB(A) – The target for the maximum allowed value****, according to strategic noise mapping for 2016* [20]			
>50	approx. 300	276	0

Table 21 – Data regarding the number of exposed residencies [20]			
Indicator value (dB)	Total number of exposed residencies	No. of exposed residencies outside agglomerations	No. of exposed residencies inside agglomerations
The total number of residencies (at 4m above the ground and for the most exposed façade) exposed to ***Lden>70 dB(A)****, according to strategic noise mapping for 2016* [20]			
>70	0	0	0
The total number of residencies (at 4m above the ground and for the most exposed façade) exposed to ***Lden>65 dB(A) – The target for the long-term maximum allowed value****, according to strategic noise mapping for 2016* [20]			
>65	0	0	0
The total number of residencies (at 4m above the ground and for the most exposed façade) exposed to ***Lnight>60 dB(A)****, according to strategic noise mapping for 2016* [20]			
>60	0	0	0
The total number of residencies (at 4m above the ground and for the most exposed façade) exposed to ***Lnight>50 dB(A)****, according to strategic noise mapping for 2016* [20]			
>50	103	103	0

Table 22 – Data regarding the number of exposed surfaces [20]	
Indicator value (dB)	Total surface (km^2)
Total surface (km^2) exposed to values of ***Lden>70 dB*** [20]	
>70	0.00

Total surface (km2) exposed to values of **Lden>65dB – The long-term target for the maximum allowed value** [20]	
>65	0.1218
Total surface (*km*^{2}) *exposed to values of* ***Lnight>60 dB*** [20]	
>60	0.5847
Total surface (*km*^{2}) *exposed to values of* ***Lnight>50 dB*** [20]	
>50	10.338

Trends, overarching processes and internal systems that underpin the implementation of ICAO Balanced Approach

The airport had one concrete runway (2014) [19] used for take-off and landing of 1800m length and 30m width, with two paved verge areas of 7.5m and a running path having 135m length and 15m width and an additional platform with four parking slots. According to these dimensional restrictions, only small types of commercial aircraft could be operated at that time. An extension was planned through the construction of a new take-off and landing runway, which was later accomplished.

In 2014 [19], no line of the public transport network was reaching the airport. A new line was planned by the local public transportation network to operate from the centre of the city (i.e. Piata Eminescu) to the airport, having four stops. One route segment was planned to last for around 30 minutes. Depending on its post-implementation evaluation, the route could be further extended to connect the train station with the airport. Currently, the plan was implemented, including the extension segment that links the train station with the airport.

Flight Procedures: Low Visibility Procedures (LVP) are available. Runway 14 is approved for CAT II operations. Both RWY14 and RWY32 are approved for LVTO. Standard Instrument Departure (SID) is available on both RWY14 and RWY32. [2]

The SPICE Project [24]

The European Project SPICE (Synchronized PBN Implementation – Cohesion Europe) is part of the implementation phase (2014-2024) of SESAR (SES) that seeks the increase of Air Traffic Management (ATM) efficiency and of Air Navigation Services (ANS) through decreasing the fragmentation level of the European airspace. Through its nature, this initiative is Pan-European. Predicted advantages through the application of SES (Single European Sky) estimate a triple increase in airspace capacity, a 50% reduction in ATM costs, a 10% safety increase and a 10% impact reduction of aviation on the environment.

SPICE involves the implementation of a navigation system based on PBN performance, exploiting RNAV (Area Navigation Systems) advantages of modern aircraft in order to support an efficient design of the airspace and the systematization of air traffic routes, in pursuit of optimizing the available airspace.

The implementation period of the project is from 2016 to 2020 and is coordinated by EUROCONTROL. Partners range from air carriers (Aegean, **Blue Air**, Regional Air Service, SATA, Tap Portugal), to air traffic service providers (DCAC, HCAA, LPS SR, NAV Portugal and **ROMATSA**), including also the Romanian Civil Aviation Authority (AACR) and the Romanian Airports' Association (AAR).

At the Romanian level, the project implies a series of activities to design, approve and operate RNAV SID/STAR systems and procedures (RNP APCH LNAV, LNAV/VNAV, LP and minimum LPV) through the use of the GNSS signal (EGNOS). The tasks of the project include data collection through the development of obstacle studies for all participant airports, as well as the design, encoding and authorization of the equipment for PBN implementation. The application of the project activities will assist the progress of controlling operations inside the Romanian airspace through PBN, thus facilitating safer and more efficient trajectories, altogether with reducing the rate of missed approach and redirection.

In the first phase of the project, i.e. the Design and Implementation Activity, all airports that are members of AAR have to collect data regarding obstacles, followed by the design of RNAV SID/STAR procedures for international airports only. The specific order for the second requirement is the following: Sibiu, Baia Mare, Bacau, Tulcea, Suceava, Timisoara, Craiova, Arad and Constanta (first stage); Iasi and Oradea (second stage); Bucuresti Baneasa, Satu Mare and Targu Mures (third stage); Cluj-Napoca and Bucuresti Henri Coanda (fourth stage).

Airport Obstacles

Table 23 - Aerodrome Obstacles for the Approach and Take-off Area/ in Circling Area and at the Airport [2]

RWY/ Affected Area	Obstacle Type	Elevation [m]	
		[m]	[ft]
RWY14 Approach	Church		
RWY32 Take-off	LM Antenna		
(Approach/Take-off Area)	Building		
	Tree		
	Antenna		
	Antenna		
	Building		
	Mast		
	Mast		
	Antenna		
	Building		
	Mast		
	Building		

	Building		
	Mast		
	High Power Mast		
RWY14 Approach *RWY32 Take-off* *(Circling Area and at the Airport)*	High Power Pylon		
	Hill		
	Antenna		
	Cross		
	High Power Pylon		
	Forest		
	Hill		
	High Power Pylon		
	Building		
	Tree		
	Mast		
	Antenna Mast		
RWY32 Approach *RWY14 Take-off* *(Approach/Take-off Area)*	Antenna		
	High Power Pylon		
	Hill		
	Cross		
	Hill		
	High Power Pylon		
	High Power Pylon		
	Forest		
	Hill		
	Hill		
	Antenna		
	Antenna mast		

Further relevant airport information

On the Western part of the airport is the Ciric forest, "Eternitatea" cemetery and Iasi Municipality. On the Northern side is Aroneanu city, on the Eastern side is Valea Lunga city and in the Southern part is UM 01175 (Military Facility) and Aviation district (with residencies).

The terrains from the immediate vicinity are mainly used for agricultural purposes, therefore no industrial sources or traffic sources to general a high level of noise exist.

Table 24 – Land-use in the proximity of Iasi Airport [19][20]	
Direction from the airport	Activity
Northern	Agricultural fields and Aroneanu Village
Southern	Agricultural fields; UM 01175 (Military Facility); Aviation District (from Iasi City)
Eastern	Agricultural fields; Valea Lunga Village (approx. 2 km from the runway threshold)
Western	Ciric forest and Iasi city

Table 25 - Number of aircraft operating on LRIA and type of aircraft (2016) [20]	
Aircraft type	Aircraft Number
A318/320	1495
ATR42/75	2757
B737	5103
DH8D=ATR	478
F80/100/ERJ	90
Others	346

It can be observed from this table that an approximative of 4% (3.7%) of the total number of aircraft used in 2016 are of non-commercial type.

Statistical data (2011) regarding the population, number of residencies and statistical distribution of population [19]			
Establishment name	Iasi Municipality	Aroneanu Locality/ Aroneanu Village	Dancu Locality/ Holboca Village
Establishment type	Agglomeration	Village	Village
No. of inhabitants	290,422.00	3402.00	11,971.00
No. of residencies	13,138.00 residential	546.00 residential buildings/ 662.00	2215.00 residential buildings/ 2472.00

	buildings/ 114,181.00 residencies	residencies	residencies
Average no. of household residents	2.52 people	2.94 people	2.94 people
Population density	3109 inhabitants per square metre	92.2 inhabitants per square metre	258.9 inhabitants per square metre
Distance from LRIA	8 km W from LRIA	3 km N-NW from LRIA	4 km SE from LRIA

<u>**THE CASE STUDY**</u>

<u>Introduction</u>

Through the years, the Romanian legislation on noise (HG 321/2005 [6]) suffered several modifications, putting in charge of developing Strategic Noise Maps and Action Plans other airports having less than 50,000 movements per year. The criteria for selecting additional airports was defined by the number of residents inside agglomerations close to an airport, i.e. airports near or inside agglomerations having more than 100,000 inhabitants. Currently, ten airports [Annex(A)] with less than 50,000 movements per year are defined as <u>Urban Airports</u>, having the responsibility of developing Strategic Noise Maps and Action Plans similar to END [5] provisions for Major Airports. The Urban Airports are: **Bucharest** (Baneasa) - Aurel Vlaicu International Airport, Avram Iancu (**Cluj**) International Airport, **Iasi** International Airport, **Craiova** International Airport, **Oradea** International Airport, **Sibiu** International Airport, Transilvania (**Targu Mures**) International Airport, Maramures (**Baia Mare**) International Airport and George Enescu (**Bacau**) International Airport. Since 2016, **Satu Mare** International Airport was included as an Urban Airport, as well [26].

<u>Identification of environmental needs</u>

In this context, the construction of a new runway was selected as a measure within the first Action Plan [19] developed by **Iasi Airport** in order to modify the direction of flight such that surrounding communities become less overflown. The project started in the same year with the Action Plan and the new runway RWY14/32 (DEP and ARR) was put in use by the end of the year. Until then, RWY 13/33 was in use, which was situated south from the new runway.

In 2015, Iasi Airport was also engaged in the developed of annoyance case studies, being the first Romanian airport involved in this area. Results from the study and the expected development of residential areas around the airport showed that noise exposure and impact for the next years risk to increase, in spite of the efforts of the airport to avoid overflying communities through building a new runway one year before. [27]

<u>Selected options in response to environmental needs</u>

Studying the extent of implementation of ICAO Balanced Approach pillars [13] started for Iasi Airport when they decided to engage with all relevant stakeholders (CAA, ANSP, airlines) and various other potential stakeholders (Ministries, local authorities, regional authorities) in order to research all available options to both prevent airport expansion limitations and community noise exposure and impact.

Conclusions drawn on practices available and applicable for Romanian Airports were formulated around the necessity of a properly-defined policy on land-use planning, which was unavailable at that moment.

Implementation processes

Territorial planning was defined as the responsibility of City Halls and Regional Counties, i.e. local and regional authorities, with further implications to the Ministry of Development and Public Administration. Airports had no involvement whatsoever with respect to noise in the development of Urbanism Plans.

In this context, Iasi Airport, initiated discussions and meetings on noise management at Romanian Airports, with the support of all other Romanian Airports and the CAA.

Dialogue was initiated between local and regional authorities and Iasi Airport on understanding the noise impact on communities around the airport and finding solutions together on reducing impact and preventing similar exposure situations. Various criteria were evaluated, e.g. economic and social impact of noise management measures, concluding that land-use planning was needed as the best solution, yet a legislative context was still unavailable. At the time Iasi Airport entered ANIMA EU Project (2017), the context was still the same.

Further experiences and research of Iasi Airport on land-use planning implementation in other European Airports within ANIMA Project, led to conclude that collaboration between relevant stakeholders is key to apply efficient noise management measures, as well as communication with other European Airports to learn from their challenges and best practices encountered during interventions. This approach was later applied to the need of a land-use planning policy for noise management.

During 2018, various meetings were initiated by Iasi Airport, gathering all potential stakeholders, from Ministries of Environment, Health, Transport, representatives from local and regional authorities, representatives of all Romanian Airports, CAA, ANSP and airlines, as well as research experts. Discussions were specifically formulated around aviation noise management, particularly land-use planning needs, together with the urgency of collaboration between all relevant stakeholders, including the communities. Data from all official meetings was disseminated through local media, in order to ensure transparency and to inform the public about current efforts of airports towards reducing noise exposure and impact. [28]

Evaluation of results. Post-implementation changes. Mitigation actions

Immediately after one official meeting, a new legislative change was proposed, empowering the status of the previous transposition of END [5] from Governmental Decision [6] to Law [11]. This change was determined by the need to ensure a better understanding of noise management and to highlight the importance of collaboration between all relevant stakeholders during noise mitigation. Various other stakeholders became officially responsible for airport noise management, compared to the previous situation, when only the airport was in charge. According to these provisions, quiet areas will be determined by local authorities in compliance with Strategic Noise Maps.

Further legislative changes occurred, e.g. the transposition of **Regulation (EU) no. 598/2014** [14], regarding ICAO BA operational restrictions, which provisioned further involvement of stakeholders in aviation noise. For example, the CAA has to support the official authority for environmental protection during the process of evaluating aircraft noise on airports and to offer assistance for conflict management between safety requirements and environmental protection requirements, while the ANSP has to provide necessary information for compliance with noise operating restrictions [29].

A new version of the "Air Code" was proposed for adoption. Provisions include the requirement for Noise Maps to be considered within Airport Development Plans during their development. In addition, recommendations were formulated for considering Noise Maps in local/regional Urbanism Plans by Local and Regional authorities for land-use planning. Acoustic zoning is proposed as a responsibility of the Ministry of Environment.

Additional changes were included in December in a rule issued by the CAA for the requirements for the design and approval of instrumental flight procedures [30]. Noise alleviation procedures are included as a provision when necessary and all relevant stakeholders have to reach a common agreement on the requirements needed for the design of new procedures or modification of the current ones, taking into account noise exposure.

Methods and tools. Interdependencies. Other relevant information

Iasi Airport is the first Romanian airport that conducted an annoyance case study, in order to determine the reaction of the surrounding communities to aircraft noise. [27]

Further developments on LRIA [25]

Future developments include the construction of an additional taxiway in order to be able to operate aircraft bi-directionally, as well as the enlargement of the processing capacity for the aircraft parking platform with 4-6 new parking spots. The estimated time of implementation is 12 months, having an estimated cost of approx. EUR 14,000. Such developments are necessary, as the current income from airport activities is lower than maintenance costs.

Due to the fact that the platform for boarding and disembarking has a limited number of parking spots, difficulties are faced in satisfying the requirements of air carriers for flight scheduling, especially during peak hours. In this respect, an extension of the platform is planned in the Southern area for a distance of 270 metres. The width of this extension is similar to the width of the existing platform.

Conclusions

As it can be easily observed from the Review of Noise Action Plans, the increase in the number of total movements is approximately of 14.7% from 2016 to 2017. The overall situation of air traffic shows a constant increase. In this respect, the **land-use planning and management** pillar of ICAO Balanced Approach was considered by the airport as being the best option to ensure the necessary protection from noise for all communities surrounding the airport. From the position of being a public airport, i.e. owned by the state and functioning under the Local and Regional Authorities, Iasi Airport, as well as almost all Romanian airports, have little decision-making competence in land-use. Therefore, communication and engagement with the relevant stakeholders and the communities were crucial in taking the first steps into including provisions of land-use planning and management within the National legislative framework.

RECOMMENDATIONS AND LESSONS LEARNT

More specific trainings on both awareness and understanding of the noise issue are needed especially for airport representatives, as well as for all relevant stakeholders, communities included. In this respect, guidance is needed for the introduction of noise management within the overall management such that environmental benefits can be obtained proportional to the increase in the performance of daily operations.

A legislative change to include and efficiently support **land-use planning and management** is considered highly important by all relevant stakeholders. Even if some provisions have been introduced within the National legislative framework, a specific policy on **land-use planning and management** is still necessary. In addition, guidance for ensuring a proper understanding and application of **land-use planning and management** is needed for all relevant stakeholders, as well as for community awareness.

Constant focus should be placed on effective communication and collaboration between all relevant stakeholders in aviation noise, in order to understand and discuss the noise situation at a National level, as well as find solutions to reduce noise impact and noise effects in a timely manner. As a result, the communication and engagement with communities can be established and/or supported by either stakeholder, depending on its competence in aviation noise. In this respect, guidance is needed for ensuring effective communication on noise management between stakeholders relevant to aviation noise.

All such measures have to be detailed in a more universal manner such that they take into account and overcome limitations such as the differences between Major Airports and airports having less than 50,000 movements per year, the differences between the National legislative frameworks of different Member States and others.

A policy on noise complaint management is needed in order to establish the competent authorities responsible for the collection and storage, analysis and assessment of complaints on noise, together with ensuring the provision of the necessary feedback, mitigation and oversight of changes.

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8.4 Case Study 4 – Kiev Airport

Kiev Boryspil International Airport

This case study provides an overview of the previous, current and proposed practices of **Boryspil International Airport (Kiev)**, as a part of their Noise Management Strategies.

The structure of the case study is constructed such that the actions and interventions accomplished by **Boryspil International Airport (Kiev),** are presented in a descriptive and detailed manner with the purpose of emphasizing lesson learning and good practices.

All information used for the development of this case study was gathered from documentary sources that are mentioned in the 'Reference' section.

The target audience of the case study includes airport operators and several other relevant stakeholders such as Air Navigation Service Providers, Civil Aviation Authorities, aircraft operators, environmental and government organisations and other interested parties.

<u>Introduction about the airport</u>

<u>Background information</u>

Air traffic growth in Ukraine was highlighted by a rapid increase in demand in 2011, reaching an overall number of 12.5 million passengers. Cargo air traffic also increased in the same year by 11%, as compared to 2010, reaching 47.2 thousand tons of cargo and mail.

The air traffic situation in Ukraine fluctuated over the years, decreasing in 2014 with 2.7%, as compared to 2013. Currently, both the number of passengers and cargo in air traffic are increasing.

More than 90% of overall Ukrainian air traffic is managed by five strategic airports: **Boryspil**, Dnipropetrovsk, Odessa, Lviv Kharkiv and Kiev (Zhuliany Airport).

Statistic data collected since 2011 pinpointed **Boryspil International Airport** as the manager of over 60% of the overall passengers and over 70% of the total air cargo.

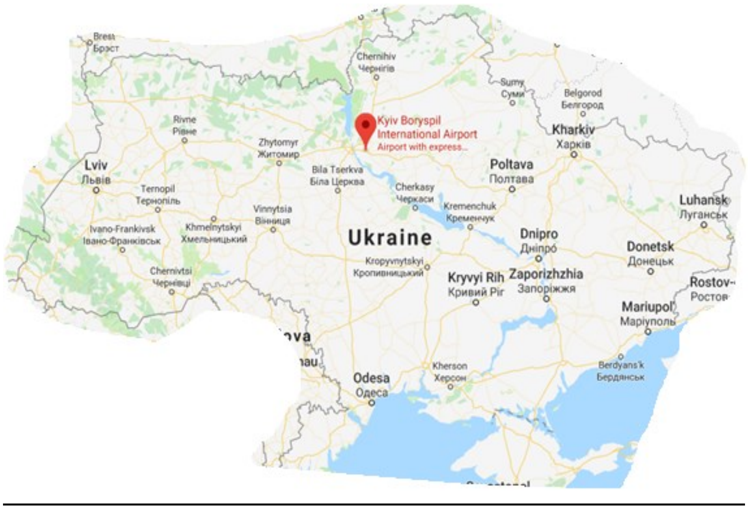

Figure 4.1 - Boryspil International Airport (Source: Google Maps)

Figure 4.2 - Boryspil International Airport (Source: Google Maps)

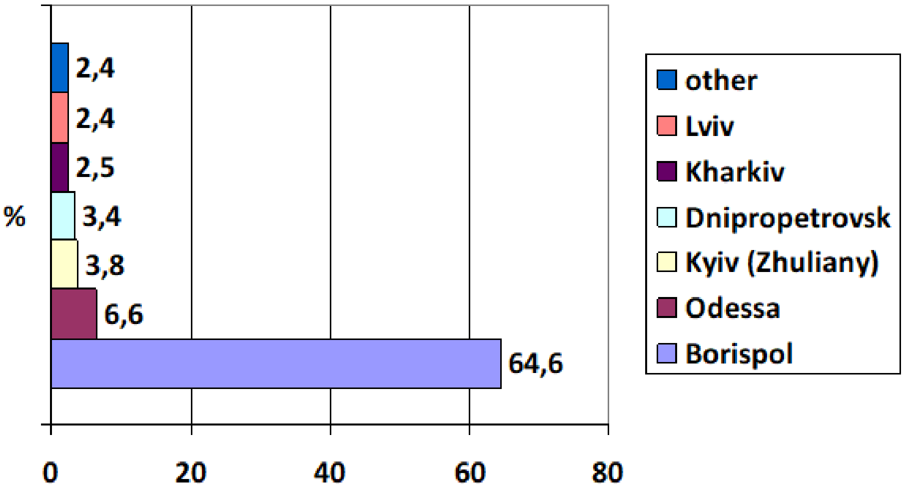

Figure 4.3 - Share of Ukrainian Airports in Passenger Transportation (2011) [3]

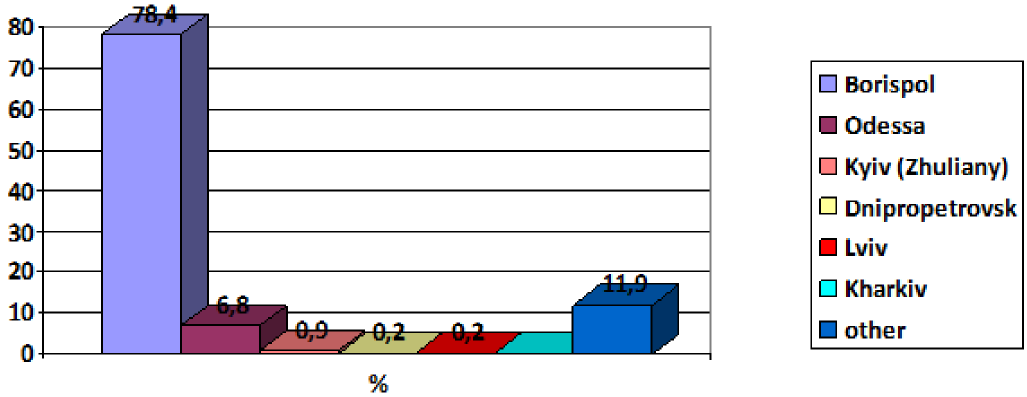

Figure 4.4 - Share of Ukrainian Airports in Cargo and Mail Transportation (2011) [3]

Table 4.1 - Aircraft movements at Boryspil International Airport expressed in thousands [3]

Year	2009	2010	2011
Aircraft movements	86	97	107

The National Noise Legislative Framework

Strategic noise maps and Noise Action Plans are still absent for all major airports in Ukraine. EU Directives related to Environmental Noise [4] and Noise Related Operating Restrictions [5][6] are not transposed in the National legal system, therefore not implemented for environmental noise control.

With regards to the END criterion defining a major airport [4], i.e. an airport having more than 50,000 movements per year, Boryspil International Airport (Kiev) is the only Ukrainian Airport compliant to this requirement. Other Ukrainian Airports are designated as City Airports, in the case when they are completely surrounded by urban agglomerations.

All certified aerodromes of airports and aerodromes of aviation enterprises in Ukraine have to develop noise maps (Noise Protection Zones), maps for third party risk (Public Safety Zones), assess the local air pollution (Sanitary Protection Zones) and the electro-magnetic fields (EM Protection Zones). These maps are mandatory to be developed to ensure compliance with the certification procedures for aerodromes of airports.

Noise level thresholds are defined in the Ukrainian legislative framework for determining the eligibility for façade sound insulation under certain circumstances, noise impact of air transport included (façade sound insulation). The criteria are described by the State Sanitary Rules [7], which state that the norms presented in the below Table are established for the limitation of residential or administrative constructions in the vicinity of an airport.

Restrictions for constructions around civil airports according to Ukrainian legislations [3]				
Type of restriction in a zone	**Daytime**		**Nightime**	
	L_{AeqD}, dBA	**L_{AmaxD}, dBA**	**L_{AeqN}, dBA**	**L_{AmaxN}, dBA**
Unsuitable for construction	■75	■90	■65	■80
Protection against noise	<75 ■65	<90 ■80	<65 ■55	<80 ■70
Limitations for residential construction	<65 ■55	<80 ■70	<55 ■45	<70 ■60

State Sanitary Rules [7], impact are developed in compliance with the requirements of the Ukrainian Law "On ensuring the sanitary and epidemic wellbeing of the population"[8].

The State Sanitary Rules [7] include a chapter titled "Protection from noise and vibration". Several criteria are included for ensuring noise protection, such as:

- The provision of the acoustic regime on the territory, compliant to the hygiene norms, should be integrated within the means of application of city planning, building and construction solutions, administrative and organizational measures.
- For ensuring the protection against noise and vibration, city planning methods should include measures for zoning the territory with settlements, measures for rational planning and for the organization of the street-road network and the development of sanitary protection zones around the main stationary sources of acoustic radiation.
- Residential buildings, pre-school establishments, schools, health care institutions and boardinghouses for the elderly should be located in the zone most distant from the sources of acoustic pollution. When choosing the type of building, especially in the first echelon near the sources of elevated levels of sound, it is necessary to take into account the protective acoustic properties of the structures and the need for maximum reduction in collective acoustic load on the population.
- In order to reduce the contribution of the street and road network to the general acoustic load on the population, it is considered necessary to use: rational planning measures that exclude main streets crossing a densely populated local area, a recreational area, a sanatorium and resort areas; artificial and natural acoustic screens; sound protective structures or protective elements in the buildings of the first echelon of the construction. When a system of street and road network is designed for a settlement, the options that reduce the total area of the acoustic discomfort zone and that take into account the current and future density of the population, should be favoured.
- All external sources of acoustic pollution should be located at certain distances from the city and from areas of recreation, based on acoustic calculations. Examples of external sources of acoustic pollution include: highways, airports, stations, industrial facilities, transformers, parking lots, boiler housing buildings, garages, playgrounds and others. Acoustic calculations should be carried out in accordance with the methods adopted by the Ministry of Health of Ukraine.

Ukraine has no statutory noise mapping procedure similar to END requirements [4]. Noise maps for any environmental noise source are created through computer modelling techniques rather than through actual noise measurements. In the case of airport noise, noise maps were developed through the use of IsoBella model. This is the civil aircraft noise model used in Ukraine, which was designed by the National Aviation University.

Noise limits have been introduced at airports individually for the day time (0700h-2300h) and the night time (2300h-0700h) [7]. Airport Operators have the responsibility of monitoring compliance. Financial fees for non-compliance are not yet established.

Specific quotas for the number of landings of noisier aircraft during the night time are not introduced in Ukraine. Some recommended restrictions are stated by the CMU Decree [9].

The Annex N18 of the Sanitary Rules [7] defines 4 Noise Protection Zones around the airports, as presented in the below table.

Noise Zoning Norms [1]				
Day time	**A**	**Б**	**B**	**Г**
Day	$L_{Aекв} \le 60$ $L_{Amax} \le 80$	$61 \le L_{Aекв} \le 65$ $81 \le L_{Amax} \le 85$	$61 \le L_{Aекв} \le 65$ $61 \le L_{Amax} \le 85$	$L_{Aекв} > 65$ $L_{Amax} > 85$
Night	$L_{Aекв} \le 50$ $L_{Amax} \le 70$	$51 \le L_{Aекв} \le 55$ $71 \le L_{Amax} \le 75$	$56 \le L_{Aекв} \le 60$ $76 \le L_{Amax} \le 80$	$L_{Aекв} > 60$ $L_{Amax} > 80$

The Annex N19 of the Sanitary Rules [7] defines the opportunity and conditions for the construction of new buildings inside Noise Protection Zones, as presented below.

Categories of buildings [1]				
Designation of buildings	**Construction of buildings inside zones**			
	A	**Б**	**B**	**Г**
Residential buildings, kindergartens	is permitted	is permitted with increased sound insulation of external enclosures that provide noise reduction, ΔL_A dBA 25	30	is prohibited
Polyclinics	is permitted in part of the zone with the levels in the daytime $L_{Aекв} \le 55$ dBA	is permitted with enhanced soundproofing, which provides $\Delta L_A = 30$ dBA		is prohibited

	without limitations, $L_{Aекв} \leq 56\text{-}60$ dBA with increased sound insulation ($\Delta L_A = 25$ dBA)			
Schools	is permitted	is permitted with enhanced soundproofing, which provides $\Delta L_A = 25$ dBA		is prohibited
Hotels	is permitted	is permitted with enhanced soundproofing, which provides ΔL_A dBA 25	30	
Administrative buildings, design and research organizations	is permitted	is permitted	is permitted	is permitted if the necessary sound insulation is provided

The Ministries of Regional Development, of Building Construction, of Housing and of Communal Services of Ukraine, adopted the Building Codes [10] that state the rules for: ensuring the noise protection of territories with normalized noise levels and construction objects with the use of urban planning; architectural and planning measures and acoustic noise reduction devices; norms of permissible noise levels in territories and buildings of different buildings; provisions for performing acoustic calculations and for the evaluation of the noise regime in the territories and in the premises of houses; requirements for sound insulation of internal and external enclosing structures of residential and public houses; the procedure for selecting and using plantation measures and acoustic means for reducing noise levels to the values set by Sanitary Norms.

The provisions of these Building Codes [10] establish the minimum requirements for acoustic indicators of any object under construction. In agreement with the customer (consumer, investor), the level of application of the requirements for sound insulation of enclosing structures and the permissible noise levels for new objects under the construction may be increased in comparison with the requirements of the Building Codes [10].

Responsible Authorities

The Ministry of Infrastructure is the main Governmental Department for Transport in Ukraine. It is responsible for Civil Aviation and establishes the overall Ukrainian Aviation Policy.

Civil Aviation Authority (CAA) is a department of the **Ministry of Infrastructure** of Ukraine and acts as the Ukrainian independent airspace and safety regulator, as well as the National Supervisory Authority responsible for the planning and regulation of the national airspace. The CAA establishes the Ukrainian airspace change processes, including how environmental impacts are taken into account. In addition, the CAA receives, analyses and decides upon proposals made for changing the notified airspace structure or certain procedures used by Air Navigation Service Providers.

The CAA has the additional responsibility of collaborating in and reviewing research regarding noise effects and proposed solutions on their reduction, together with formulating recommendations on these findings for the Government. Furthermore, the CAA is responsible for monitoring noise around airports, for installing noise protection zones around airports and for inspecting the construction of buildings inside declared noise zones.

Ukrainian airports are responsible for providing air navigation services in the airspace closest to the airport and for their standard instrument departure and arrival routes. They are responsible for the noise protection zones in their vicinity, ensuring the compliance with settlements and human activities inside them.

The approach on the Balanced Approach

Summary of the National Noise Legislative Framework. Airport implementation processes

Some provisions of ICAO Balanced Approach and END [4] were transposed into the National legislation within the Ukrainian Air Code [11]. This article establishes the ICAO procedures with respect to the introduction of noise-related operating restrictions at Ukrainian airports. These include: taking into account costs and benefits of new measures; being non-discriminatory on grounds of nationality or identity of air carrier or aircraft manufacturer and being no more restrictive than necessary in order to achieve the environmental objectives for a specific airport; ensuring any performance-based operating restriction is based on the noise performance of the aircraft, as determined by ICAO certification procedures.

The review of Noise Action Plans and previous Balanced Approach interventions

END [4] is not transposed into the national framework, therefore Strategic Noise Maps and Action Plans are not required. Nonetheless, noise maps are developed by all Ukrainian airports and enterprises for their aerodrome certification, such that noise boundaries (Noise Zones) around airports are properly defined, in line with their operations and further planned developments.

ICAO Balanced Approach pillars are not transposed within the Ukrainian legislative framework.

Trends, overarching processes and internal systems that underpin the implementation of the Balanced Approach

Control of Noise at Source: The Aviation Rules of Ukraine [12] grant the Government the ability to introduce noise control measures to limit or mitigate the effect of noise connected with take-off or landing aircraft. Airport Operators can introduce differential charges to incentivise the use of quieter and cleaner aircraft. This measure is not currently used in Ukraine.

PART 21 from the Aviation Rules of Ukraine [13] sets out the noise certificate requirements for both propeller and jet aeroplanes registered in Ukraine. It states that no aircraft can land or take-off in the Ukraine without a noise certificate issued by its competent authority, which meets at least the equal requirements to those for Ukraine registered aircraft. The regulations refer to noise certification chapter standards and limits issued by ICAO.

Operational Procedures: A range of noise controls relating directly to aircraft operations at any airport are published in the AIP [14]. Available information cover measures such as the Continuous Descent Approaches (CDAs), noise abatement procedures and night flight restrictions. Even so, they are not mandatory, nor currently applied.

It is recommended that the procedures for the initial phase of departure and final phase of arrival to be designed is such a manner to avoid overflying the residential area.

Land Use Planning (i.e. planning for future developments): art. 5.21 of [7] requires that the location of the aerodromes (for the use of helicopters) under construction should be transferred outside urban and rural settlements in accordance with the requirements of the Building and Construction Norms [16] (replacing [15]). Compliance is particularly related to the requirements of Art. 10.1.14 [16] regarding new airports, aerodromes, heliports, take-off and landing sites, helicopter take-off and landing sites (except helicopter sites on buildings and hospitals) that must be situated outside agglomerations.

The distance between the boundaries of an airfield of a new aerodrome (including heliports not located on buildings and hospitals), the aircraft routes and tracks (initial phase of departure and final phase of landing) and the boundary of existing/prospective building and mass leisure venues should be set as to ensure, in these areas, normative values of acoustic (noise) pollution.

It is recommended for airports to be connected by rapid types of passenger transport with the stations of the city transport, with the city centre, with other airports and population centres. In this regard, the walking distance to the transit stations should not exceed 100 metres.

The distance from the boundary of the airfield (including helicopter airfields), from the radio and meteorological stations, from the testing stations of aircraft engines and other aerodrome objects, from the routes of aircraft to the exit boundary or from prospective construction and mass recreation areas should provide hygienic norms inside these areas, noise in accordance with [17][18], as well as the maximum permissible levels of electromagnetic radiation.

Sanitary Norms [18] require that assessment of non-constant noise for compliance with the permissible levels should be carried out simultaneously for the equivalent $L_{A\ \text{экв}}$ and maximum $L_{A\text{макс}}$ sound levels, dBA.

Acceptable values of the equivalent and maximum sound levels on the territory of the building should be taken according to Sanitary Norms [18] with further amendments to them on the nature of noise, location of the object for external noise sources [18]. As an example, for territories adjacent to residential buildings, it is recommended that the equivalent sound level should not exceed 55 and 45 dBA and the maximum sound levels should not exceed 70 and 60 dBA from 7 to 23 hrs and from 23 to 7 hrs accordingly. The equivalent and maximum sound levels for noise created on the territory by means of aviation, automobile and railway transport are assessed on distance 2 m from the protective structures of the first echelon of residential buildings, hotel buildings, dormitories, wrapped in the direction of the main streets of the city. For railway and aviation noise, a positive correction of 10 dBA is allowed. These requirements are further reinforced in Annex N16 of [7].

The Building Codes [10] contain rules for designing noise protection of territories with normalized noise levels and construction objects with the use of urban planning, as well as rules for architectural and planning measures and acoustic noise reduction devices. In addition, they include norms of permissible noise levels in territories and buildings of different buildings, provisions for conducting acoustic calculations and evaluations of the noise regimes in the territories and in the premises of houses. Further provisions are described with regards to the requirements for sound insulation of internal and external enclosing structures of residential and public houses, together with the procedure for selecting and using plantation measures and acoustic means for reducing noise levels to the values set by Sanitary Norms.

The provisions of these Building Codes [10] establish the minimum requirements for acoustic indicators of any object under construction. In agreement with the customer (consumer, investor), the level of requirements for sound insulation of enclosing structures and permissible noise levels for new objects under the construction may be increased in comparison with the requirements of these Building Codes [10].

The Order No. 721 from Ministry of Infrastructure [19] states that "The procedure for coordinating the location and height of objects at the aerodrome territories and objects whose activities may affect the safety of flights and the operation of radio civil aviation devices", which requires the Aerodrome Operator to ensure mandatory compliance with the statement "…indicates the influence of the construction object (reconstruction) on the ornithological situation in the area of the aerodrome and at the aerodrome territory and must provide evidence materials regarding the assessment of the location of the building in relation to the sanitary protection zone and the developmental zones defined around the aerodrome regarding the conditions of aviation noise and electromagnetic radiation, as well as public safety zones, regarding the conditions of aviation events risk".

The Rules for Certification of Civil Aerodromes of Ukraine [20] require that evidence-based documentation must include maps of the aerodrome territory with boundaries of the zones of restriction for residential development around the aerodrome under the conditions of impact of aviation noise, electromagnetic radiation, third party risk, the boundaries of sanitary protection zones from atmospheric pollution conditions, together with explanatory notes for the aforementioned and conclusions regarding the use of the lands within these zones.

Since 2016, the CAA developed and adopted a State Target Programme for Airport Development in Ukraine to be implemented until 2023 [21] according to which airports become the property of Airport Operators as state enterprises, including the necessary land that becomes their permanent property.

ICAO Balanced Approach was described by the Air Code of Ukraine [11] as a main approach to be used for noise control around the airports. Nonetheless, these principles were never implemented in Ukraine for mitigating the impact of aircraft noise.

Noise impact mitigation and communication are described within the "Balanced accounting of flight safety and environmental requirements" [22], which is partially implemented.

Operational restrictions are maintained partially, yet Airport Operators can introduce differential charges to incentivize the use of quieter aircraft.

THE CASE STUDY

All the certified aerodromes of the civil airports and aerodromes of the aviation enterprises in Ukraine have to develop noise maps (Noise Protection Zones), as well as maps for third party risk (Public Safety Zones), local air pollution (Sanitary Protection Zones) and electro-magnetic fields (EM Protection Zones). These maps are mandatory for the certification procedure of the airports.

Ukraine has noise level thresholds established by regulations for determining the eligibility for façade sound insulation under certain circumstances, including for air transport noise impact (façade sound insulation). These provisions are set out in the State Sanitary Rules [7], which state that the norms are set for the limitation of residential or administrative construction in the vicinity of an airport.

The State Sanitary Rules [7] are developed in accordance with the requirements of the Ukrainian Law "On ensuring the sanitary and epidemic well-being of the population" [8].

There is one designated airport that is regulated directly by central Government, via the Ministry of Infrastructure of Ukraine. This is Boryspil International Airport. Noise controls at the designated airport act as best practice for other Ukrainian airports.

A comprehensive review of the noise intervention

The identification of environmental needs

The Rules for Certification of Civil Aerodromes of Ukraine [20] require that evidence-based documentation must include maps of the aerodrome territory with boundaries of the zones of restriction of residential development around the aerodrome under the conditions of impact of aviation noise, electromagnetic radiation, third party risk, the boundaries of sanitary protection zones from atmospheric pollution conditions (with explanatory notes) and conclusions regarding the use of the lands within these zones.

Ukrainian airports are responsible for noise protection zones in their vicinity, ensuring the compliance with settlements and human activities inside them.

Implementation processes

According to the general rules applicable for Civil Aviation in Ukraine, the certification of aerodromes of civil airports and aerodromes of aviation enterprises, must include the definition of a noise area, therefore the development of noise maps. Furthermore, an explanatory report is designed such that the impact of aviation noise is specifically detailed, based on current available data and on predicted traffic fluctuations or growth.

Noise maps are constructed using a software program that takes into account the statistics with the number of movements used by the airport. At the moment when noise maps are designed, the most recent data is used, thus including information from the previous year. Further data included refers to information about the fleet mix, expected changes in the current fleet configuration, e.g. a specific number of aircraft planned to be bought before the development of the next noise map, number of aircraft planned to be scrapped, number of new routes to be opened and others. By taking into account all aforementioned data, together with other strategic business developments, including infrastructure modifications, a noise map is designed starting from the current available data and taking into account predicted changes for the next 5, 10 or 15 years and for the maximum operational capacity of the aerodrome based on the model of runway capacity in terms of aviation safety.

Noise maps for any environmental noise source are developed through computer modelling techniques (IsoBella Model – Ukraine's Civil Aircraft Noise Model, NAU) and in most cases, except for Zhuliany (Kiev), Odessa and Boryspil Airports, without noise measurements.

Reports based on the obtained noise maps are developed such that a strategy in terms of land use can be further determined based on the overall air expected traffic growth and airport developments. Noise indicators used are the Leq and LAmax in order to depict the average and maximum noise exposure scenario that can develop in the next 5, 10 or 15 years and for the maximum operational capacity of the aerodrome based on the model of runway capacity in terms of aviation safety. These reports have to be included and sent for obtaining the certification of the aerodrome.

Type of restriction in a zone	Daytime		Nightime	
	L_{AeqD}, dBA	L_{AmaxD}, dBA	L_{AeqN}, dBA	L_{AmaxN}, dBA
Unsuitable for construction	≥75	≥90	≥65	≥80
Protection against noise	<75 ≥65	<90 ≥80	<65 ≥55	<80 ≥70
Limitations for residential construction	<65 ≥55	<80 ≥70	<55 ≥45	<70 ≥60

Figure 4.5 - Restrictions for constructions around civil airports according to Ukrainian legislations [3]

All information gathered regarding the current noise situation at the airport, together with the predicted noise situation for the next 5, 10 or 15 years and for the maximum runway operational capacity are used for determining the noise boundaries of the airport, which are further transposed as areas of restriction for residential development under the conditions of aviation noise impact. In this case, residential buildings are prohibited in areas surrounding the airport where noise exposure has been assessed as 'unsuitable for construction' through the use of Leq and LAmax noise indicators.

For aerodrome certification, the scenarios that are taken into consideration for the calculation of noise expose maps are: the number of aircraft operations equal to the present-day intensity; the predicted number of aircraft operations for the next 10-15 years; the maximum airport operational capacity ensuring safe operations. For airport reconstruction/expansion programmes, two scenarios are considered for the development of noise exposure maps, i.e. the number of aircraft operations equal to the current intensity and the predicted number of aircraft operations for the next 10 years, taking into account aircraft fleet changes.

Three scenarios were considered for Boryspil International Airport (Kiev) in 2011:

1. The first calculated scenario took into account the <u>fleet and the intensity of aircraft movements</u>. It showed that a noise level equal to 75 dBA Leq, which determines an area to be considered unsuitable for construction, is not present in any residential area around both runway directions.
2. For the second scenario, a <u>doubled intensity of aircraft movements for the year</u> was taken into account and <u>the fleet is changed</u> in compliance with Chapter 3 of ICAO Annex 16 (Volume I) [23] and Directive 2002/49/EC [4]. Due to the fleet change, contours characterized by 55, 65 and 75 dBA are similar to the contours obtained from the first scenario.

3. The third scenario considered an intensity of aircraft movements as equal to the maximum runway capacity, together with a fleet compliant to Chapters 3 and 4 of ICAO Annex 16 (Volume 1) [23].

As a main consequence, the residents that live closest to the airport are not exposed to high levels of noise as they are situated outside noise zones, i.e. outside limit contours.

Methods and tools. Interdependencies. Further relevant information

Noise complaints are collected, recorded and processed by the airport and the CAA.

Monitoring compliance with noise limits is the responsibility of the airport operator. Noise monitoring is overseen by the CAA.

Conclusions

By taking into account predictions regarding the noise situation around airports, both airport development and population health are protected in a preventative manner. In this way, airports, irrespective of their category, either major airports or having under 50,000 movements per year, can ensure means of protection for the population and reduce both noise exposure and impact as such contours can be used in line with the overall expected airport development.

A close cooperation between the airport and city administrations resulted in successful definitions of airport noise zones, such that all interests are represented, i.e. population protection against noise, airport expansions and residential developments, thus being a best practice that accounts for the development of air traffic and its economic implications, while taking into account the environmental needs. The approach considered by Boryspil International Airport (Kiev) in terms of best available option and best practice was oriented more on optimising processes and their performance, i.e. noise zones definition, rather than searching for technical solutions, as façade insulation is already mandatory by Ukrainian legislations.

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8.5 Case Study 5 – Ljubljana Airport

This case study provides an overview of the previous, current and proposed practices of **Ljubljana Airport**, as a part of their Noise Management Strategies.

The structure of the case study is constructed such that the actions and interventions accomplished by **Ljubljana Airport,** are presented in a descriptive and detailed manner with the purpose of emphasizing lesson learning and good practices.

All information used for the development of this case study was gathered from the airport, interviews with relevant stakeholders and online sources. Interviews included representatives from the **airport, airlines, ANSP (Air Navigation Service Providers) and other relevant stakeholders (Ministry of Infrastructure, Ministry of Environment and Spatial Planning, Municipality of Kranj, Ombutsman)**. The interview findings were correlated with all other available information and included within the case study. Most of the topics of the interviews were formulated around the knowledge, understanding and application of ICAO Balanced Approach, together with further actions designed to reduce and mitigate noise and its effects.

The target audience of the case study includes airport operators and several other relevant stakeholders such as Air Navigation Service Providers, Civil Aviation Authorities, aircraft operators, environmental and government organisations and other interested parties.

Background Information

Fraport Slovenija is the operator of Ljubljana (Joze Pucnik) Airport, having as its core business the airport management and operation, airport infrastructure development, provision of ground handling services and other commercial activities. This is the central Slovenian international airport, managing approximately 97% of the total passenger air traffic in Slovenia.

Fraport Slovenija, formerly known as Aerodrom Ljubljana until April 2017, is 100% owned by the German company Fraport AG Frankfurt Airport Services Worldwide (Fraport AG), since 2014. The company owns several parts of land, enabling both airport expansion and development of other complementary activities.

The strategic location of the airport is considered ideal for the development of flight connections and further activities related to the airline industry, as it is located at the crossroads of air traffic flows between the Pannonian Basin and the Po Valley, as well as between the Middle East and the European Union, through Istanbul Strait.

Table 5.1 - General Airport Information [1]

Name of the	Fraport Slovenija

company	
Aerodrome location indicator and name	LJLJ – LJUBLJANA/BRNIK
Aerodrome geographical and administrative data	
Direction and distance from the city	348° and 20 km from the centre of Ljubljana city
Elevation	388 m (1274 ft)
Reference temperature	27.5° C
AD Administration	Fraport Slovenija, d.o.o.
Types of traffic permitted (IFR/VFR)	IFR and VFR
Passenger facilities	
Transportation	Public buses, taxies, car rental agencies, shuttle service
Radio navigation and landing aids	
Type	VOR/DME, DVOR/DME, MKR ILS RWY 30 L/OM, MM, GP 30, DME, LOC CAT IIIB

Table 5.2 – General Airport and Air Traffic Information [2]	
Number of employees	428
Total number of passengers	1,688,558 (19.6% growth from 2016)
Number of passengers in public traffic	1,683,071
Total number of aircraft movements	34,444
Number of aircraft movements in public traffic	26,045
Total cargo	24,314 [t]
Air cargo	12,327 [t]
Scheduled flight connections	26
Charter flight connections	26

Table 5.3 - Runway Physical Characteristics [3]

RWY Designator	TRUE BRG MAG BRG	RWY Dimensions [m]	THR elevation [m]
12	126.38° TRUE 123° MAG	3300 x 45	THR 388.3
30	306.41° TRUE 303° MAG	3300 x 45	THR 362.9

The airport has a 3,300 metres long runway used for both departures and arrivals, being equipped with modern technologies that allow landings in reduced visibility conditions compliant to ICAO IIIB category.

Before 2015, air traffic was declared as moderate, following a 10% increase in 2015, when compared to the previous year.

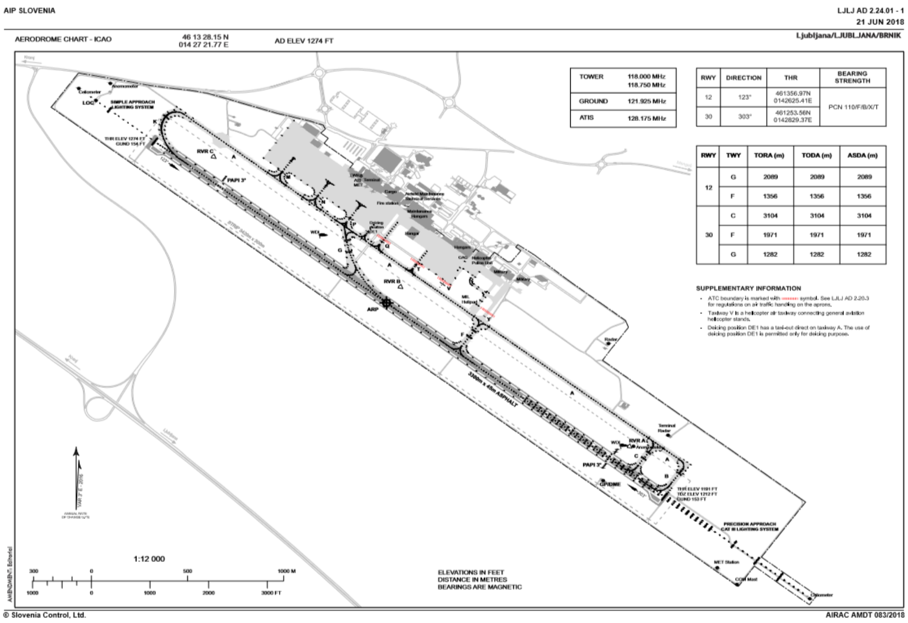

Figure 5.1 - Aerodrome Chart – ICAO [4]

Ljubljana Airport is an active member of various expert groups operating under ACI Europe (Airports Council International Europe), as well as a member of the Aviation Security Committee that deals with civil aviation security issues at airports. Other memberships include the Regional Airport Forum, ACI Communications Group and Digital Communications Forum.

Applicable Noise Rules and Regulations

General Noise Rules and Regulations in Slovenia

The Environmental Noise Directive (END) was implemented in Slovenia in 2004 through the *Decree on the assessment and management of environmental noise* [5].

Limiting values for environmental noise are set by the *Decree on limit values for environment noise indicators* [6]. *Rules on initial measurements and operational monitoring of noise sources and on conditions for their implementation* exist and are applied in Slovenia [7].

Four noise sensitive areas (industrial – IV, residential/retail/manufacturing – III, mainly residential – II and nature/quiet areas – I) were defined by the Ministry of Environment and Spatial Planning, where most residential areas are classified as Zone III, or Zone II. In addition, limit values were established for each noise area.

Aviation Noise Rules and Regulations in Slovenia

Since no airport in Slovenia qualifies as a "major airport", Strategic Noise Maps and Action Plans compliant with END are not needed. Ljubljana Airport (letališče Jožeta Pučnika) has the highest number of movements per year, e.g. 32,000 in 2008.

Limiting values for aviation noise are set by the *Decree on limit values for environment noise* [6]. Four noise sensitive zones are defined, where one zone (Zone III) includes areas in the vicinity of airports. Small airports have lower limits than major airports (i.e.>50,000 movements/yr). The limits for Zone III and small airports are: Lden = 58 dBA, Lday = 58 dBA, Levening = 53 dBA, Lnight = 48 dBA.

Table 5.5 – Airport Limit Values [8]

Type of airport	Noise Zone	Lden/Lday [dBA]	Levening [dBA]	Lnight [dBA]
Below 50,000 movements/year	Zone II	52	47	42
	Zone III	58	53	48
Above 50,000 movements/year	Zone II	60	55	50
	Zone III	65	60	55

The Council Directive 89/629/EEC of 4 December 1989 on the limitation of noise emission from civil subsonic jet aeroplanes has been transposed [9].

The position regarding the implementation of ICAO BA operating restrictions was established in 2012 at a meeting within the National Assembly, stating that: "The Republic of Slovenia supports the adoption of a proposal for a regulation of the European Parliament and of the Council on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports in the framework of a balanced approach and the repeal of Directive 2002/30/EC of the European Parliament and of the Council".

ICAO Annex 16 "Environmental Protection" is mentioned as part of the aviation legislation [10].

Noise Control at Source ("Rules on Noise Emission of Aircraft") are also present in National Regulations [11].

When the number of airport operations is increased, the National Institute of Public Health (NIJZ) or the National Laboratory of Health, Environment and Food (NLZOH) performs a health impact assessment. An increase in the number of flights is not proportional to an increase of noise, therefore all such information is further included in the assessments, including aircraft categories. The assessment and opinion issued by either NIJZ or NLZOH are sent to the Ministry of Health, which sets the position regarding the spatial plan for the Ministry of Environment and Spatial Planning. They further take into consideration the noise limits for different areas regarding the land use (industrial, residential/retail/manufacturing; mainly residential and nature/quiet areas). The responsible institution performs the environmental noise impact on public health according to the National Legislation for Spatial Planning, involving the Environmental Protection Act [12], the Spatial Planning Act [13], the Decree on environmental encroachments that require environmental impact assessments [14] and the Siting of Spatial Arrangements of National Importance Act [15].

Guidelines for national spatial plans are in preparation at the Ministry of Health, including aviation noise and recommendations for compliance with ICAO Balanced Approach.

Further discussions regarding legislative changes consider a change in the noise limit values for airports that are not major in order to establish limit values comparable to road traffic and major airport limit values. Such an action might imply changes from 58 to 65 dBA for Lden and 48 to 55 dBA for Lnight.

Additional expected changes include a change in the Aviation act and development of "Rules on Noise and Aircraft Emission Control".

The approach to ICAO Balanced Approach and Noise Management

Slovenia has no airport exceeding 50,000 movements per year, therefore Strategic Noise Maps and Action Plans are not required for END compliance. Nonetheless, Ljubljana airport performs noise monitoring and collects all necessary data for mapping environmental noise. Examples can be found in references [16-18].

General Overview

Regulations that are in force to avoid excessive aircraft noise in the populated areas from the vicinity of the airport include various provisions for the application of **Noise Abatement Procedures** [3]. The aforementioned state that aircraft not certified in compliance to ICAO Annex 16 (Vol. I, Chapter 3) are not permitted. Exemptions can be granted by the Civil Aviation Agency (CAA) of Slovenia in justified cases.

In order to reduce noise disturbances, all aircraft operators that use the airport shall follow the recommended noise abatement procedures from the manufacturer. In addition, they have to always ensure that the aircraft is operated such that unnecessary noise disturbances are not generated in the areas surrounding the airport, especially during the intervals where nighttime restrictions apply. Such compliance shall not be required during adverse weather conditions or for safety reasons.

One instrument departure procedure is in use at Ljubljana Airport as a Noise Abatement Procedure that uses a steep climb gradient. This was designed in order to reduce noise exposure for communities living in the Western side of the airport.

Supplementary noise alleviation measures refer to the use of Auxiliary Power Units (APU). Restrictions include that APU shall be started no earlier than 30 minutes before the engine start-up (off-block time) and be operated no longer than 30 minutes after the engine shutdown (on-block time). In addition, APU shall be started only if aircraft maintenance makes it unavoidable, in which case the service period shall be kept as short as possible.

Reverse thrust, apart from idle, shall not be used in the interval 22:00-06:00 LT (21:00-05:00 UTC), except for safety and operational considerations.

Night flying restrictions are also included under the chapter of NOISE ABATEMENT PROCEDURES within the AIP, where the interval of application is between 22:00-06:00 LT (21:00-05:00 UTC), in which two restrictions apply for noise abatement reasons. First of all, RWY30 will not be normally used for departures during the interval 22:00-00:00 LT (21:00-23:00 UTC), while pilots shall expect departures from RWY12. Second of all, departures from RWY30 between 00:00-06:00 LT (23:00-05:00 UTC) are not permitted.

Such restrictions do not apply to departures including safety, meteorological, technical and SAR reasons.

Run-up tests are presented as another category of noise abatement procedures [3], according to the Slovenian AIP. Engine ground runs on the aprons are not permitted when they are not associated with the planned aircraft departure. Exceptions for engine check starts and run-up tests to the ground IDLE power may be granted by the ATC (main apron) and GAC (general aviation apron) in justified cases. During such engine ground runs, continuous radio communication shall be ensured with the ATC and GAC. Engine ground runs having the performance level greater than IDLE must be performed in the Engine Run Zone. Exceptions may be granted by the ATC in justified cases for the use of the authorized area (run-up position) within the maneuvering area, during which continuous radio communication shall be ensured with the ATC. Such ground runs with performance level greater than IDLE may be performed in the interval 06:00-22:00 LT (05:00-21:00 UTC), for which time limit exceptions are granted for engine tests on ERZ AAT for aircraft on the line maintenance.

Engine tests on Maximum Take-Off Power are not allowed.

Operator Adria Airways d.o.o. is a major operator at Ljubljana Jože Pučnik Airport, actively engaged with the Ministry of Infrastructure, CAA, Slovenia Control and Ljubljana Airport in the development of operational procedures that take into account the reduction of the noise imprint on the environment during departures and arrivals.

Further considered actions include the implementation of Continuous Descent Approach (CDA), displaced landing thresholds and reducing power/drag. A recommendation includes the revision of non-standard procedures in terms of noise impact.

Due to the lack of National Regulations for **land-use planning and management** for aviation noise, no specific measures are established.

Runway operations are the main source of noise in the airport area, this being the reason why all noise management actions were initiated the airport [2].

In December 2008, a systematic approach to monitoring noise by continuous measures of noise in the immediate surroundings of the airport was established. Based on the data sent by measurement units into the control centre, noise sources are identified and noise burden is determined on a daily and yearly basis. As a main result, noise maps are produced on a yearly basis. Data acquired is correlated with radar data in order to ensure an easier and more reliable manner of identification of various sources of noise. Such measures are performed in compliance with both National and International Regulations, in cooperation with external performers in four most exposed points, focusing on settlements under the take-off and landing surfaces. According to these results, air traffic noise as an average monthly indicator has fluctuated below the prescribed limit value of noise in the environment. Two measuring points obtained data showing that the level of noise for the limit indicator is achieved, particularly in the evening summer days, when the level of traffic is increased. In this respect, a sound level meter was relocated in 2014 from Lahovče, where the measuring results have constantly been below the limit values, to Kranj. The motivation was that this area was exposed to a higher number of movements, according to the aircraft departure procedure in use since 2013 [8].

Low levels of noise emissions are perceived as essential for the quality of life in local settlements, therefore the airport decided to provide the information on noise measurements to locals to the fullest extent. Apart from the regular periodical noise reports, an interactive application on the website is available, where people can monitor the average noise indicators of overflying aircraft over the settlements during take-off and landing [18].

A policy on insulation is unavailable at the moment.

Recommendations from interviews include considering noise as a criterion for building authorisations. In addition, the need for a legislation for land-use planning and noise zoning was expressed.

The Environmental permit for noise emissions due to the operations of Ljubljana Jože Pučnik Airport has been extended in 2015, being valid until the end of November, 2020.

The Airport is using **operational restrictions** only as an action to reduce noise exposure, during the night time (00:00-06:00 CET), when departures in the direction of Šenčur Municipality are not permitted. As a general practice, clearances are not granted for departures in the direction of Šenčur during the interval 22:00 – 00:00 CET. This agreement, including a limited number of flights above settlements during the night was established between the airport and the local authorities, therefore it was ensured that the noise limit is never exceeded during the nighttime. Results showed a significant reduction of noise complaints.

Trends, overarching processes and internal systems that underpin the implementation of ICAO Balanced Approach

Flight Procedures

The flight procedures applicable for flights within the Ljubljana TMA (Terminal Maneuvering Area) for the approach, holding and departure, are based on the provisions from ICAO Annex 6 ("Operation of Aircraft"), ICAO Annex 14 ("Aerodromes"), Doc 4444 – RAC/501 ("Rules of the Air and Air Traffic Services (PANS-RAC)"), Doc 8168 – OPS/611 ("Aircraft Operations (PANS-OPS), Volume I and II") [3].

RNAV SID/STAR (Area Navigation Standard Instrument Departure Route/Standard Arrival Route) procedures are applied and based on GNSS only for RNAV 1 (P-RNAV) certified aircraft. RNAV instrumental procedures are developed in compliance with ICAO PANS-OPS Doc 8168, Volume II criteria and with EUROCONTROL Guidelines for the design of Terminal Procedures for Area Navigation. RNAV 1 (GNSS) certified aircraft shall plan RNAV SID/STAR. A database coding table according to the ARINC 424 standard exists for each SID and STAR procedure. SIDs also include the textual description of each procedure [3].

In the case of airborne RNAV equipment failure, the ATC will provide radar vectors. Procedures are designed at or above MRVA and are monitored by radar.

Aircraft not equipped with appropriate RNAV systems that are departing or arriving shall plan their route according to published conventional procedures [3].

Due to the lack of DME facilities, the use of DME/DME is not acceptable [3].

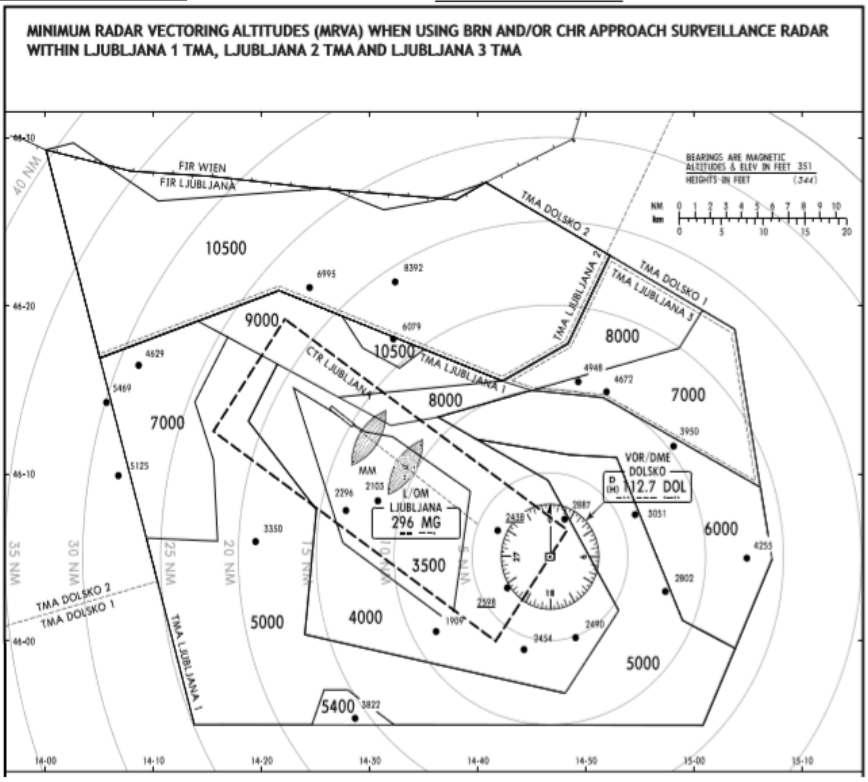

Figure 5.2 - RADAR VECTORING CHART – ICAO [19]

RNAV STAR procedures are defined by a route that is associated with a profile which includes flight levels/altitudes and speed restrictions. Air crews should plan RNAV STAR in compliance with the vertical restrictions specified by STAR charts, unless they are specifically cancelled by the ATC. If no different instructions are given by the ATC, the aircraft shall follow the speed restrictions published in RNAV charts. If possible, CDO (Continuous Descent Operation) should be applied through the entire STAR procedure [3].

RNAV SID procedures may include a published initial cleared level, as well as level restrictions at specified waypoints. Cleared levels issued explicitly by the ATC shall override the published level [3]. SID charts and other detailed information can be found in Annex (2).

The holding procedure is designed above VOR/DME DOL as a conventional, multi-entry holding pattern. This holding procedure is available for non-RNAV 1 (P-RNAV) certified aircraft, as it is not designed as a part of the RNAV system [3].

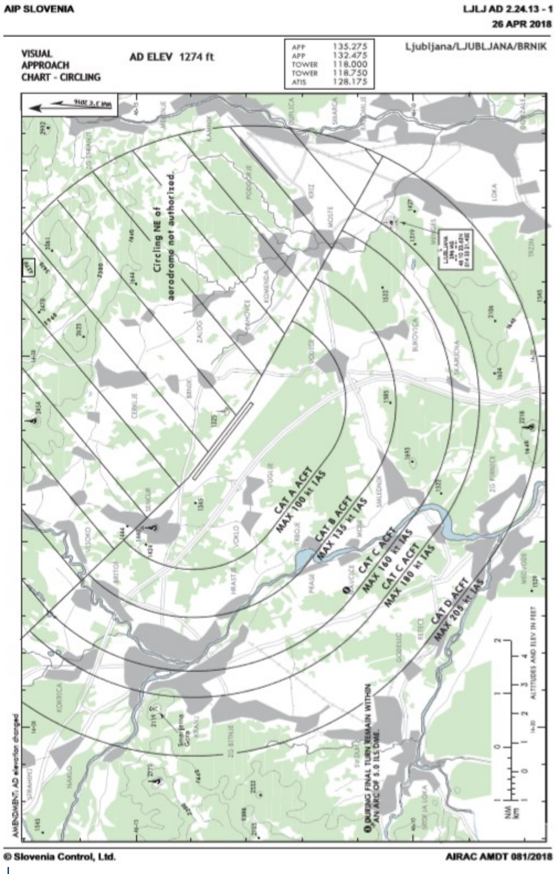	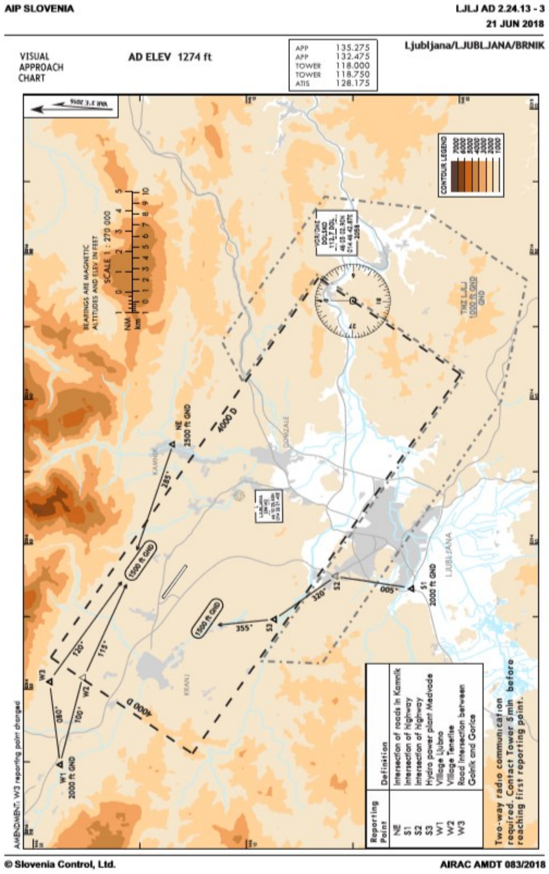
Figure 5.3 - VISUAL APPROACH CHART – CIRCLING [20]	**Figure 5.4 - VISUAL APPROACH CHART** [21]

VFR flying aircraft having the intention to enter Ljubljana CTR shall follow the procedures that include as reporting points the intersection of roads in Kamnik from North-East; the highway intersection and the hydro-power-plant Medvode from South; the village Ljubno, the village Tenetiše and the road intersection between Golnik and Gorice from West [3].

In the case of low visibility operations, CAT II/III approach and landing operations are authorized on RWY30. The minimums for the categories of precision approach and landing operations are as it follows in the table below.

Minimum Values for the Categories of Precision Approach and Landing Operations [3]			
CAT II	RVR ≥ 300 [m]	and	200 [ft] > vertical visibility ≥ 100 [ft]
CAT IIIA	RVR ≥ 175 [m]	or	100 [ft] > vertical visibility ≥ 50 [ft]
CAT IIIB	175 [m] > RVR ≥ 125 [m]	or	Vertical visibility < 50 [ft]

Such operations are subjected to the serviceability of the available facilities/systems and procedures. The CAT II/III facilities available on RWY30 are: ILS LOC (IIIE4), co-located GP/DME OM, MM; no-break battery power supply; lighting; precision approach CAT II and III lighting system; threshold and runway end lights; runway centre line (15 [m] intervals) and runway edge light (60 [m] intervals); touchdown zone lights; taxiway edge lights and colour coded taxiways centre line lights on TWY B, C, F, K and G; daylight markings on maneuvering area; secondary power supply (switch over time 1 [second]); RVR assessment system at position ALPHA (touch-down zone), BRAVO (runway mid-point) and CHARLIE (stop end). The fixed minimum required RVR value for CAT III approach at Ljubljana Airport is 125 [m] [3].

Guided Low Visibility Take-Off (LVTO) can be performed on RWY30 and non-guided LVTO on RWY12. The facilities required for non-guided LVTO are: threshold and runway end lights; runway centre line (15 [m] intervals) and runway edge light (60 [m] intervals); taxiway edge lights and colour coded taxiways centre line lights on TWY B, C, F, K and G; secondary power supply (switch over time 1 [second]); RVR assessment system at position ALPHA (touch-down zone), BRAVO (runway mid-point) and CHARLIE (stop end) [3].

Table 5.7 - Fixed Minimum Required RVR Value for LVTO at Ljubljana Airport [3]

Guided LVTO	100 [m]
Non-guided LVTO	125 [m]

When LVTO is performed with RVR below 400 [m], the aircraft operator shall request LVP procedures to be provided. Generally, LVP are applicable for arriving and departing traffic [3].

A detailed description of local flying restrictions can be found in Annex (4).

Airport Obstacles

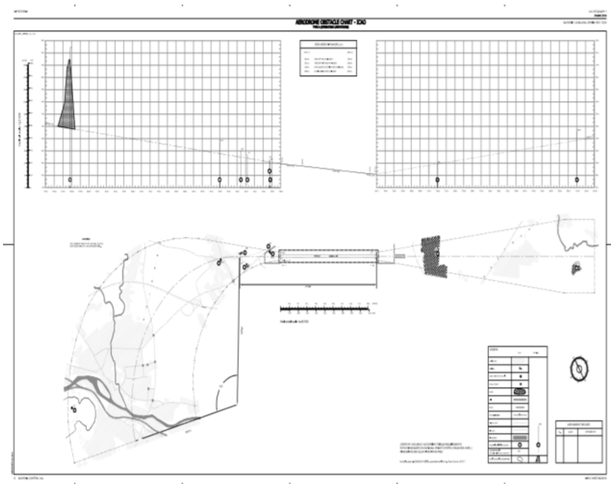

Figure 5.5 - Aerodrome Obstacle Chart – Type A (Operating Limitations) [22]

Table 5.8 - Aerodrome Obstacles for the Approach and Take-off Area [3]

RWY/ Affected Area	Obstacle Type	Elevation [m]
RWY30 Approach *RWY12 Take-off*	Forest	467.5
	Forest	389
RWY12 Approach *RWY30 Take-off*	Building	396.5
	Anemometer	400
	Forest	412
	Forest	422
	Building	442.5
	Antenna	671

Further relevant airport information

Occasional bird concentrations are expected on and in the vicinity of the airport [3].

A military airbase is located in the proximity of the airport.

THE CASE STUDY

Introduction [2]

Based on regular meetings with local municipalities and recorded complaints, the airport concluded that noise is an important issue for communities, followed by local air pollution and climate change.

Apart from all previously mentioned interventions and noise management actions undertaken by the airport, the development of Sustainability Reports on a yearly basis is an exemplary model for Community Engagement within Aviation Environmental Management [23], currently incorporated as a part of Land-Use Planning and Management within ICAO Balanced Approach. Various aspects regarding the daily operations of the company are presented and described in a transparent manner, together with their implications to the overall environment, including communities. Benefits are highlighted, together with all past, current and proposed efforts to overcome negative effects that can result from such operations, including noise management.

The development of the airport is described as focused on understanding and assessing their importance in the overall environment, being aware that the business organization and the development of infrastructure levels have a direct impact on economic, social and environmental aspects. In this respect, such business can support the employment sector, encourage entrepreneurship and the development of new infrastructure. Apart from the aforementioned, the airport acknowledges and understands the negative impact that such operations can bring to the environment, therefore a strong commitment on dealing with environmental issues was declared.

In this respect, a systematic collection of all endeavours in terms of sustainable development was created for the first time. This measure was necessary in order to provide all relevant information about the approach of the company to sustainability and to ensure transparency, showing that their projects resulted in positive results by being incorporated into daily operations.

Since 2014, the ownership of Ljubljana Airport changed to Fraport AG, a German company. Within this context, various work processes were changed, adjusted and optimized, therefore 2015 was the year dedicated to focusing on internal organization changes. Similar objectives included a focus on changes with external visibility (2016), by planning a reconstruction of the passenger terminal to improve passenger experience and eliminate airport bottlenecks. In addition, a project of relocating the road passing the airport was planned such that it will enable a spatial development of a business-logistics zone on the north side of the airport. All these projects were formulated as a part of the integration process with Fraport Group.

Airport objectives include the pursuit of development and growth, while taking into consideration a sustainable environmental orientation, customer satisfaction and good quality of life standards for employees. The aim of the environmental management system is to ensure sustainable action for the environment through the development and optimisation of protective measures and minimisation of negative effects.

Identification of environmental needs [2]

Currently, there is no airport in Slovenia exceeding the number of 50,000 movements per year. Therefore, all interventions and relevant actions were voluntarily launched at the initiative of the airport.

The current strategy of the airport is focused on sustainable development, therefore environmental management represents an important pillar within the overall business objectives, including customer satisfaction and community engagement to become in line with the operational development. The assessment of results from many noise monitoring activities and recorded complaints, noise was assessed as the main environmental issue.

In addition, a method or tool to assess the performance of the company was needed in order to have a clear and realistic view of the level of accomplishment of proposed objectives from their sustainable development strategy, especially in terms related to environmental management, where noise was assessed as being the main issue.

Selected options in response to environmental needs [2]

The development of Sustainability Reports was focused on achieving and maintaining sustainable communication both internally and externally, such that the performance of internal day-to-day operations can be assessed against environmental impacts. Objectives established in this respect provided a definition of sustainable communication such that it could approach a planned and systematic in-house and external communication, while pursuing the principles of being proactive, honest and transparent when engaging with the public. In addition, a non-discriminatory communication style, together with providing timely responses were outlined as highly important.

The objectives established for communication are: enhancing reputation and credibility of the company, raising awareness of the identity and benefits of the company, building trust in the company, establishing a direct relationship with the service users, based on dialogue and highlighting advantages, by positioning the company as an advanced, well-regulated and development oriented organization which intensively monitors trends in the field of aviation and cares for the needs and wishes of all users by providing them a comprehensive care.

Implementation processes [2]

All processes originated from the implementation of the Environmental Management System in compliance with ISO 14001 requirements. Further steps led to the development of Sustainability Reports (since 2016), in compliance with GRI (Global Reporting Initiative) Standards, in order to ensure and promote Sustainable Communication, i.e. the quality of the information, together with the transparency of processes while delivering reliable data.

Their structure is developed such that an effective communication of their sustainable objectives and strategy is ensured and can be chronologically understood. The content of the report is selected through the formulation of the 'matrix of materiality'. Criteria for selection include the relevance, involvement of stakeholders and sustainable context. Final data selections are further shaped through the filters of additional subcriteria: balance, comparability, accuracy, clarity and reliability of data. During all these processes, various departments are involved, including an environmental expert.

An important approach to promoting Sustainable Communication was the use of the Matrix of Materiality. This is a tool that supports the company in identifying and managing opportunities and risks, in relation to the strategic public. The matrix contributes to an in-depth understanding of the company in terms of sustainable development, having together all relevant areas, from environmental issues to economic and wider social aspects. Since 2017, the Matrix of Materiality was harmonized with the sustainability guidelines of Fraport AG.

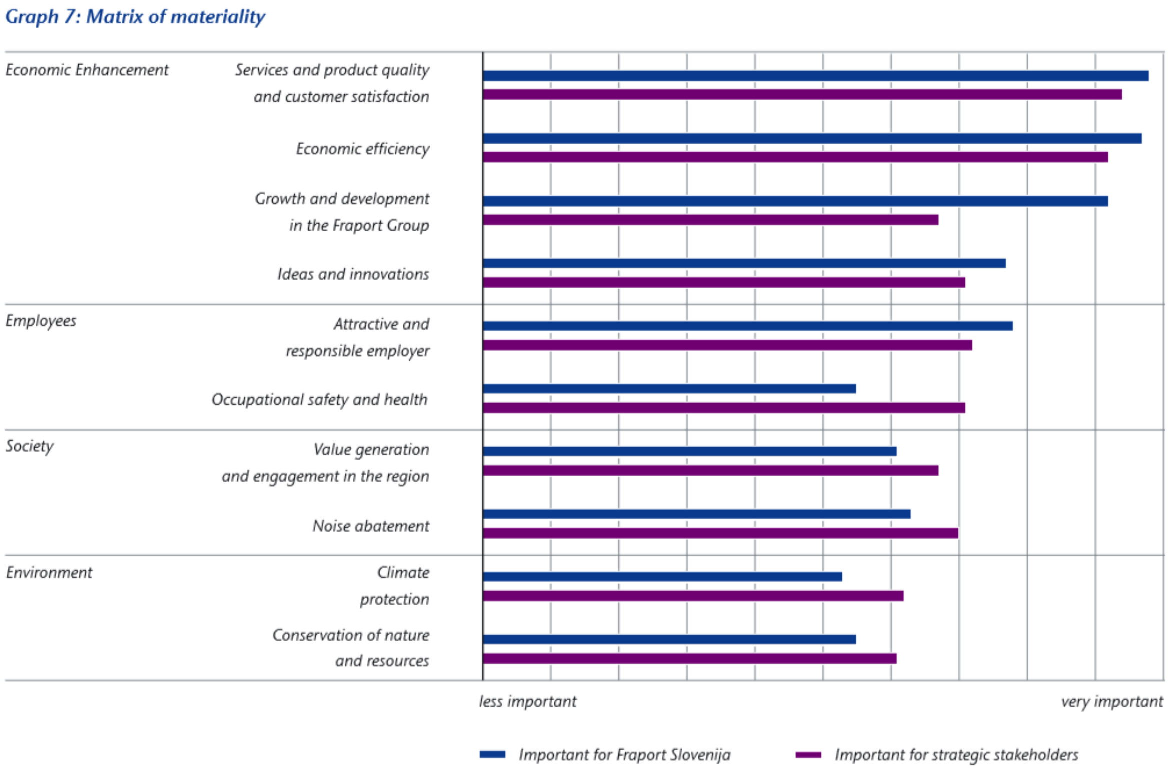

Figure 5.6 – Matrix of Materiality [2]

The key materiality areas in communication have been established by the airport through the use of GRI Guidelines and through interactive dialogue with representatives from relevant stakeholder groups. In this respect, the airport with the strategic stakeholders work continuously towards ensuring effective protection against noise.

In order to establish effective means of communication, the strategic stakeholders were clearly defined, in line with the output data from the Matrix of Materiality. Furthermore, the airport has established several goals, according to the needs of each stakeholder, as well as methods and tools to contribute to the accomplishment of each goal.

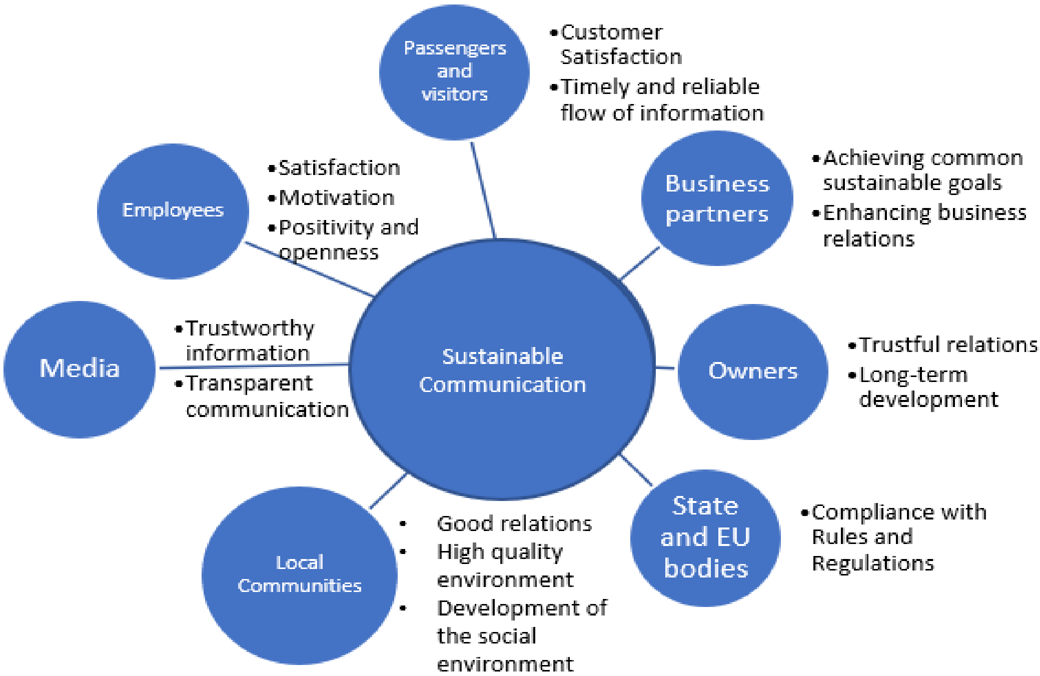

Figure 5.7 - Examples of established airport goals in relation to Strategic Stakeholders [2]

The following strategic stakeholders were identified and defined by the airport: employees, passengers and visitors, business partners, owners, State and EU bodies, local communities and Media.

Established goals vary according to each stakeholder and range from satisfaction and motivation (employees), to customer satisfaction (passengers and airport visitors), achieving common sustainable goals (business partners) or establishing and maintaining good relations, together with ensuring a high-quality environment for the local communities.

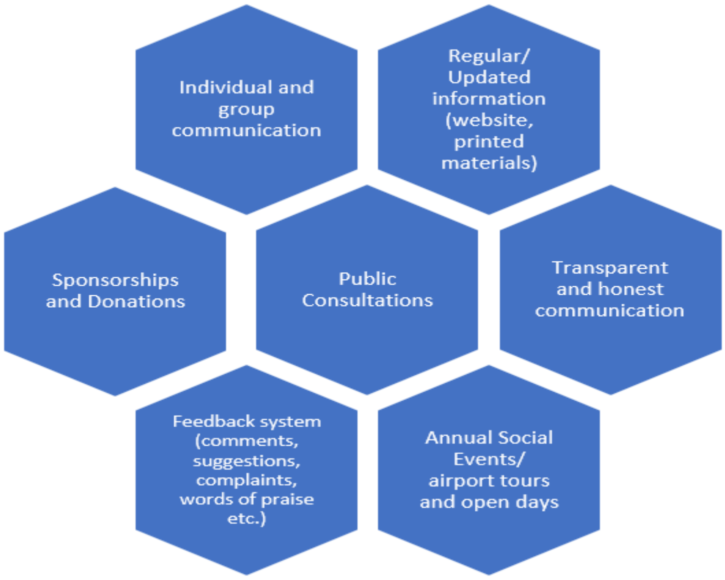

Figure 5.8 - Examples of Communication Tools used in relation with the local communities [2]

Noise complaint management is developed from different points of view. First of all, different communication channels are available for the airport to deal with noise complaints. Options include direct phone call, classic mail, Social Media (Facebook) and filling an online form on the website. Specific noise issues can be further addressed on regular meetings with local municipalities, since the airport has established regular communication with the local municipalities in terms of distributing noise reports by demand or special analysis of specific noise events. All complaints and noise-related issues are recorded and managed by the Quality Management System of the airport (ISO 9001 certified), therefore noise data and received complaints are presented on the Management Review Meeting of the Airport on a yearly basis, within internal documents/minutes.

Evaluation of results. Post-implementation changes. Mitigation actions

Continuous investments and efforts in the knowledge and well-being of employees, together with the development of a well-defined Personnel Policy contributed to the internal development of a culture of sustainability. These processes were dealt with great care since 2015 in order to ensure the establishment of an efficient culture internally such that to externalise its principles after 2016. Training employees and raising awareness regarding the environmental impact of individually performed tasks through transparency is an ongoing process. Using Sustainable Reports as a tool for analysis and assessment of progress related to predicted objectives, the development and continuity of a culture of sustainability was ensured in a knowledgeable and professional manner, while environmental issues were managed in a more effective manner. As a main result, the status of the airport company was ranked among the best employers.

Focus on the development of employees includes the development and maintenance of a respectful, responsible, safe, pleasant and healthy work environment, while encouraging a healthy and socially responsible life style. At a corporate level, it is planned a continuation of socially responsible activities that will include a wider airport community in sustainable activities.

A clear performance-based analysis and assessment of the all airport operations and further interventions was obtained, having an important contribution to the annual overview of the company. This showed that previous sustainability forecasts have been accomplished, while traffic growth increased (20% in passenger traffic and 23% in cargo). Such well-established structure allowed the airport to formulate an efficient decision-making process such as to benefit from the favourable economic conditions both Nationally and Internationally and from existing opportunities, while developing new others.

Sustainability Reports developed by Ljubljana Airport were awarded by the Republic of Slovenia.

Continuous attention is given to maintaining good and ethical relations, as well as a positive dialogue with all the stakeholders of the company, in order to ensure the development of projects for a cleaner and healthier environment, to manage in a responsible manner all the energy resources and to focus on ensuring noise protection.

Methods and tools. Interdependencies. Other relevant information

Together with the local community Šenčur, the airport planned to install a natural noise-reduction barrier to contribute to the reduction of the noise burden from the neighbouring settlements. Additional results and feedback are expected in the following years when the vegetation noise barrier, planted at the end of December 2016, will reach its maximum height growth. The estimated noise reduction is approximately 1-2 dB [8].

In 2017, the new by-pass road or the access road to the airport was completed (planned in 2015), a new strategy was adopted for the company operations and the company entered a new investment cycle. Transparent information and communication with all relevant stakeholders (as defined in Sustainability Reports) was a great contributor to the development of the aforementioned. The primary investment will be a new passenger terminal, scheduled to be opened in 2020. Through this approach, the company pursues to adjust the basic infrastructure to current needs that account for traffic growth and to increase the level of airport services. Such investments imply the beginning in terms of development of the company strategy, based on four basic pillars for future development, i.e. passenger traffic, business activity, cargo traffic and development of the Aviation Academy. Currently (2017), the acquisition of the certificate for the airport infrastructure and for the airport operator is issued by the CAA. All aforementioned objectives are declared in line with the Environmental Management System, such that environmental protection is ensured by accounting for noise effects, by supporting the transition to a low-carbon society, by separating waste and obtaining energy efficiency, as well as by using renewable energy sources.

Further activities launched by the airport are focused on the development of the social and cultural environment. In this respect, social, cultural, sporting and health activities and events are supported by the airport, including continuous access to education and trainings for their employees.

The Department of Real Estate Management from the airport deals with the airport development. Several projects that are mainly related to the development of airport infrastructure are planned, including: the State Road Relocation, the Passenger Terminal Extension and "Airport City". The State Road Relocation is a project that involves the relocation of the road passing by the airport, in collaboration with the Republic of Slovenia and the Municipality of Cerklje na Gorenjskem. Finished in 2017, the obtained road section has a length of 2.4 km with three roundabouts and ensures ease of access to the terminal and the airport city areas [24].

Figure 5.9 - State Road Relocation Project [24]

The Passenger Terminal Extension is a project proposed to overcome current difficulties and to prepare for predicted increases in the number of passengers, as the existing passenger terminal reaches its capacity ceilings during the highest season. The expansion is expected in the summer of 2020, having an additional 10,000 square metres, including a new departure hall, a new luggage sorting area, a duty-free shop, a new business lounge, as well as further food, beverage and promotional areas.

The “Airport City” is a project focused on developing the commercial infrastructure of the airport such that it meets the needs for hotel accommodation and ensures office spaces, commercial premises and logistics services which are currently unavailable. Three areas are covered for development (approx. 12.8 ha): Area 1 (yellow) to accommodate a hotel, Area 2 (red) for logistic facilities and Area 3 (blue) for logistic facilities.

Figure 5.10 - Airport City Project [24]

Area 1 (yellow) – approx. 2.2 ha; Area 2 (red) – approx. 5 ha; Area 3 (blue) – approx. 5.6 ha

A spatial plan was performed and is available and Fraport Slovenija d.o.o. is currently looking for investors for the facilities.

Further planned airport infrastructure developments include the construction of a new connector TWY J and shoulders on the taxiways, together with new aircraft ground handling and winter maintenance facilities. In addition, a practice area and buildings for the Aviation Academy are planned on the landside, as well as moving the General Aviation terminal, build commercial premises, expand the parking garage facilities and the facilities for firefighting and maintenance departments. Third party investors are able to build aircraft maintenance hangars, a new control tower, logistics and aircraft fueling facilities or commercial buildings in the area designated as "Airport City". The two largest renovation projects include the passenger terminal (2032-2035) and the runway reconstruction (2028-2031).

Fraport Slovenija, as part of the Fraport Group, is an active promoter of the internationally adopted standards, guidelines and principles, especially UN Global Compact principles, Universal Declaration of Human Rights, commitments to reducing air emissions within international aviation and others.

European Green Office Certificate – Ljubljana Airport won in 2013 the award "European Green Office Certificate", being also a holder of a special prize for the best Green Office Management System. Employees formed a Green Team that dealt with various fields of operation (energy, water and fuel consumption, waste management, occupational health and safety etc.). The same team is also informing and training their other colleagues on how to achieve and maintain 'green offices' and sustainability.

Energy supplied to the airport by suppliers is 100% generated from renewable energy sources.

Conclusions

Ljubljana Airport performs monitoring of noise and has all information needed for mapping the environmental noise, even if it does not exceed 50,000 movements per year. They are actively engaged in the development of Sustainability Reports since 2016, in order to promote sustainable communication in managing noise at such level that an improved quality of life is enabled for the local citizens.

RECOMMENDATIONS AND LESSONS LEARNT

One important issue that was raised is related to the necessity to establish a legislative framework for airports that cannot be classified as major airports. A main consequence of such action is the lack of noise policies or unclear and ineffective provisions for aviation noise. This further results in poor involvement of the relevant stakeholders in noise management. Additional reasons for defining specific noise management criteria for airports that are not classified as major include the fact that many airports might never achieve 50,000 movements in the next 20 years or at all, as in the case of Ljubljana Airport which is the largest international airport in Slovenia. Other airports might risk to never achieve this number of movements due to the lack of effective legislative frameworks on noise for smaller airports.

Guidance for establishing effective communication on noise management between all relevant stakeholders is highly needed, for all airports.

The effectiveness of noise mitigating actions is hard to be assessed and compared to other airports, since a common framework for noise management for airports that are not major is unavailable.

A more efficient method for planning flights that accounts for all constraints (slots, limited runway capacity etc.) is needed in order to be compliant to operating restrictions effectively.

In hindsight, the communication of any change and intervention should have also been presented to and discussed with the local communities before implementation.

A clear methodology for dealing with noise complaints is needed.

Further meetings between all relevant stakeholders are needed.

Further trainings on air traffic noise management are needed.

Public participation in environmental issues is highly demanded by communities. They also require more efficient and transparent information on environmental issues, including National regulations, programmes, reports and action plans.

Guidelines may be needed for airports on available methods and tools to assess their performance in terms of environmental management. In addition, guidance is needed on how to include environmental management, particularly noise management, into the overall management processes of a business such that they are aligned to a sustainable development approach, where environmental benefits can be obtained from day-to-day operations and development limitations are reduced or eliminated.

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8.6 Case Study 6 – Vienna Airport

BACKGROUND

Vienna Airport is the largest airport in Austria. It acts as a hub for Austrian Airlines, and in 2018 served a total of approximately 27m people (representing annual growth of 10.84%), and over 240,000 aircraft movements. The airport has two run ways (29/11 and 16/34) that are able to operate with no restrictions in terms of aircraft size.
Located 17km west of central Vienna, the airport is surrounded by mostly rural areas but there are a number conurbations in the proximity of the airport, particularly Essling and Groß-Enzersdorf to the North, which are particularly relevant for the below described case study.
The airport was privatised in 1992. It is 20% owned by the Province of Lower Austria, 20% by the City of Vienna, 10% by an employee participation foundation, 39.8%, by Airports Group Europe S.à r.l., and 10.2% as market free float. It is operated by Flughafen Wien AG and serves as an important airport both for Northern Austria, and also Bratislava, Slovakia, located just 40km to the West. It is the largest Airport in Austria acting both as a hub for Austrian Airlines and Eurowings, but also as a base for several low-cost carriers.
The airport has three terminals, and two runways which enable the airport to serve large aircraft up to the Airbus A380. Traffic at the airport is forecast to increase, with current capacity expected to be reached in approximately 2025. In anticipation of growth, the 1998 Master Plan to 2015 detailed a number of expansion projects at the airport. Significantly this included plans for a third runway to help increase airport capacity and to meet demand under the rationale that such growth has significant local socio-economic benefits.

Approach to the Balanced Approach

There is no law in Austria regarding airport noise, however noise is a very important issue for Vienna Airport, with the airport having a considerable noise footprint the includes over two million people. Noise has been of concern to the airport since the construction of its second runway in 1972 with opposition to aircraft noise reaching a critical point when the airport announced plans for a Third runway - of which local communities were not consulted. This led to significant conflict with the airport and objections to the runway being given approval. In response, the airport embarked on a mediation process with airport stakeholders in 2000 (see Section X.X) in order to re-establish trust with community members and to ensure that full consultation regarding future noise management interventions, and re assessing the location of the third runway.
As a result of this mediation process the airport has a long-standing history of seeking to reduce its noise impact. Indeed, interviews conducted in ANIMA Task 2.1 identified that the Environmental Noise Directive (Directive 2002/49/EC) and the ICAO Balanced Approach (EU Regulation 598/2014) had little influence on the airport, as the mediation contract went much further than the END did in terms of pro-active action to manage noise. The Balanced Approach came after the Mediation Process and was incorporated into airport decision making, however it had little impact on airport activity due to these existing noise abatement measures and the extensive processes gone through in the mediation process and its subsequently created Dialogue Forum. The results being the successful decline in airport complaints and opposition. Today, changes regarding noise-induced operational restrictions require the involvement of the Dialogue Forum and its many members, and can only be implemented after an established procedure has been

followed. Existing balanced approach measures implemented by the airport are listed in the below Table. The airport follows a number of operational procedures designed to minimise noise impact, and these are particularly influenced by the Dialogue Forum. In terms of restrictions these are typically imposed by the responsible administration and not by the airport, however discussions in the Dialogue Forum lead to restrictions in the number of flight movements during night that went beyond legal compliance. Significantly for land-use planning, the airport came to agreements with local authorities and communities to limit the approval of, and subsequent construction of new developments in the land surround the airport. This agreement was arrived at in return for a commitment to adhere to noise zone ceilings that would see the size of noise zones not increase in size.

Overview of Balanced Approach in Vienna Airport		
Operational Procedures	Land-Use Planning	Operating Restrictions
Noise mitigating descent and ascent techniques based on RNP	In the course of the mediation process, the Flughafen Wien AG (Aiport Vienna AG) and the neighbouring communities agreed contractually on the abandonment of building land/ housing area in areas, based on the predicted aircraft noise zone of a three runway system, with a L_{den} of 54 or 55, respectively.	Night flight restrictions for single runway directions/ departure routes between 21:00h-07:00h
CDO and CCO when possible	Areas subjected to more than 54dB day and 45 dB night properties can receive between 50%-100% of insulation costs for windows and doors.	Limitation of the number of flight movements during core night time of 4.700/a since 2010. In case of the commencement of a possible 3rd runway: 3.000/a.
Curved Approach on RWY 16 (testing phase)	Noise absorption measures.	Limitation of APU operating time of max. 30 minutes before take-off/ after landing.
RF-Turns after take-off from RWY 16	Winter gardens constructed in highly noise exposed residences.	
Variable parking positions for engine test runs dependent on the wind		

Noise monitoring and data

There are 15 fixed and 3 mobile noise monitoring terminals in operation at Vienna which continuously record sound levels of overflights and from which day LEQ (6-22) and night LEQ (22-6) values are drawn. The fixed terminals are located based on political reasons – i.e. to measure noise at highly populated areas and those requested by mayors and communities who used their local expertise to suggest optimal locations. Most of these terminals have been in the same location since 1990. If/when the 3rd runway is constructed additional terminals will be placed to better monitor noise implications from the expansion.

The three mobile terminals are used to give people data for certain issues or when there is a lack of data regarding, say a complaint or query from the community. They are often deployed linked to complaints or when flight track changes occur.

Modelling uses a wide range of data, including flight tracks, aircraft mix, environmental data, population data, topography and weather data (i.e. noise can reflect down from clouds for example in valleys). Temperature, wind and humidity are also considered. However, despite all of this the airport believe that the main things that people care about and want data on is the numbers of aircraft overflying given communities, the length of peak/rush hours, and peak noise levels.

Since 1992, the aircraft noise monitoring system FANMOS has been measuring the noise levels of all flights. The radar and flight information required for the recording is provided by Austro Control. This cooperation is done on a voluntary basis in lieu of any national legislation relating to aviation noise management in Vienna. FANMOS merges this data with events registered on the ground by the noise monitoring terminals and is thus able to also ensure compliance with prescribed approach and departure routes. Wind force, take-off weight and type of aircraft influence the actual flown route. The data are evaluated and summarized in a measurement report published on-line for access by communities at https://flugspuren.at. The data made available via FANMOS is supplemented by an annually produced report on noise produced by the Vienna Dialogue Forum[20]. The report comes in two forms – a simplified report to communicate headline information, and a more comprehensive data report. Noise maps published by the Dialogue Forum are based on the "Sydney Model" to show the regional distribution of overflights that produce peak noise levels above 65 dB, to better reflect the way in which noise is consciously perceived by inhabitants.

For annual calculations, and additional LDEN value is recorded for air events in the evening (1900-2200) with a surcharge of 5dB, and during 2200-0600 with a 10dB weighting.

Data is used to prove the adherence to minimum noise procedures, to analyse flight track data and to modify SIDs to reduce noise impact, to calculate noise zones, and to assist with land-use planning around the airport. Importantly the airport uses data provided by Austro Control to respond directly to complaints and issues brought up by communities to the Dialogue Forum. Adherence to flight tracks is evaluated on a daily basis, and if there are violations, the airport approaches the ATC for justification – and if non is provided the airline and individual pilots may also be contacted for explanations of non compliance.

Case Study: Curved Approach (via the Dialogue Forum)

This case study describes the on-going implementation of the curved approach on a flight path into Vienna Airport to avoid the conurbation of Aspern. In doing so, the intervention would reduce the numbers of people exposed to noise, but would also result in newly

[20] https://www.Dialogue Forum.at/oeffentlichkeitsarbeit/evaluierungsberichte

exposed people in the area of Groß-Enzersdorf. The case study considers aspects of noise-sharing, modelling, monitoring, trials and engagement processes all linked to this one operational procedure. The processes are embedded in the Vienna Dialogue Forum, which itself has routes dating back to a mediation process that began in 1998. The case study thus starts off with an introduction to the Dialogue Forum and its underpinning processes, before turning to the Curved Approach itself.

Vienna Airport Dialogue Forum

In 1998 Vienna Airport published their 2015 Master Plan. This document outlined plans to turn the airport into a modern hub airport that would link Eastern and Western Europe, thus ushering in a new era of growth in terms of passenger and aircraft movements. To facilitate this growth a central component of the master plan was the construction of a new, third, runway. Shortly after its publication, however residents expressed concerns about the runway, notably of its potential negative environmental impacts. Concerns lead to complaints and ultimately campaigns against this third runway, and included a frustration that such communities had not be exposed to any substantial consultation. Trust in the airport took a significant hit, and the airport and local authorities realised that the region could only develop and benefit through airport expansion if both the economic interests of the airport and its citizens were equally taken into account. Aware of the disconnect between resident concerns, and the potentially significant benefits of expansion that would be afforded to the region, the airport set about conducting a period of mediation negotiations to find environmental, socially and economically desirable outcomes in the interests of the stakeholders.

At the time the mediation discussions represented the largest environmental mediation process in Europe. The process was structured in such a way that new emerging issues could be accommodated, and that information could be communicated transparently, whilst also giving citizen groups an active role in engaging with aviation experts. Importantly this included Austro Control - the air navigation services provider that controls Austrian airspace. An Austro Control representative took an active role in the mediation process, in so doing be able to explain complicated information about airport operations (i.e. what is and is not possible) to stakeholders, whilst also being able to respond to data requests and perform modelling and analysis as required – for instance when determining the placement of flight tracks. In total, 50 different parties were included in the mediation process. These include the mayors of communities in the vicinity of the airport and of Vienna Districts (the *Neighbours Committee*); the mayors + some action groups + the federal states (the *Dialogue Forum*); the business community (the *Businessforum*); the public at large (the *Visitair Center*); the members of the Römerland Carnuntum Region (27 communities between Vienna and Bratislava).

The mistrust that developed form the proposals for a third runway was an important stumbling block in reaching an initial compromise, and so the first stages of the mediation process were to re-establish trust between the airport and its community stakeholders. This process was built on the sharing of knowledge through the airports flight track and monitoring system (FANMOS), and through an early agreement to follow the three pillars of sustainability in the mediation process – economy, environment, and society. In so doing the economic and social benefits of the airport were acknowledged by community members, as well as the environmental impacts of airport operations being taken into consideration. Following significant discussions, in 2003 a 'partial contract' was agreed which outlined agreed measures to reduce the number of people affected by aircraft noise, and to relieve the burden of noise felt by those living in noise affected areas. Ultimately this lead to the final mediation contract being signed off in 2005. The key, legally-binding outcomes being:

1. 35 million euros for technical noise protection. The noise limits of the Vienna Airport noise protection program are well below the statutory limits. Measures include

insulation programmes, sound absorption measures and the building of winter gardens at certain residences.

2. Halving night flights. The number of over flights between 23:30 and 5:30 would be gradually reduced to 3,000 movements per year.
3. Limited airport growth due to "noise zone ceilings." Noise zones around the airport will not increase after the third runway is put into operation, and the municipalities will not devote any new homes to the noise zone above 54 dB.
4. Longer overflow-free times at night for late aircraft.
5. Environmental Fund for Sustainable Development. Flughafen Wien AG pays 0.20 Euro per passenger per day and 0.60 Euro per passenger per night to a fund to support environmental initiatives in the region. In 2014 the environment fund raised 6.4m Euros.
6. Dialogue Forum Vienna Airport. The dialogue initiated in the mediation process will be continued through a multi-stakeholder Dialogue Forum that would ensure the established close working relationships could be maintained, and that consultation with stakeholders would continue going forward.

Noise zones on which these agreements were based were determined in collaboration with local communities and other mediation members, with noise zones eventually being defined as a combination of average noise level contours (LEQ) and number of events (N65). Defined corridors for landing and departure routes were determined with the community, and an agreement was made so that any increases in aircraft movements would require a reduction in average noise levels for individual aircraft.

The mediation process also saw the location of the third runway be determined with the support of all members. It was agreed to place the runway parallel to the slope of existing runway 11/29, at a distance of 2,400m to the South. This distance could have been smaller (and thus cheaper), however by moving the runway to such a distance it was possible to avoid overflying near by residential conurbations. A restriction on this runway was also agreed up on to limit its use in the direction 29L. Moreover aircraft landing at this runway would be required to use the Curved Approach to avoid overflying the City of Vienna.

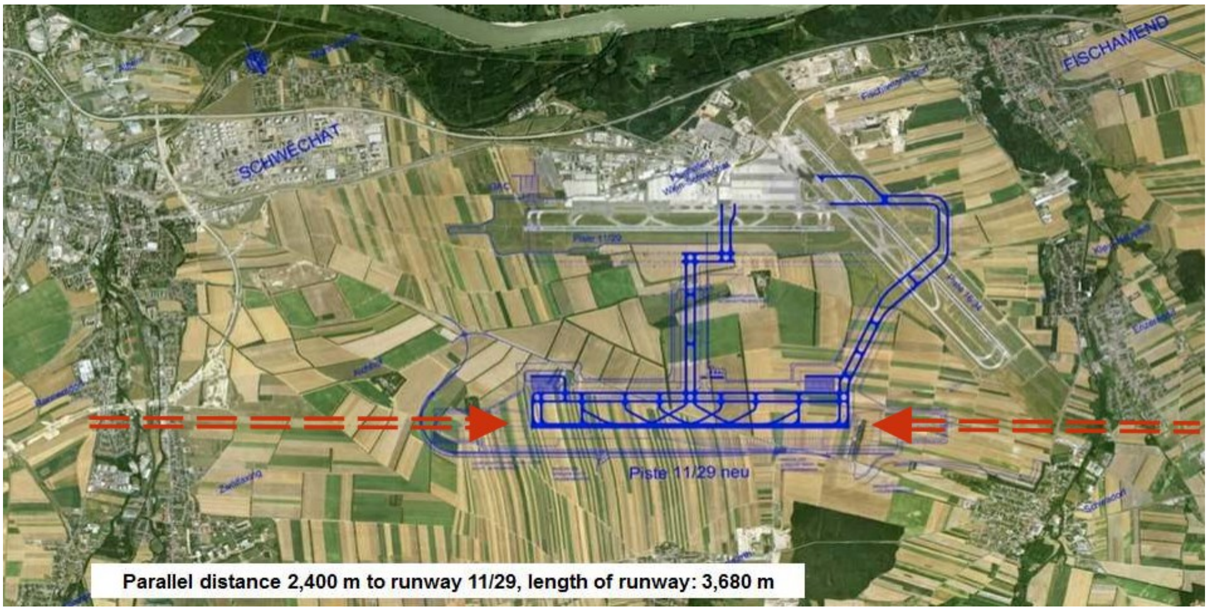


Figure 6.1 – Proposed location of the third runway

In terms of operational procedures, several other agreements were made, notably minimum noise routes to avoid overflying communities, and improved flight track procedures, developed through cooperation between the ATC Autrocontrol and airlines. Such procedures are regularly reviewed by the Dialogue Forum, with any changes made to SIDs investigated with the airports flight track monitoring system (FANMOS), and results used for further negotiation.

The airport is also subjected to a number of noise-based restrictions. Night flights are required to be gradually reduced to 3,000 movements per year, with night-time departures and arrivals in certain directions prohibited. Night runway closures (runways 11 and 34) have been implemented to avoid over flights of populated areas between the hours of 2300-0600 and 2100 and 0600 respectively. Night departure routes have also been developed for all runways with westerly directions.

The Dialogue Forum

A key outcome of the mediation was the creation of the Dialogue Forum to continue the dialogue started in the mediation, and that the airport today believes is a a best-in-class example of airport-community engagement, The forum is a non-profit organisation representing approximately 2 million people, across 120 municipalities, the provinces of Vienna, Lower Austria and Burgenland, as well as numerous citizens' action groups. The forum monitors compliance with the agreements made through the mediation process and deals with issues, questions and conflicts that arise as an on-going basis, as related to existing airport activity, and any proposals for future expansion. Members of the forum are:

- 14 citizen initiatives
- 10 regional communities
- 5 Vienna districts
- 3 Provicnces
- 8 Provincial offices and other agencies
- Airline representatives
- Air Traffic Control
- Vienna Airport

That so many of the stakeholders present in the mediation process committed to forwarding the discussion via the dialogue forum is testament to success of this process, and the commitment of all participants to continue effective communication and outcomes that benefit the entire region.

The forum meets 4 times per year and publishes annual documentation as a collaboration between stakeholders which presents annual noise data, explanations behind the figures and any future developments at the airport. This collaborative approach can be seen as unique from the approach taken at many airports, where such documentation is typically produced by airports for the benefit of communities.

The airport always communicates to communities, via the Dialogue Forum before implementing any operational change. They believe that not following this process even once can lead to mistrust that can take many years to re-establish. Moreover, the airport tries to include all communities in discussions – not just those directly impacted by proposed changes. This is important as it can help to ensure that voices are heard, as well as limiting any unintended consequences, for example by avoiding situations where there are 'winners' and 'losers' from a given operational change. In terms of new complaints or queries from community members, the following process is adhered to.

1) A Dialogue Forum call centre to takes calls initial calls and attempts to answer queries directly over the telephone.

2) For more complicated queries a written response is provided by the forum which may go into more detail regarding airport operations, or to provide already available data.
3) In special cases, Austro Control are asked to respond (for example for a call for a new flight track) by looking into the data and performing new modelling. An Austro Control representative will then attend a Dialogue Forum meeting to explain the data and to respond directly and in person to relevant parties. This ensures rich contextual responses can be given with dialogue based on openness and transparency. Austrocontrol works closely with the Dialogue Forum and all data can be made available to the forum upon request, except confidential information that could, for example, have implications for safety. The appointed person to this task is typically called upon to provide data to help find solutions to challenges and debates regarding nose and to help find agreeable outcomes for all parties.

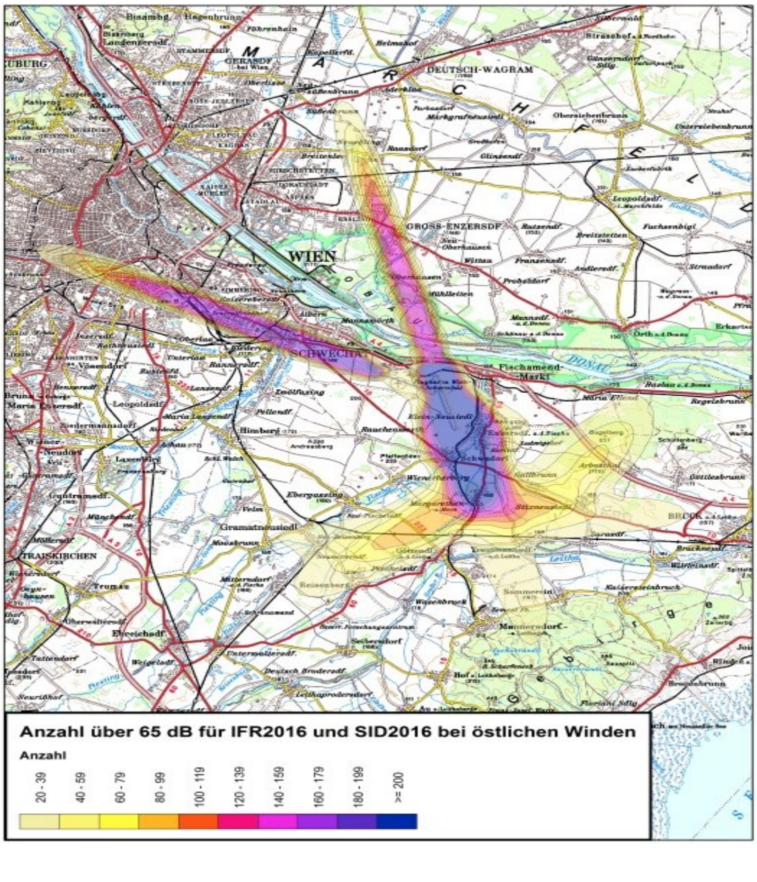
If an idea is proposed by the Dialogue Forum, this is communicated to Austro Control who checks these proposals against ICAO requirements, and aircraft performance capabilities, before performing modelling. The results are fed back to Dialogue Forum members from the appointed representative directly to stakeholders to help ensure clarity of understanding, to answer and questions, and to learn about further requests for information if appropriate. Calculations and modelling also includes carbon and air quality implications.

An environmental impact assessment on the third runway as designed by the Dialogue Forum showed it offered a higher level of environmental protection than statutory compliance alone. Moreover, none of the citizens' initiatives negotiating at the Dialogue Forum appealed against the decision of the runway to obtain approval in the assessment of the runway being 'sustainable'.

The Curved Approach

As previously stated, one of the outcomes from the mediation process of the third runway was that it would only take landings arriving on a curved approach. Unlike a standard landing procedure where aircraft follow a long, straight-line landing, the curved approach is a satellite-controlled landing method that sees aircraft swivel in just before the runway and start their approach. The curved approach is a relatively new operational procedure available to the industry. In the case of Austria it had been previously applied at Innsbruck Airport.

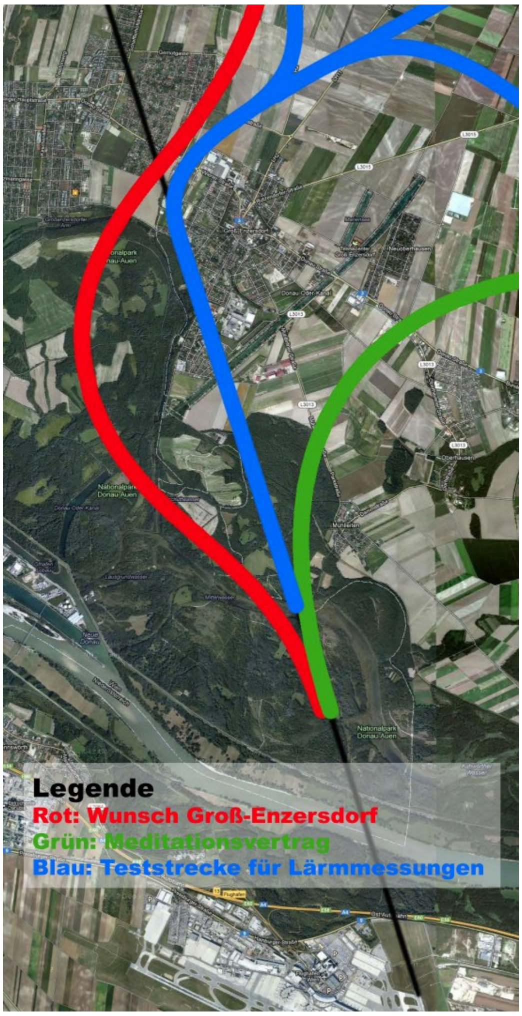
By including this procedure in the mediation contract, the concept of a curved approach gained much exposure and communities began to enquire if such an approach could be used elsewhere to help avoid



overflying currently exposed populations.

Figure 6.2 – Proposed curved approach

Examples of such communities are Aspern and Essling, located to the North of the airport, and currently being overflown by arrivals to runway 16 (see Figure X below). The community requested that a curved approach be applied so that this large conurbation could be afforded significant respite from noise exposure that it had been subjected to since that runways construction.



The call for this operational change was raised to the Dialogue Forum, and it was here that the multi-stakeholder background of the forum in which proposals were reviewed by all communities played a key role. The community of Groß-Enzersdorf (approximately 10,000 inhabitants) objected to this proposed changes as they were concerned that the curved approach would result in increased noise exposure in their community. Of three proposed routes they were only willing to accept one (the red route in Figure X).

Of particular concern to the community was that aircraft flying on a curved approach would see greater levels of noise produced on the inside of the curve, where aircraft engines would be pointed slightly closer to the ground. In response the Dialogue Forum created a Curved approach Working Group in order to find an outcome that would be best suited for all communities. A key consideration of the group is to not transfer the burdens of noise onto others. Thus proposed flight paths were assessed on their ability to fly over uninhabited areas with the aim of noise delivering newly exposed populations.

Figure 6.3 – Options for the proposed curved approach

Through discussions in the Dialogue Forum it was decided (in association with Austro Control) to commence trials to assess the impact of aircraft flying on the curved approach. Air quality and carbon emissions where not assessed as a priority in these trials as noise is the primary area of concern for communities.

Noise monitoring terminals were placed along the new flight path and placed symmetrically to assess noise distribution on the ground with one noise monitor placed directly under the flight track and one to either side. Measurements were taken for over 2.5 years – with the time frame determined by obtaining an adequate sample. This required such a long trial as there are significant restrictions on how many aircraft are actually able to use the curved approach. Firstly, the aircraft must have the technical prerequisites to do so. Secondly, pilots must have obtained the appropriate level of training in order to fly this special kind of route. Thirdly the aircraft must be flying from an appropriate direction and with the appropriate winds.

In terms of technology, aircraft could easily be adapted to perform the landing, although at present not all are equipped to do so. The airport is considering differential landing charges for those who are not able to fly the curved approach in order to help with the transition to improved technology. The fact that the curved approach was used at Innsbruck meant that some pilots were appropriately trained to fly the new approach, however as most pilots were trained by Lufthansa, and few airports in Germany use the curved approach, the required training was often lacking. The result was that only 30-40% of aircraft approaches are able to use the curved approach.

The results of these trials presented by the Dialogue Forum showed little change from noise exposure from the conventional straight-line approach to the runway.

CONCLUSIONS

Results from the trials also found that there was negligible difference (1.5dB) between the 'inside' and 'outside' edges of the curve. This went someway to appeasing the concerns of the Groß Enzersdorf. The provision of full data and cooperation with Austro Control helped to build trust between the community and the airport, however concerns were still held about exposing new residents to noise. Such concerns were held both by community members but also other stakeholders (local politicians) who were worried that although the curved approach could potentially reduce the number of people exposed to significant levels of noise, the proposed changes would result in newly exposed people and thus be a difficult decision. Discussion on the approach have temporarily been suspended until these elections have finished.

This case is an example of the complexities of noise sharing and how collaboration between stakeholders – including between individual communities is essential in ensuring that optimal outcomes have been arrived at.

8.7 Case Study 7 – Frankfurt Airport

Overview

Frankfurt Airport (FRA) served more than 69.5 million passengers in 2018, thus posting a new record high in the airport's history. Compared to 2017, traffic at Germany's largest airport grew by some 5 million passengers or 7.8 percent. It also increased by 5.1 percent to some 31.6 million metric tons.

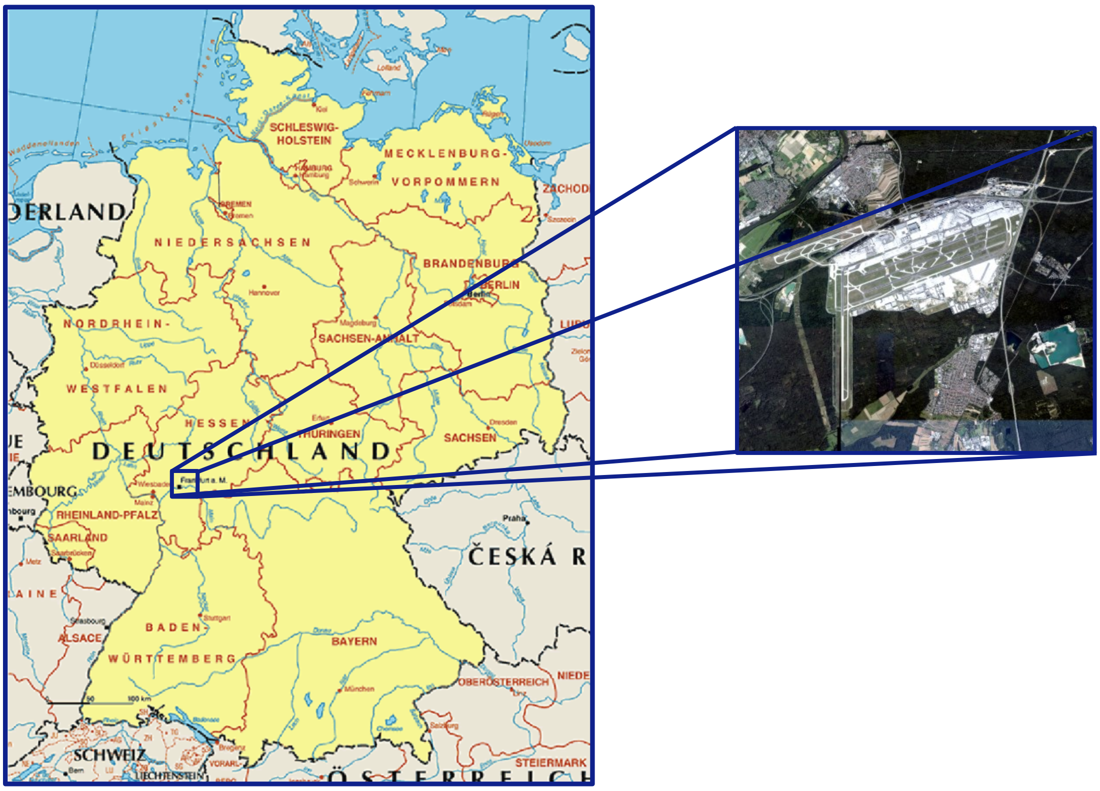


Figure 7.1 – Location of Frankfurt Airport

For the last winter timetable, Frankfurt was served by 89 passenger airlines flying to 262 destinations in 100 countries worldwide. With 128 intercontinental destinations, almost half of all destinations were intercontinental (beyond Europe).[1]

In Europe, Frankfurt Airport ranks second in terms of cargo tonnage and is the fourth busiest for passenger traffic. With about 55 percent of all passengers using Frankfurt as a connecting hub, Frankfurt also has the highest transfer rate among the major European hubs. [1]

Frankfurt Airport City has become Germany's largest job complex at a single location, employing approximately 81,000 people at some 450 companies and organizations on site. Almost half of Germany's population lives within a 200-kilometer radius of the Frankfurt intermodal travel hub – the largest airport catchment area in Europe. [1]

History

1924	Opening of Airfield at Rebstock Site in Frankfurt/Main, operated by "Südwestdeutsche Luftverkehrs AG"
1936	Start of flight operations at today's airport site in Frankfurt: "FRA"
1939-'45	World War II: Construction of first Runway
1945	End of WW II: 77% of airport destroyed, US took over airport control
1949	2^{nd} FRA Runway "South"] constructed in less than 1 year during Berlin airlift
1954-'55	Resumption of civil aviation businesses by "Flughafen Frankfurt/Main AG"
1972	Inauguration of FRA Terminal 1
1984	3^{rd} FRA Runway "West" goes into service
1994	Inauguration of FRA Terminal 2
2001	Initial Public Offering: new company name "Fraport AG"
1997 until today	Focus on international expansion: asset deals such as Hanover and Xi'an; concessions, a. o., in Delhi, Antalya, Lima, Varna & Burgas, St. Petersburg; as well as management contracts in Cairo, Dakar, Riyadh & Jeddah
2011	4^{th} FRA Runway "Northwest" goes into service
2014	International portfolio expanded with Ljubljana airport and AMU Holdings
2015	Construction start of FRA Terminal 3
2016	FRA JV with Gebr. Heinemann founded to operate 27 retail stores
2017	Take over of airport concessions for 14 airports in Greece
2018	Jan: take over of Fortaleza and Porto Alegre airport concessions in Brazil Apr: take over of JFK T5 master retail concession

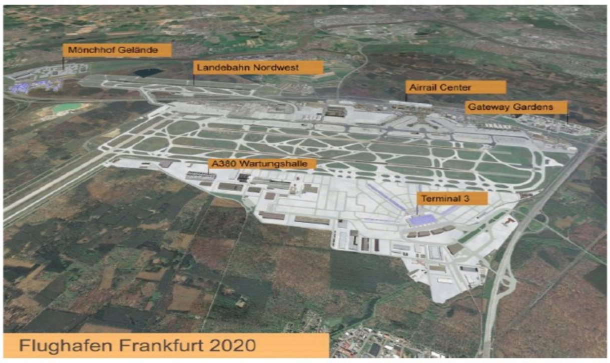
"noise pact", as well as setting up a permanent Regional Dialogue Forum ('Regionales Dialogforum') as follow-up of the mediation throughout the entire process.

Between 2000 and 2008 was the period of that Regional Dialogue Forum. Its main goals were: Continuation of the dialogue, objectification of the discussion by information and expertise, guidance to the approve procedures and keeper of the mediation results. It was composed of 33 members, representatives of towns and cities, NGOs, industry, airport, airlines and air traffic control, churches and trade unions. There were 57 meetings to discuss and decide on the outcome of the project teams' work (Five project teams – Night Flight Ban, Anti Noise Pact, Optimisation, Ecology-Health and Long term Perspectives- they had 289 more meetings), 19 studies were ordered and 20 hearings took place. A Citizen's Advice Bureau was built up as a liaison agency and information Centre.

There were two plan approval procedures in which the airport operator applied not only for an expansion but also for a night flight ban (like the mediation process agreed), but finally in December 2007, the Decision of the Hessian Ministry for Transport on the plan approval procedure included a permission to have 17 movements between 23:00 and 05:00 and 150 movements from 22:00 to 06:00. The public debate was served: "violation of mediation agreements or not".

Expansion of Frankfurt Airport

Legal basis:	Planning approval notice of December 18, 2007
Competent authority:	Hesse Ministry of Economics, Transport and Regional Development
Commissioning:	Runway Northwest, October 21, 2011, Terminal 3 scheduled for 2021 (Pier G) and 2023



2 takeoff and landing runways
1 takeoff runway
2 terminals
New: 1 landing runway
1 terminal

Projection for the expansion case*:

Passengers:	88.3 million
Cargo:	3.16 million metric tons
Movements:	701,000

* Expected growth delayed by global financial and economic crisis, among other things

Figure 7.3 – Planned expansion of the Frankfurt Airport

In 2008 the Forum Airport and Region (Forum Flughafen und Region – FFR) was established as a successor of the Regional Dialogue Forum and finally after almost 14 years since the beginning of the mediation process, on 21st of October of 2011 the new landing runway started its operations.

Less than 10 days later, on 30th of October of 2011 the night flights were banned from 23:00 to 05:00 due to a decision of the higher administrative court in Hesse. On 4th of April of 2012 the final decision of the Federal Administrative Court established: Night flight ban from 23:00 to 05:00 and a maximum of 133 flights in total from 22:00 to 23:00 and from 05:00 to 06:00 (average per night/year).

- Exceptions for landings: Possible until 0:00 local time, but not more than average of 7,5 per night/year. Moreover, the operations should be planned between 22:00 and 23:00 and their delay cannot result from the scheduling.
- Exceptions for take-offs: Only possible if the reason for delay could not be influenced by airline, needs prior permission by HMWEVW (Hessian Ministry of Economics, Energy, Transport and Housing)
- Exceptions for special cases (Medical, safety etc.)
- Only Chapter 4 Aircraft

"Balanced approach" in Frankfurt? [6]

Firstly, by Directive 2002/30/EC of the European Parliament and of the Council of 26 March 2002 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports.

The report from the Commission of 15 February 2008 entitled 'Noise Operation Restrictions at EU Airports' pointed to the need to clarify in the text of Directive 2002/30/EC the allocation of responsibilities and the precise rights and obligations of interested parties during the noise assessment process so as to guarantee that cost-effective measures are taken to achieve the noise abatement objectives for each airport

After 12 years, it was necessary an update of how to use operating restriction measures is required to enable authorities to deal with the current noisiest aircraft to improve the noise environment around Union airports within the international framework of the Balanced Approach. Thus, a new Regulation (EU) Nº 598/2014 of the European Parliament and of the Council of 16 April 2014 on the establishment of rules and procedures regarding the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC.

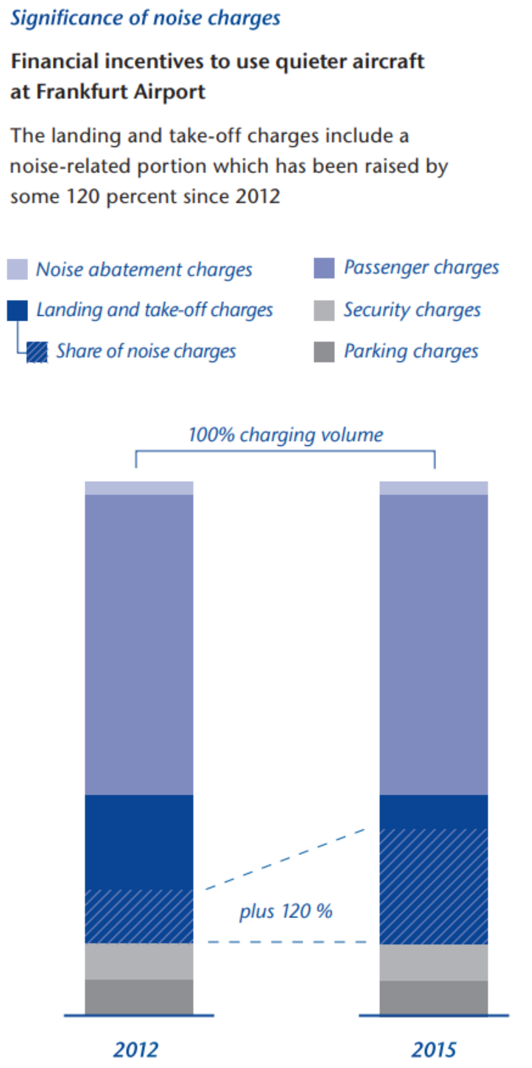


Figure 7.3 – Charging structure at Frankfurt Airport

Reduction of Noise at Source [1]

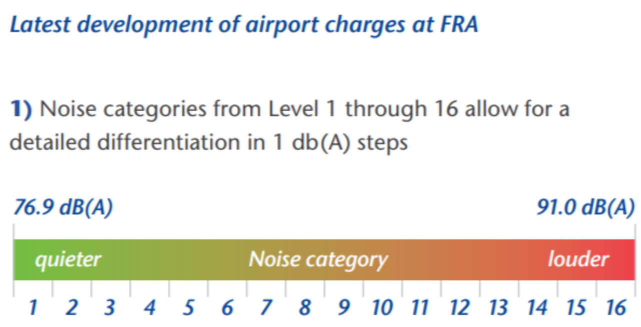
Measures for active noise abatement are directed toward avoiding or reducing the noise directly at the source, or at least achieving a better distribution. The expert committee "Active Noise Abatement" of the Airport and Region Forum (FFR) has formulated appropriate proposals.

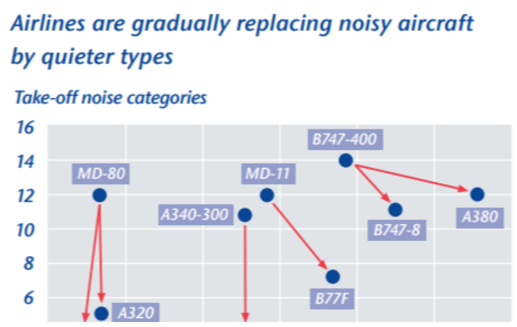
Frankfurt airport operator (Fraport AG) continuously contributes to aircraft noise reduction efforts. Starting in the 1990s, Fraport has been taking account of aircraft noise in its airport charges and in 2001 Frankfurt Airport was the first airport in Germany to introduce airport charges based on effectively measured noise.

Back in 2010 these noise charges were even further spread: using noisy aircraft became more expensive for the carriers. This charge component was then further differentiated in the years 2013, 2014 and 2015 (120% in 3 years). Every charge calculation is based on the aircraft type being allocated in one of 16 noise categories measured at Frankfurt. Higher charges for aircraft movements operated during the late evening or early morning hours serve as an incentive to shift these movements into the daytime. A night curfew applies at Frankfurt between 11 p.m. and 5 a.m.

<u>Noise abatement charges</u>

- Per departing passenger or per 100 kg of freight on landing and take-off
- Depending on the noise category of aircraft and the time of arrival/departure
- Legal noise abatement measures in the vicinity of the airport





A further innovation was the introduction of a Noise Rating Index (NRI), with the aim of incentivizing airlines to use technologically advanced aircraft. Depending on how the individual aircraft is classified, a reduction of up to 10% on noise-related charges is granted.

The New Incentive Model GBAS

(Ground-Based Augmentation System - new navigation system enabling aircraft to make satellite-assisted precision approaches).

Frankfurt Airport was the first international hub in Europe to introduce an Airport Charges Regulation, and to offer regular GBAS-CAT I approaches since September 2014. Since March 2017, **Frankfurt Airport can be approached at a steeper glide path angle, GBAS 3.2°**. In this way, the new GBAS technology will make a significant contribution to noise abatement and to protecting people and the environment in the vicinity of the airport. **Fraport AG is supporting the equipping of aircraft with GBAS technology**. This applies this year to aircraft that are newly licensed in 2019 and equipped with GBAS, including its activation, and aircraft that are retrofitted with GBAS in 2019 or whose GBAS is activated in 2019. Consequently, the flight crews of the airline need to be licensed for GBAS landings (OPS approval). Airlines will then receive €100 per landing for each aircraft that has been equipped with GBAS in 2019. This incentive applies for the first 100 landings of the GBAS equipped aircraft, resulting in a maximum total incentive per aircraft of €10,000. [1]

Vortex generator reduces noise emission – upgrading the A320 Family

A circular pressure equalization opening of the tank on the underside of the aircraft wing generates tonal sounds during the course of the flight. The noise produced during this process is comparable with the noise that arises when air flows over the opening of a glass bottle. The faster the air flows over the opening, the louder the noise becomes. These characteristic sounds for the A320 Family are particularly noticeable in the approach phase when engine power is low. The new component causes the oncoming air to swirl in front of the opening and this prevents the generation of noise. In February 2014, the first Airbus A320 was supplied with vortex generators and since October 2014 the Airbus A319, A320 and A321 aircraft in operation have been gradually upgraded with vortex generators. Evaluation of the measurement results indicates that the vortex generators **reduce the level of noise during approach by up to 4 dB.**

Fitting the engines of Lufthansa's B737 fleet with acoustic panels

This is a noise reduction measure for Boeing 737 jetliners with CFM-56-3 engines. Replacing twelve acoustic panels at the engine inlet reduces the aircraft noise both during take-off and landing. Lufthansa implemented this measure for the B-737 aircraft stationed at Frankfurt Airport already at the end of 2011. This has led to a recertification for the B737 fleet into the quietest noise category.

Withdrawal of Lufthansa's B737 fleet

All B-737s have been replaced by newer aircraft. Noise reduction was possible in all take-off and departure flight phases.

Modernization of fleets

In 2014, Lufthansa placed a large order for modern long-haul aircraft. Along with the use of Boeing B 777-9X and Airbus A 350-900 jetliners, it is expected that kerosene consumption, and thus also CO_2 emissions, can be reduced even further, and that acoustic emissions will decrease, too. However, not all the new aircraft are destined to be part of Frankfurt fleet, and Frankfurt still has a few A 340 flying around.

Land use planning and management

Planning instruments: [3] [10]

A further important measure to reduce noise is land-use planning. This instrument is included in the German Act of Protection against Aircraft Noise, October 2007. This act requires the establishment of noise protection areas at commercial airports as well as military airfields with the operation of jet or heavy transport aircraft. The noise protection area is subdivided into two daytime protection zones and one night-time protection zone. The act contains different limit values for the individual zones. A distinction is made between existing and new or significant expanded airports. Furthermore, there are different limit values for airports and military airfields, which are displayed in the below tables.

Overview of the limit values for existing airports or airfields according to the Act for Protection against Aircraft Noise

Type of airport/airfield	Daytime protection zone 1	Daytime protection zone 2	Nighttime protection zone	
	$L_{Aeq\ day}$	$L_{Aeq\ day}$	$L_{Aeq\ night}$	N x L_{Amax}
Civil airport	65dB(A)	60dB(A)	55dB(A)	6 x 57dB(A)
Military airport	68dB(A)	63dB(A)	55dB(A)	6 x 57dB(A)

Overview of the limit values for new or substantially expanded airports or airfields according to the Act for Protection against Aircraft Noise

Type of airport/ airfield	Daytime protection zone 1	Daytime protection zone 2	Nighttime protection zone			
			Until 31.12.2010		From 01.01.2011	
	$L_{Aeq\ day}$	$L_{Aeq\ day}$	$L_{Aeq\ night}$	N x L_{Amax}	$L_{Aeq\ night}$	N x L_{Amax}
Civil airport	60dB(A)	55dB(A)	53dB(A)	6 x 57dB(A)	50dB(A)	6 x 53dB(A)
Military airport	63dB(A)	58dB(A)	53dB(A)	6 x 57dB(A)	50dB(A)	6 x 53dB(A)

The calculation of the noise protection area is carried out based on a prediction on the future flight operations as well as on the description of the flight routes in the surroundings of the airport[21].

[21] First Decree on the Implementation of the Act on Protection against Aircraft Noise, Decree on the Acquisition of Data and the Calculation Procedure for the Establishment of Noise Protection Areas of 27 December 2008. Amended 2015.

In the whole noise protection area, the construction of noise-sensitive buildings (e.g. hospitals, schools) is generally prohibited. In the daytime protection zone 1 as well as in the night-time zone, the construction of new dwellings is also not allowed.

For existing residential buildings located in these zones, the Act of the Protection against Aircraft Noise contains provisions that oblige the airport operator to cover the costs for constructional soundproofing measures at these buildings. Moreover, the expenses for the installation of ventilation systems in rooms that are predominantly used for sleeping, are to be reimbursed by the airport operator for buildings in the night-time protection zone. Expenses incurred for constructional soundproofing measures including the ventilation systems are reimbursed to a maximum amount of 150 € per square meter of living space. The noise insulation requirements are specified in a statutory decree[22].

In the case of construction of new or the expansion of existing airports, these regulations are supplemented by compensation arrangements for deterioration of the quality of outdoor living space (terraces, balconies etc.) in daytime protection zone 1. Further details such as the extent of the outside living area that requires protection and the compensation for impairment in this area are also laid down in a statutory decree[23]. The compensation has to be paid by the airport operator.

Building restrictions

Zone 1 and night zone: All building is prohibited, except if the Regional Government gives its explicit authorization in cases of major public interest. (Section 34 of the German Federal Building Code). The exceptions are a controversial point.
Zone 2: There is no ban on housing. However, public buildings such as schools, hospitals and retirement homes need a specific authorization by the Regional Government.

Mitigating instruments: [1]

Financial resources provided for structural noise abatement measures. Measures directed toward passive noise abatement aim to reduce the noise level in rooms inside buildings by carrying out adjustments to building structures. Frankfurt Airport (Fraport) has comprehensive obligations for around 86,000 households in the Frankfurt area under statutory legislation. Their entitlement to submit claims is defined by a noise abatement zone which was established by the Hesse Government on the basis of the very strict rules of the Aircraft Noise Abatement Act (Fluglärmgesetz). Furthermore, Fraport AG have set up a Regional Fund amounting to €270 million together with the Hessian Government, and this fund is used to finance additional measures. Statutory payments for passive noise abatement and payments from the Regional Fund can only be granted on application.

Fraport maintains a comprehensive package of information and services on the company website https://www.fraport.com/noise-abatement in order to provide assistance to residents in determining their claims and supporting the application. In 2013, the Compensation for Outdoor Living Areas Regulation pursuant to the Aircraft Noise Law

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Instructions on the Acquisition of Data on Flight Operations and the Calculation of Noise Protection Areas. December 2008

[22] Second Decree on the Implementation of the Act on Protection against Aircraft Noise, Decree on noise insulation measures of 8 September 2009

[23] Third Decree on the Implementation of the Act on Protection against Aircraft Noise, Decree on compensation for impairment of the outside living area of 20 August 2013

came into force. For the first time, this regulation introduced as a statutory requirement compensation for the impaired use of the outdoor living area in the Day Protection Zone 1 of Frankfurt Airport. This affects a total of approximately 12,500 households, primarily in Flörsheim, Frankfurt, Nauheim, Neu-Isenburg, Rüsselsheim und Raunheim. The level of the compensation is either determined based on a statutory flat-rate amount, depending on the type of property, or by means of an expert report on the marketable value of the property. Applications for this compensation can be submitted to Darmstadt Regional Council. The outdoor living area includes e.g. lawns, gardens, terraces, balconies, roof gardens, and similar communal outdoor facilities such as playgrounds at an apartment block. The buildings can be houses and apartments used for residential living or institutions like nurseries or schools. However, the entitlement only applies to plots of land on which building structures were erected before 13 October 2011 – the day on which the noise abatement zone was defined – or which planning approval had been obtained prior to this date. The entitlement is phased according to the strength of the noise pollution. Since 13 October 2016, Day Protection Zone 1 has qualified for entitlement. 2,700 applications had already been submitted to Fraport up to the start of the submission period in October 2016. The period for application submissions ends on 12 October 2021.

Financial instruments: [1]

As part of its voluntary Casa program, Fraport AG was buying residential properties that are flown over at especially low altitudes, i.e. beneath 350 meters (985 feet), or compensated the owners financially. The application deadline for the program was on October 1, 2014. This offered an alternative to homeowners who had purchased or built a property before the plans about the airport's expansion were discussed and who now found their house right under the entry line to the airport.

Within the context of the noise-abating package of measures "Together for the Region - Alliance for Noise Abatement 2012" Fraport AG had significantly upgraded the Casa program in 2012 ("Casa 2"). Altogether the volume of measures taken within the Casa program amounted to over 100 million euros.

Households may make claims for passive noise abatement protection for their homes in the framework of the Passive Noise Protection Program. These noise abatement protection measures are meant to reduce the noise level within buildings.

Within the framework of the current "Passive Noise Abatement" program, corresponding measures are being brought forward beyond the statutory regulations and are given extra budgetary resources from the Regional Fund. The budget comprises some 150 million euros for the Passive Noise Abatement Program and 265 to 2570 million euros for the Regional Fund. The Regional Fund is part of the "Alliance for Noise Abatement 2012", launched on February 29, 2012.

The program differentiates between four protected zones, which were created in compliance with the applicable limit values shown in the amended noise protection laws. The noise protection areas thus determined are composed of two daytime protection zones and one night-time protection zone and since 2013 also of one area covered by the Regional Fund.

Operational procedures [1]

Noise abatement flight procedures

Continuous Descent Operations (CDO), referred to in the past as Continuous Descent Arrival or Approach (CDA); More frequent Continuous Descent Operations.

Noise Abatement Departure Procedures (NADP); RNAV SIDs. Improving departure procedures, limiting the speed at a certain point in the departure. Continuous Climb Operations (still under development).
Modified approach angles, staggered, or displaced landing thresholds; Gliding angle of up to 3.2 degrees on the Runway Northwest became standard on December 19, 2014 after more than two years of testing this measure. The results of the test operation had been completely positive. Measurements made by the German Aerospace Centre during the entire test phase at seven noise measurement stations at Frankfurt Airport showed a reduction of the maximum noise level from 0.5 to 1,5 dB(A) depending on the site of the measurement station and the type of aircraft.

Steeper Approach procedures. In this procedure the approach flight is initiated from a relatively high altitude, at about 8,000 feet, (approx. 2,400 meters) using an angle of 4.49 degrees. Once approximately 2,000 feet (600 meters) have been reached, the light beacon of the instrument landing system (ILS) is geared to from above in a 3.0 or 3.2 angle.

Point Merge procedure is a novel method for sequencing arrival flows. Instead of using the current flight paths, arrivals are bundled into funnel-type structures and guided towards final approach. This technique is to support continuous descent operations in higher altitudes for a longer time span.

Modified Arrival Routes. By raising the minimum altitude of arrival sectors, approaches will be kept in higher flight altitudes for a longer period of time.

Low power/low drag approach profiles; Raising the minimum downwind approach angle by 1,000 feet on the Northern and on the Southern.
Raising the altitude for starting final approach up to 5,000 feet. The altitude for aircraft coming from the South and turning to start final approach is raised from 4,000 to 5,000 feet (approx. a 300 metre difference). In the parallel independent operation the turning operations from the South must continue to be 1,000 feet lower than from the North, thus 4,000 feet in the South and at least 5,000 feet in the North. Lengthening the Instrument Landing System (under development). The vision is to raise the altitude for approach flights turning to start final approach by 1,000 feet (300 meters). When turning from the North, this will be accomplished by gearing to the ILS approach light beacon at 6,000 feet and when turning from the South at 5,000 feet. In order to implement this measure, the range of the instrument landing system (ILS) needs to be expanded.

Minimum use of reverse thrust after landing: Monitoring the use of reverse thrust. An acoustic monitoring system was implemented at Runway Northwest for westerly operations (runway designator 25) in May 2015. This system is now being tested and optimized. A reverse thrust with higher load levels represents a disturbing noise event in the nearby residential areas. Reducing such cases of use equals means less disturbances.

Introduction of a Ground Based Augmentation System (GBAS)

GBAS is a satellite-based precision landing aid that is additionally supported by a ground station. This technology considerably improves the accuracy of satellite navigation. Aircraft equipped with GBAS receivers may determine their own position so accurately that precision landings are possible without requiring an ILS. The new landing system permits:

- To raise the approach angle from 3.0 degrees to 3.2 degrees on Runway South and on Runway Centre (25L/C and 07 R/C), a measure that had so far only been possible using conventional ILS technology (instrument landing system) on the Runway Northwest, and here they have already been integrated into regular operations.
- The GBAS technology provides the possibility to use curved, segmented approach procedures without affecting capacity. Such procedures make it possible to direct arrivals around densely populated areas.

The installation of "Ground Based Augmentation System" (GBAS) navigation made Frankfurt Airport the first international air traffic hub in Europe to host satellite-based precision approaches for appropriately equipped aircraft.

Since the second quarter of 2017, the steeper approaches using GBAS navigation are being tested on the South and Centre Runway. Up to 49 different approach routes can be supported with a single GBAS ground station. The new airport charges introduced in early 2017 incentivised the use of GBAS to make application of the GBAS navigation system even more attractive for airlines.

Spatial management

Noise preferred arrival and departure routes; Increased use of westerly direction. Some residential areas in the western part of the airport are directly adjacent to the airport premises, which means that they are flown over in the landing direction 07 at very low altitudes. This is the reason why operation direction 25 is the preferred scenario at Frankfurt Airport. On a yearly average this direction is used at some 70 %[24] of all days.

Fewer take-offs via Frankfurt and Offenbach during easterly operations. Relocating the take-offs from the 07-N (long) to 07-0 departure route to relieve the urban areas located below the 07-N (long), in particular Frankfurt and Offenbach.

Flight track dispersion or concentration; Flying around densely populated metropolitan areas. No aircraft can start final approach above the residential areas of Mainz and Offenbach.

Noise preferred runways; Procedure for alternate use of runways permits noise respites. From 23 April 2015, the noise respite model 4 recommended for testing by the Frankfurt Aircraft Noise Committee (FLK) and by the Airport and Region Forum (FFR) 2016 underwent testing for flights routed in a westerly direction, which is the main operating direction for the airport. This means that specific take-off runways are not used alternately in the early morning and late evening hours. Frankfurt is the first major international airport to support an operational restriction on night-time flights including a preferred runway usage concept. This extends the night-time quiet period by one hour in the approach corridors. The main beneficiaries from bundling landings in the evening hour between 22:00 and 23:00 on the South Runway are the people living in the south of Frankfurt and to the north of Offenbach. However, Neu-Isenburg and southern Offenbach experience more noise pollution by the exclusive use of this runway during this hour. Nevertheless, the night time quiet period here is extended beyond the core time between 23:00 and 05:00 because the South Runway is not used for landings between 05:00 and 06:00. The morning approaches are then scheduled on the Runway Northwest and the Centre Runway, all morning take-offs are scheduled for the South Runway. The monitoring results obtained during the test phase confirmed the potential for reducing noise pollution that had previously been calculated, such that the "noise respite" concept was incorporated into regular operations after a year of testing.

[24] In 2018 it was 50%

Ground management

Hush houses and engine run up management (location/aircraft orientation, time of day, maximum thrust level): Noise-reducing screening walls. An engine test-run facility reduces the noise emissions towards nearby residential areas. The facility built at Frankfurt Airport was the subject of a zoning request by Fraport. This facility allows reducing the peak level from engine test runs by up to 5 dB(A) thus affecting the residential areas considerably less.

Auxiliary power-unit (APU) management: Provision of Pre-Conditions Air Units. Both with a view to noise emissions and pollutant emissions, stationary units operate considerably more efficiently than auxiliary power units. Consequently, this measure allows reducing ground noise in the immediate surroundings.

Taxi and queue management; Towing; Taxi power control (taxi with fewer than all engines operating). Reducing ground-level engine noise by using electrically driven aircraft tractors (TaxiBot/E-taxi) Thanks to electrical drives, taxiing movements of aircraft performed at the airport with running engines should be reduced or made without the airplane's own engines. One way to accomplish this is to use electrically driven aircraft tractors, controlled in the cockpit of the towed aircraft (TaxiBot). Another way consists of fitting a wheel hub motor to an aircraft's main landing gear serving as an electrical drive (E-Taxi).

Operating restrictions

Restrictions have been implemented, related to the type of aircraft

Specific bans

MD11, B747 and A380 are banned from the new runway

Night flight

Between 22:00 and 08:00, marginally compliant aircraft are banned
Between 22:00 and 06:00, only chapter 4 compliant planes are authorized
Since October 2011, a curfew is applied between 23:00 and 05:00

Community engagement

Noise Monitoring System

The German Civil Aviation Law (Section 19a) obliges the operators of civil airports which are served by airline traffic to set up and operate installations for the measurement of air traffic noise near the airport. The operation of these installations is regulated in more detail by a German standard which is called DIN 45643 "Measurement and Assessment of Aircraft Noise". The measurement results are correlated with radar data at different airports in order to determine the exact correlation between passing aircraft and air traffic noise incident. Pursuant to the Civil Aviation Law, the measurement results must be transmitted to the competent aeronautical authorities and to the Commission on Aircraft Noise. Many German airports publish the results of the air traffic noise measurements on a regular basis.

Monitoring aircraft noise Fraport AG operates a total of 29 stationary measuring stations and three additional mobile measurement containers in the neighborhood of the airport. The data from the measuring stations provide continuous monitoring of aircraft noise development. They are used to categorise aircraft types for noise-dependent take-off and landing fees, and for documentation of unusual aircraft noise events.

Forum Flughafen und Region, throughout its environment and communication center (UNH - Umwelt- und Nachbarschaftshaus "Environmental and Neighborhood House") manages a network of 9 fixed monitoring stations and 2 mobile ones. The Environment and Neighborhood House is an observer of developments in the region, a neutral information service provider and a mediator between the conflicting parties. A central task for them is to carry out independent aircraft noise measurements and to make the results available to the public. The UNH also offers municipalities to become a location for a mobile measuring station for a period of about 3 months.

Advisory Committee pursuant to the German Civil Aviation Acts

A committee for all German airports advising the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the Federal Ministry of Transport and Digital Infrastructure prior to the adoption of legal provisions on aircraft noise or emissions of pollutants from aircraft was formed on the basis of the German Civil Aviation Law (Section 32a). The committee issues recommendations on measures for protection against air traffic noise. It consists of both representatives of the aviation industry and citizens affected by air traffic noise as well as various other institutions.

Commissions on Aircraft Noise at the civil airports

Pursuant to the German Civil Aviation Act (Section 32b) commissions advising the aviation authority on measures for the protection against aircraft noise and against air pollution from aircraft have been established at all major civil airports. The Commission on Aircraft Noise meets on a regular basis to discuss local problems with aircraft noise and to elaborate proposals for improvements. The Commission is made up of both representatives of the aviation industry and citizens affected by aircraft noise as well as various other institutions. Usually not more than 15 members: representatives of towns and cities affected by aircraft noise, NGO against aircraft noise, airlines, airport operator, supreme federal state authorities and in individual cases additional members. It must be informed and consulted on issues regarding noise protection and measures against air pollution. The Commission holds a veto right. Note that this kind of body was created because of the first contestations against airport developments and in order to enhance the transparency of the decision-making process. Advises the permit authority and the German air navigation service provider on mitigation of noise and air pollution Works closely with Airport and Region Forum.

The Airport and Region Forum (Forum Flughafen und Region, FFR) [7] [8]

The Airport and Region Forum (Forum Flughafen und Region, FFR) was established in 2008. This forum continues the work of the previous Regional Dialogue Forum (RDF), brings together representatives of the aviation industry, municipalities, relevant authorities, practitioners and researchers and aims above all to implement active noise abatement measures. The main tasks are:

- Inform mainly neutral, correct and transparent
- Improve communication and cooperation between Frankfurt Airport, its users and the residents
- Noise monitoring
- Environmental monitoring
- Social monitoring

Board of Directors

(1 independent member, 1 representative of aviation industry, 1 representative of towns and cities)

Steering Committee (decision-making body)

(Members of Board of Directors, representatives of Hessian State Chancellery, Hessian Ministry of Transport, Expert Group and Aircraft Noise Commission)

Expert Group on Active Noise Abatement

Identifies and analyses active noise mitigation measures

Representatives of airport, airline, ATC, pilots, research institutes, towns and cities, authorities

Convent Airport and Region

Discursive dialogue, no decision making body. About 60 members that were proposed by the affected municipalities, from the aviation side, the state politics (parties), environmental and local NGOs, trade associations, trade unions and churches. Appointed by the Hessian Prime Minister

Environment and Communication Centre

Information and administration

Figure 7.5 – Region Forum organisational chart at Frankfurt Airport

The Expert Group on "Active Noise Abatement" of the Airport and Region Forum (FFR) is in charge of:

- Identifying measures for active noise abatement and verifying them for suitability, applicability and ICAO conformity
- Checking and creating the preconditions for approvability
- Calculation of noise impact

The Basic conditions for work are:

- Safety and capacity requirements are met
- Noise reduction is achievable
- Technical and operational feasibility at Frankfurt airport
- No legal approval in advance

This Group included Fraport AG and other partners from the airline industry, German Air Navigation Services (DFS), the State Government and the region to develop the last action plan comprising 19 new measures. These include noise-reducing approach and take-off procedures, a concept involving alternating use of runways, and financial incentives to promote the use of maximally quiet aircraft. The success of the measures is monitored using comprehensive monitoring and the results are posted on the website of the Environmental and Neighbourhood House.

Environment and Communication Centre is in charge of:

- Inform mainly neutral, correct and transparent
- Improve communication and cooperation between Frankfurt airport, its users and the residents
- Noise monitoring
- Environmental monitoring
- Social monitoring

Investigation into the impacts of aircraft noise on health and quality of life [11]

The Forum in 2011 launched the NORAH Noise Impact Study ("Noise-Related Annoyance, Cognition, and Health") primarily financed by the State of Hesse (later by the Umwelt- und Nachbarschaftshaus) with the aim of conducting more detailed research on the effects of aircraft noise on health and quality of life. NORAH is the most extensive investigation into the effects of exposure to aircraft, road and rail traffic noise that has ever been carried out in Germany. It was conducted by nine independent scientific institutes from all over Germany, under the management of the Ruhr University Bochum and it has been divided into three modules. The study was concluded in October 2015 and the results were published throughout Germany. The first module of the study deals with potential noise pollution and the associated impairment for quality of life. The second module addressed the health risks that could be linked to all traffic noise modes. The learning performance for children was the subject of the study's third module.

Land Use Planning case study

Spatial Planning System in Germany [9]

Despite the federal nature of the country, spatial planning systems are fairly uniform. At the local level the "Federal Building Code" (Baugesetzbuch, BauGB) and the "Federal land use Ordinance" (Baunutzungsverdordnung, BauNVO) apply all over Germany, making detailed land use planning very homogeneous.

Länder (except city states) have adopted "statewide" spatial plans where airports are outlined but not regulated. "Regional Plans" covering several districts are adopted in many of the Länder. These plans include a more detailed delimitation of the airport grounds and may define "settlement restriction areas" based on noise, but do not regulate airport uses.

Local framework plans and regulatory plans, covering only part of a municipality, are adopted by local authorities or local planning associations but must be approved by a higher administrative authority, usually the district. Regular spatial plans are not used to regulate airport creation or development. The spatial planning legislation provides for special planning instruments to plan and implement large infrastructural projects, including airports.

Regulations and permits [9]

Construction permits

In principle all construction works require a building permit issued by the local authorities. There is no generalised exclusion of infrastructure projects from the building permit requirement.

Large infrastructural projects, however, usually follow special planning procedures which do not lead to an ordinary "building permit" and are not handled by the local authorities.

Environmental permits

EIA is regulated in accordance with EU legislation, including the evaluation of plans and programs, but applies to a larger number of projects. Airports require an EIA when runway length exceeds 1,500 m and the approval of the German National Parliament.
A specific evaluation is conducted for projects which may affect protected areas.
All potentially contaminating activities require either an EIA or an environmental permit, but airports are excluded from this requisite.
Environmental permits are integrated with the building permit. Regional authorities in charge of environmental permits issues this integrated permission after consultation with the local authority. Water related permits are processed separately.

Airport planning and construction [9]

Policy and planning

The Federal government has a general competence regarding aviation but all competences with respect to airports are in the hands of the Länder.

National
The "Federal Transport Infrastructure Plan" (BundesVerkehrswegePlan, BVWP), which is adopted by Parliament, is basically an infrastructure investment program oriented essentially towards rail, road and waterways, but does not include airport projects since these are not within the competence of the federation. It includes only some very broad statements about enhancing the competitiveness of German airports. The "Airport Concept of the Federal Government" (Flughafenkonzept der Bundesregierung) adopted in 2000 analyses investment requirements needed to accommodate demand, lists proposed actions, including the modification of noise legislation, and puts air transport in perspective with other modes but does not go into details.

Airport
There are no statutory airport plans. Each airport may prepare its own internal development strategy but in order to create a new airport or expand an existing one it is necessary to go through a special "planning decision procedure" (Planfeststellung) and will often require a "spatial planning procedure" (Raumordnungsverfahren) in order to determine the impact on spatial plans and define the spatial framework for the new project. Both procedures require an environmental impact assessment.

Spatial impact

Implementation of ICAO Annex 14 requirements
Safeguarded areas are implemented by defining a construction restricted area (Bauschutzbereich) formed by a series of concentric circles and a widening inclined plane beginning 500 m from the ends of the runways. In the inner areas (1.5 km radius) all constructions, trees, power lines, etc. must be authorized by the aviation authority, in the outer areas such authorization is only necessary when building heights exceed between 25 m and 100 m depending on the distance.
All constructions within these areas must be authorized by the Land's aviation administration. The limits of safeguarded areas are made public but not integrated into spatial plans. Affected property owners are notified.

Noise Impact
The noise impact of airports was regulated in 1971 by The German Act of Protection against Aircraft Noise (Gesetz zum Schutz gegen Fluglärm). The Act defined 2 land use restriction areas where residential uses, hospitals, schools are restricted. An

important modification in October 2007 came into force as it was mentioned before, establishing new and more restricted limits.

Risk prevention
There are no legal provisions concerning risk analysis, but in Frankfurt, risk has been the object of specific evaluations.

Land reserve for future construction
Land for future construction can be reserved in ordinary spatial planning documents or by means of the specific planning instruments (Planfeststellung) which must be used for airport development.

Construction

All new airports, or substantial modifications, must be authorized following a "planning decision procedure" (Planfeststellungverfahren) which serves both as planning and building permission. The permit is issued by the aviation authorities in each Land.
The "planning decision" replaces all permits, authorization or licenses that may be required by law, it covers both airport construction and operation.
A regular building permit is needed for airport buildings, since the "planning decision" covers only the infrastructure.

Operation
A permission of the local Government is required.

Airport noise and air quality

Noise
Air traffic noise is regulated under specific legislation, requiring the delimitation of noise protection zones where land use restrictions are posed, and some insulation measures receive financial assistance.
Night curfews, quota count systems and noise charges are used in many airports to contain airport noise.

Air quality
Clean Air Plans and Action plans must be adopted when certain levels are attained for a number of days. Polluting activities may be restricted or banned in contaminated areas
Air pollution is taken into account in the special planning procedures used for the construction or enlargement of airports.
Information from monitoring stations does not evidence aviation related problems with air quality in or around airports.

<u>Frankfurt airport</u>

Frankfurt airport had an expansion process between 1997-2011 and provides a good example of how the German system operates for the construction or expansion of airports, how it relates to spatial planning, and how environmental concerns (especially noise) are taken into consideration.

When the airport operator, Fraport AG, decided in 1997 that it was necessary to undertake a major expansion, the "Minister President" of the Land of Hesse indicated that it would be convenient to carry out first a mediation process in which all interested parties could be heard in order to reach a consensus on the major options for the future airport development, as well as to build a closer relationship between the airport and its neighbours as it was mentioned previously.

At the end of the process the "mediation report" included a series of recommendations and proposals which had no legally binding force but carried a lot of weight. The report confirmed the need to expand the infrastructure but recommended a ban on night flights and an agreement on a "noise pact", as well as setting up a permanent Regional Dialog Forum throughout the entire process.

On the basis of the outcome of the mediation process and the work of the Regional Dialogue Forum, the operator prepared the documents needed to initiate the "spatial planning procedure" (Raumordnungsverfahren) and filed the application in October 2001. The documents included three possible alternatives, which were evaluated in detail from all points of view, technical, economic and environmental. It focused on the compatibility with existing spatial plans and with environmental planning and legislation. The documents were then examined by the administration and submitted to all affected local authorities as well as citizen organizations, trade associations and public interest organizations. Any interested citizen was able to examine the documents and submit an opinion.

At the end of the "spatial planning procedure" the President of the Darmstadt district issued a "regional planning statement" (Landesplanerische Beurteilung) on 10 June 2002, pointing out the need to amend the objectives of the regional plan for South Hessen in order to achieve compatibility of the North-West alternative with the requirements of regional planning. Moreover, the "statement" set a number of conditions to be met by the operator in order to insure compatibility with regional planning.

Due to the Hessen-wide importance of the expansion of Frankfurt Airport, the

development plan of the Land of Hesse was amended in order to include regional planning objectives and principles for the airport's development.

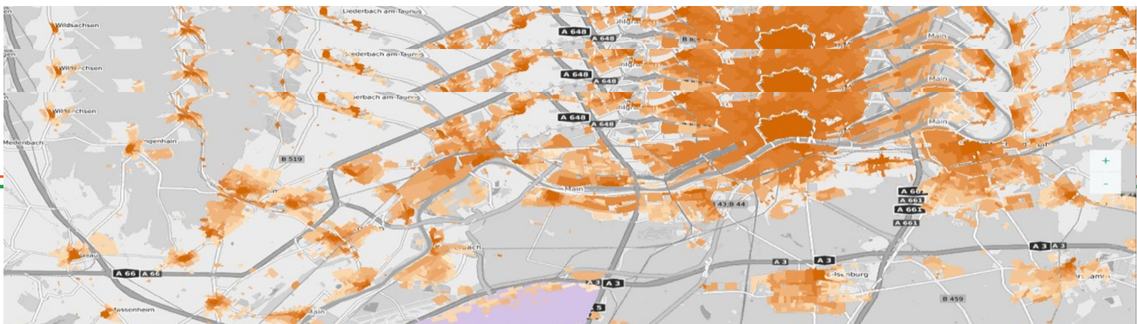
The airport operator prepared the detailed project documentation required to initiate the "planning decision procedure" (Planfeststellungsverfahren) and filed the application before the Darmstadt district administration on 9 September 2003, and after several requests for additional documents and clarifications, the district administration considered the application to be complete. On 24 November 2004 the documentation was put on public display and it was announced that comments could be submitted for a month.

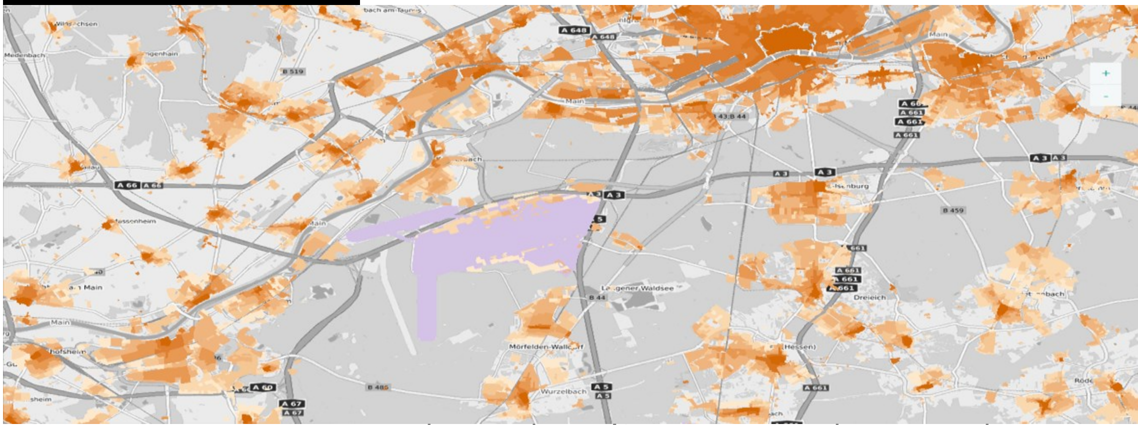
The documentation was made available to 57 local communities and 327 public authorities were invited to comment on the proposal. The participation process resulted in over 120,000 written submissions.

The final decision (Planfeststellungsbeschluss) in December 2007, the Decision of the Hessian Ministry for Transport on the plan approval procedure included all the necessary permits to begin the construction of the new infrastructure, as well as a decision on all the operational restrictions. It authorised having 17 movements between 23:00 and 05:00 and 150 movements from 22:00 to 06:00, as it was mentioned before.

Management effectiveness in Land use Planning around Frankfurt

Nevertheless, the next pictures show the land evolution of the last 60 years:





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Wiegandt et. al.) / RWTH Aachen (Prof. Selleet al.) on behalf of BDL (German Aviation Association) about 6 airport regions: CGN, DUS, FRA, HAJ, HAM, MUC shows interesting outcomes:

Findings of the study [3]:

Building developments are getting closer and closer to airports; above-average development of residential areas in the vicinity of Frankfurt Airport

Closing of gaps between buildings; densification and consolidation of existing residential areas; some new residential areas

Consequence: Increase in the number of people affected by aircraft noise; new conflicts can be expected

Growth pressure in thriving regions –partly triggered by airports

Planning tools have not been exhausted; instead, building permits with no land use plan (Section 34 of the German Federal Building Code)

Higher-level regional and state planning frequently acts with caution (topical example: residential restriction zone in the new Hesse regional development plan scaled down significantly)

Recommendations of the study [3]:

Manage residential development activity based on land use plans instead of on building permits on the basis of Section 34 of the German Federal Building Code in order to broach the issue of conflicts and balance interests in a better way.

Preventive conflict mitigation and mediation of interests in the regional and state planning through consistent designation of residential restriction zones

Continue confidence-building measures (discussion groups, joint data collection).

Strengthening of inter-municipal cooperation (e.g. joint land use planning/ projects, partly in cooperation with airport; example Mönchhof Logistics Park)

Objective: Noise abatement through residential development management

What were the problems? [5]

Before the new version came into force in 2007 the Federal Air Traffic Noise Act from 1971 mainly regulated noise insulation. In some Länder additional regulations were introduced to avoid future conflicts due to aircraft noise. In the Land of Hesse different noise zones were established through spatial plans. The current regulation is that **no new residential areas** and no new mixed used areas **should be planned** within noise zone LDN 60 dB(A) (settlement restriction area - 'Siedlungsbeschränkungsgebiet').

- The noise zones were **based on forecasts** that became not always true. Noise zones changed significantly in shape and size over the years (forecasts did not

come true; in the past very often much more aircraft movements than expected) as a result residential area were developed in zones which were not expected to become as noisy.
- For different towns and cities, the noise zones meant that there is no or very limited opportunity for further development. They therefore requested a compensation theme

It is important to remark that in Frankfurt region there is a lack of affordable housing which leads to a big pressure to build dwellings.

New regulations [5]

The Hessian **regulation on regional equalisation of burdens** ('Gesetz über den Regionalen Lastenausgleich') in force since 1. January 2018.
Land provides **21 highly aircraft noise affected towns and cities** with 22.6 million Euros until 2021. (Money comes from dividend of the Land's company shares of Fraport.)
Amount of money for towns/cities depends on number of affected inhabitants and extent of noise pollution.
Money to be spent for social matters, education, child care, employment and apprenticeship initiatives, improvement of public building's noise insulation and air conditioning, building and maintenance of public recreation areas.

'Lärmobergrenze' (Upper noise limit)

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:
- area within LD = 55 dB(A) **should not become bigger than** 22.193 (16.955 in 2017) hectare and
- area within LD = 60 dB(A) **should not become bigger than** 8.815 (6.911 in 2017) hectare

Monitoring **every year.**
Measures to be taken **if areas are exceeded**
Fixed in the development plan of the Land
May help to **establish a lasting noise zone**

Some towns are adopting:
- Voluntary commitment of town to stabilise number of inhabitants
- By revision of the existing binding land-use plans
- Plans to limit building density

CONCLUSION and Lesson learned

Land-use planning can contribute to avoiding future noise problems, but noise insulation rules and additional regulations bidding new residential areas are not enough. Local Authorities and Communities requested a **compensation scheme for Outdoor Living Areas** (implemented by a new amendment of the law in 2013) and on **regional equalisation of burdens** (implemented by a new amendment of the law in 2018). Moreover, there are voluntary programs like CASA to rebuy dwellings.
For establishing noise zones reliable forecasts are needed noise zones should last. Long tradition **of establishing noise zones around the airport** to avoid future conflicts due to aircraft noise **but based on forecasts that did not turn out to be accurate**. Noise zones changed significantly in shape and size over the years, as a result residential area were developed in zones which were not expected to become

as noisy. Since 2017, there are a **new voluntary agreement about area inside noise footprints per year**.
Interest/right of growth of airport and surrounding towns/cities must be deeply studied and balanced. Land Use Planning is a global problem, that must be treated jointly by the different stakeholders. **Shared responsibility**. There are **voluntary agreements** with the airport for specific areas and **voluntary commitments** of some towns to stabilise the number of inhabitants.
Usually additional noise mitigation measures are required.
Night-flight ban, noise mitigation package, noise respite, regulation on regional equalisation of burdens and 'Lärmobergrenze' (upper noise limit) in Frankfurt-Rhein-Main region are the outcome of participative processes (mediation etc.) and structures that helped to achieve tailor made mitigation measures, knowledge, transparency and understanding for problems and constraints for the other parties.

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8.8 Case Study 8 – Cluj-Napoca Airport

Overview

This case study provides an overview of the previous, current and proposed practices of **Cluj Airport**, as a part of their Noise Management Strategies.
The structure of the case study is constructed such that the actions and interventions accomplished by **Cluj Airport,** are presented in a descriptive and detailed manner with the purpose of emphasizing lesson learning and good practices.
All information used for the development of this case study was gathered from the airport, interviews with relevant stakeholders and online sources. Interviews included **airport representatives, local community and city hall representatives, local environmental agency , local and Romanian ANSPs (Air Navigation Service Providers), the CAA (Civil Aviation Authority, TAROM airline and relevant National Ministries (Environment, Transport)**. The interview findings were correlated with all other available information and included within the case study. Most of the topics of the interviews were formulated around the knowledge, understanding and application of ICAO Balanced Approach, together with further actions designed to reduce and mitigate noise and its effects.
The target audience of the case study includes airport operators and several other relevant stakeholders such as Air Navigation Service Providers, Civil Aviation Authorities, aircraft operators, environmental and government organizations and other interested parties.

Background information

The airport is located in Cluj-Napoca, the largest urban center of Transylvania
(over 320,000 inhabitants) and placed geographically, economically, historically and culturally, in the heart of this historic region with 7 millions of inhabitants. The airport is situated on the E576 road, about 10 km east of the Cluj-Napoca city center and 12 km from the railway station. The size and the location make it the main airport in Transylvania (north-western Romania). The destinations offered by the Cluj Avram Iancu International Airport to passengers are varied, given fact that there are up to 45 domestic and international destinations to 21 countries of destination in Europe and the Middle East, operated by Tarom, Wizz Air, Lufthansa, Lot Polish Airlines, Blue Air, Turkish Airlines and Aegean Airlines.
Cluj County has approximately 700.000 inhabitants. From this point of view, Cluj-Napoca airport can be compared
with the airports from European cities such as Geneva and Stuttgart that annually registers 12 and 9 million passengers. Cluj
Avram Iancu International Airport R.A. is part of the modern regional airports in Europe, being the second largest airport in Romania in terms of passenger traffic and the first regional airport of the country. It is also the first airport in the category of subordinated to the County Councils from Romania. Within a range of 170 km around the city, live about 3 million potential passengers whose service is a fundamental concern for Cluj airport.

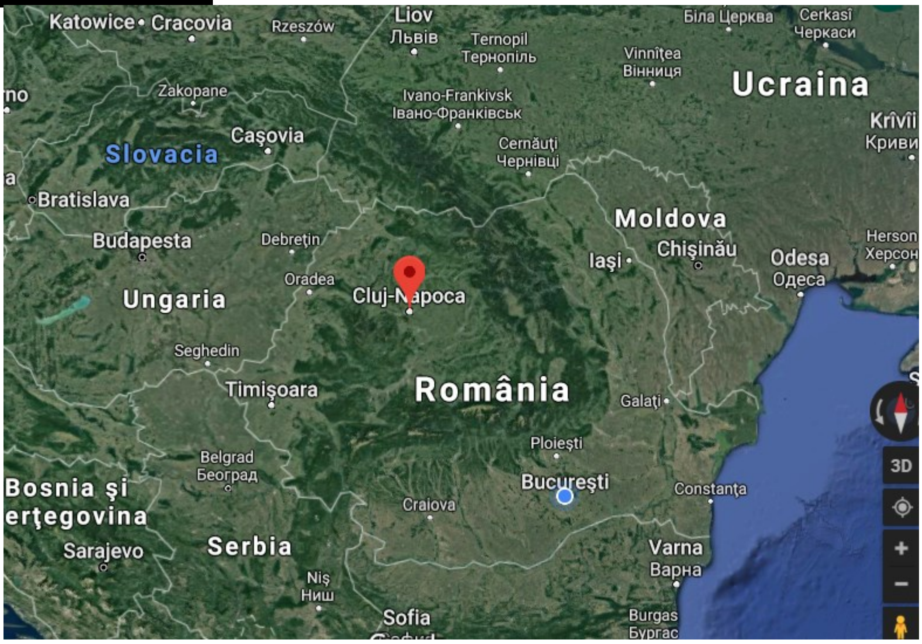

Figure 8.1 – Location of Cluj-Napoca Airport [1]

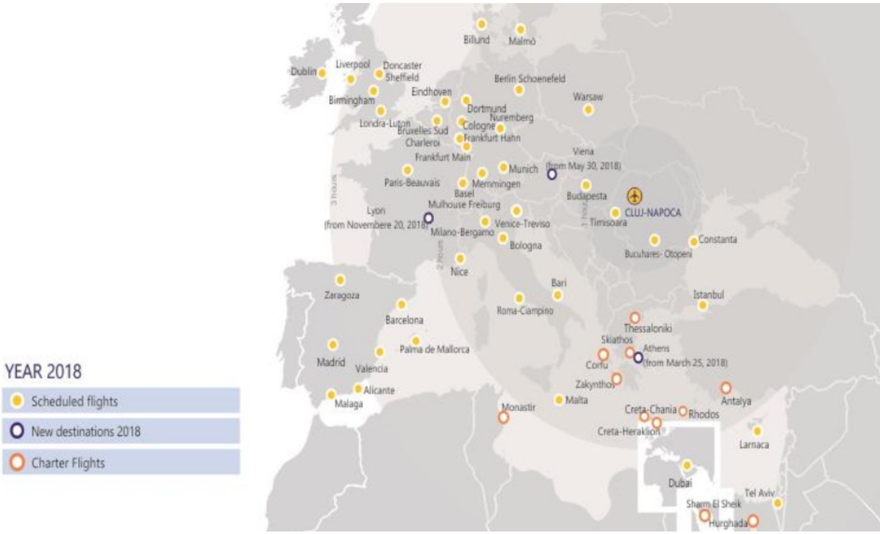

Figure 8.2 – Cluj-Napoca Airport flight connections [2]

LRCL AD 2.2 AERODROME GEOGRAPHICAL AND ADMINISTRATIVE DATA

1	*ARP co-ordinates and site at AD*	464721N 0234132E on RWY centre line, 1457M from THR07
2	*Direction and distance from city*	9 km East from Cluj Napoca.
3	*Elevation/Reference temperature*	1039 FT / 26.3°C
4	*Geoid undulation at AD ELEV PSN*	133 FT
5	*MAG VAR/ Annual rate of change*	5°E (2015) / 7.0'E
6	*AD Administration, address, telephone, telefax, e-mail, AFS, website*	Aeroportul Internaţional Avram Iancu Cluj Str. Traian Vuia, nr. 149 , Cluj-Napoca, cod 400397 Tel: +40-(0)264-307500; +40-(0)264-416702; +40-(0)264-416708 Fax: +40-(0)264-416712; +40-(0)264-307505 Telex: 031288 AEROPCL R AFS: LRCLRAYD e-mail: office@airportcluj.ro SITA: CLJAPXH WEB: www.airportcluj.ro
7	*Types of traffic permitted (IFR/VFR)*	IFR/VFR
8	*Remarks*	Nil

Figure 8.3 – Cluj-Napoca Airport Geographical and administrative data [3]

From 1996 until 2017, Cluj Avram Iancu International Airport registered high growth rates of passenger air traffic. This increase was determined by an effective and efficient management, by the adoption of marketing strategies
that generated the development of air traffic and attracted new air operators on Cluj market (Tarom, Wizz Air, Lufthansa, Vueling, Lot Polish Airlines, Blue Air,Turkish Airlines, Aegean Airlines). Also, at the Cluj Avram Iancu
International Airport we have three airlines that operate international cargo transport: Silver Air and Swift Air. The charts below present the evolution of passenger’s air traffic embarked/ disembarked from Cluj Avram
Iancu International Airport:

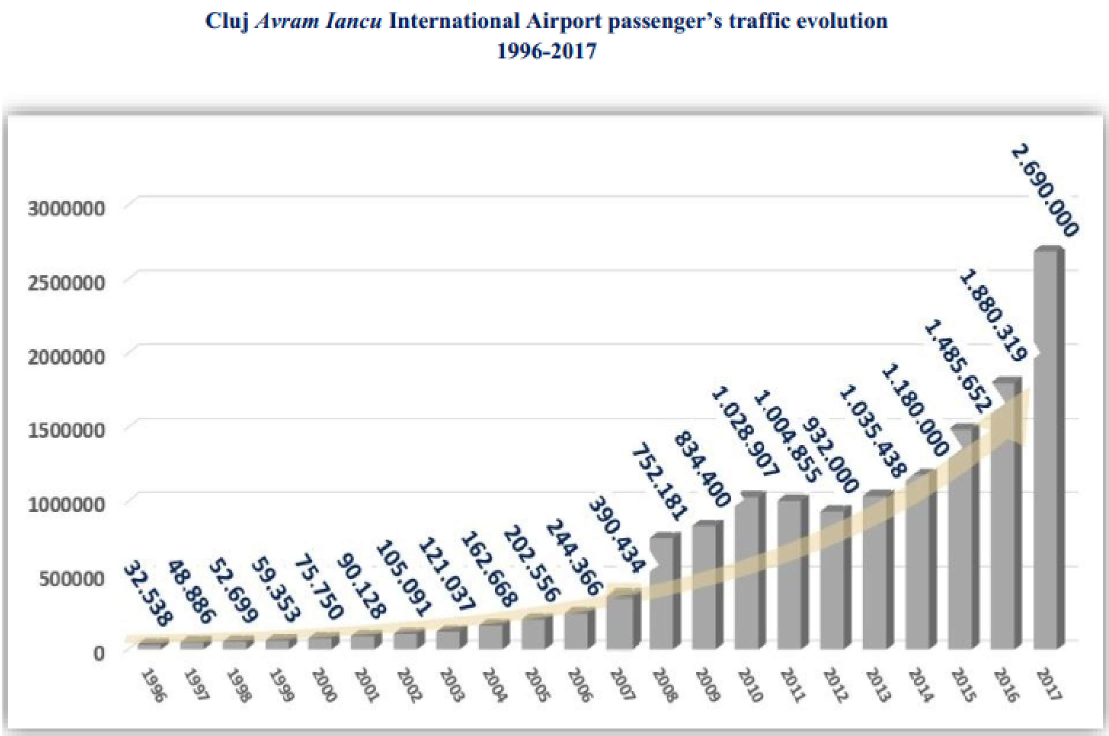

Figure 8.4 – Cluj-Napoca Airport Passengers traffic evolution 1996-2017 [2]

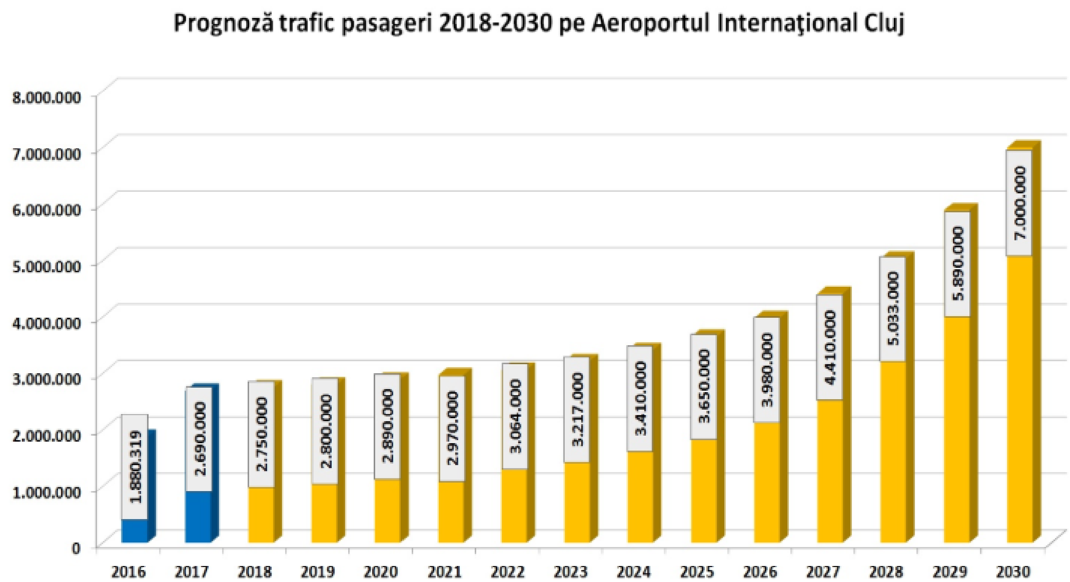

Figure 8.5 – Cluj-Napoca Airport Passenger traffic forecast 2018-2030 [2]

LRCL AD 2.12 RUNWAY PHYSICAL CHARACTERISTICS

Designations RWY	*TRUE BRG*	*Dimensions of RWY (M)*	*Strength (PCN) and surface of RWY and SWY*	*THR co-ordinates RWY end coordinates THR geoid undulation*	*THR elevation and highest elevation of TDZ of precision APP RWY*
1	2	3	4	5	6
07	071.83°	2040 x 45	114/R/B/W/T Concrete	464706.53N 0234026.61E 464724.70N 0234147.26E GUND 133FT	THR 1037 FT
25	251.84°	2040 x 45	114/R/B/W/T Concrete	464724.70N 0234147.26E 464704.10N 0234015.86E GUND 133FT	THR 1023 FT TDZ 1023 FT
Slope of RWY-SWY	*SWY dimensions (M)*	*CWY dimensions (M)*	*Strip dimensions (M)*	*OFZ*	*Remarks*
7	8	9	10	11	12
-0.1% (135 M) -0.4% (540 M) -0.24% (960 M) 0.00% (345 M)	Nil	60 x 180	2160 x 210	Nil	Nil
0.00 % (345 M) 0.24% (960 M) 0.4% (540 M) 0.1% (135 M)	Nil	60 x 180	2160 x 210	Nil	Nil

Figure 8.6 – Cluj-Napoca Airport Runway physical characteristics [3]

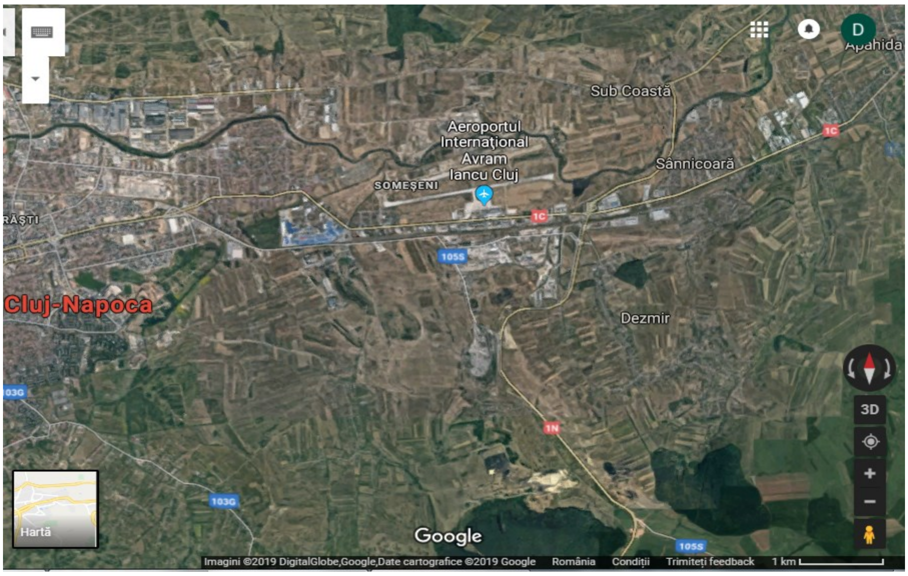

Figure 8.7 – Cluj-Napoca Airport surroundings areas

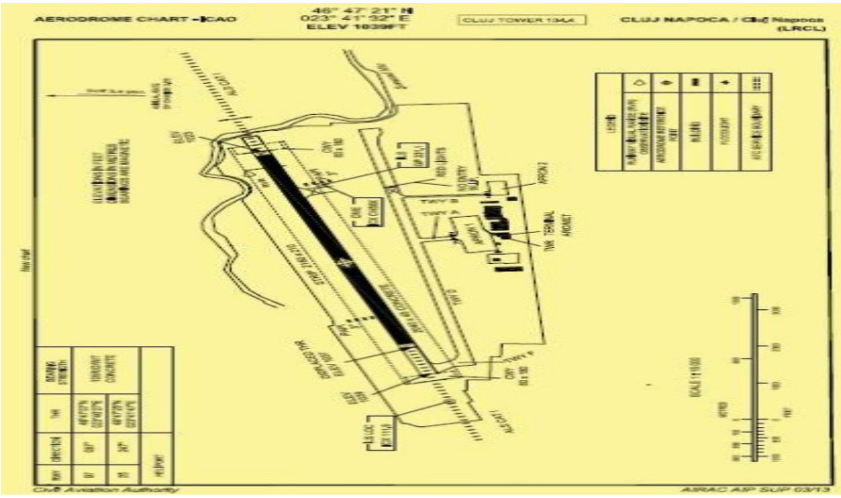

Figure 8.8 – Cluj-Napoca runway map [3]

Investment projects with possible noise issues

Two important projects are expected for Cluj Airport which might imply supplementary noise issues:

Extension of 07/25 runway

Figure 8.9 – Runway extension project [2]

Runway extension from 2040 m to 3420 m represents a necessary investment in order to cope with the future traffic development of the highly dynamic economic Cluj area. Unfortunately it requires a correction of Somes river over a distance of 7 km. This is a difficult task due to supplementary financial needs and environmental issues. Even so there is a strong determination from the Airport and Cluj Local Authorities to move things on. The project should be finalized within the next few years. Increased expected noise due to higher traffic might be reduced by better use of the longer runway as declared the Airport management.

Development of intermodal transport infrastructure for passengers and cargo

This is an ambitious project for further development of the Airport and has the following characteristics: cargo capacity 50000 tons/year; total surface 46570m^2; cargo hall surface 6180m^2.
It should be mentioned that this investment becomes effective in conjunction with the runway extension which allows more and heavier traffic which might result in increasing the noise figures.

Applicable Noise Regulations

The Environmental Noise Directive [4] was transposed into the National Legislation in 2005 (H.G. 321/2005) [5]. Further updated and modified versions were published through the years, together with the necessary framework for the implementation and

evaluation of its provisions. As a main result, the development of Strategic Noise Maps and Action Plans is mandatory for major airports. Romania has only one Major Airport, that being Bucharest Henri Coanda International Airport.
Its alignment to END is furthered in 2007 (H.G. no. 674/2007 [6]), 2012 (H.G. no.1.260/2012 [7]) and 2016 (H.G. no. 944/2016 [8]) through modifications and completions done under the provisions of the Law no. 52/2003 [9] regarding the decisional transparency of the public administration.
A new Noise Law [10] was initiated in 2018, transposing the updated version of the Environmental Noise Directive, i.e. together with the Annex of the EU Directive 996/2015 [11] establishing the common methods of noise evaluation at the EU level. The implementation of the Noise Law will repeal the previous transposition of the Environmental Noise Directive, together with all its subsequent legislation.
Regarding ICAO Balanced Approach [12], recent legislative changes include the transposition of the Regulation (EU) no. 598/2014 of the European Parliament and Council of 16 April 2014 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC (August, 2018) [13].
A detailed description of the Romanian Legislative Framework regarding Aviation Noise can be found in Annex (A). Responsible Authorities for aviation noise are detailed in Annex (B).

Overview – Approach to the BA

Summary of national regulations and how they have been implemented by the airport; AIP Data on noise operations/restrictions/other LUP data

The only noise abatement procedures for Cluj Airport as it appears from AIP Data refer to the use of APU during ground operations (LRCL AD 2.21) and very recently (Dec 2018) the use of NADP1 for RWY 25 became compulsory. Also the use of either NADP1 or NADP2 for RWY 07 is recommended (LRCL AD 1.1-3).

Review of Noise Action Plans and previous BA interventions

Cluj airport is not a major airport as defined by END but an airport near urban area of more than 250000. Until now they have implemented the END requirements regarding the Strategic Noise maps and Noise action plans.
The present NAP created in 2018 was build on 2016 traffic data and a forecast for the period 2017-2022 . A noise mitigation study by using preferential RWY for departures and arrivals was conducted . This was ordered by the Airport during 2018. An important remark is that the new NAP takes in consideration the noise data coming from the use of the new RWY 07/25 which started to be used from the end of 2013 and replaced the old 08/26 RWY which became a ground operations facility. The new 07/25 RWY was proposed within the previous NAP as a noise mitigation solution for some communities around the airport, like Apahida and Sanicoara due to the new orientation compared to the old one.
The main noise mitigation interventions proposed within NAP consider short term and long term solutions. Even if NAP does not present the solutions in a systematic way using ICAO BA pillars we chose this type of presentation:

Noise at source

Currently, the aircraft does not comply with ICAO standards, Annex 16, volume I, "noise", Chapter 2 aircraft or FAA FAR Part 36, Chapter 2 (commonly called in aircraft

"Chapter 2") are not eligible for operating international airport Mumbai "Cluj. Moreover, a significant proportion of aircraft operated on International Airport Cluj meet related standards class R7 (3, amendamentul7, Chapter 4) according to the ACI Aircraft Noise Rating Index 2010. This fact is confirmed by the EASA document. A. 064.3 from 30.01.2018, which certifies that the A320 aircraft produced by Airbus, meet the standards set out in ICAO document, Annex 16, volume I, 3rd Edition, Amendment 7, chap. 4. At the level of the year 2017, from the total of 24,633 aircraft that have transited the Cluj Airport, a number of 11,802 were class A320 aircraft. Also in the year 2017 and also operated a number of 2,998 class aircraft Boeing 737-800 aircraft image according to EASA. IM. A. 120 of 09.04.2013 are also certified as complying with the noise standards set out in the ICAO Annex 16, volume I, 3rd Edition, Amendment 7, chap. 4.

LUP management, communication and community engagement

Cluj Airport aims to promote and support at national and local level, the following measures:

- in order to ensure the necessary legal framework and coherent development and support they promoted at Ministry of Transports and Government a draft proposal for the elaboration and approval of legislative acts regulating construction and zoning of the system in the areas bounded by the maps conflict resulting from strategic noise maps in the areas protected, to ensure at least maintain, if not reduce, the number of people exposed to noise;
- Further promoting at the level of local authorities to draft a proposal for zoning regime in the vicinity of buildings from Cluj-Napoca international airport according to related indicators contours of Lden noise and Lnight resulting from strategic noise mapping. Rationale this measure consists of the advantages of the adoption and use of a mode of planning to ensure strategic development in synergy with the residential development of airport activity.

As a remark, the NAP points out that reducing the level of noise generated in inhabited areas, as set out in the action plan adopted following the SNM carried out in the year 2015, after the entry into service of the new runway , namely "promotion at the level of the authorities local draft proposal for zoning regime in the vicinity of buildings from Cluj-Napoca international airport. "has been achieved by the inclusion in the General Plan of Urbanism of the Cluj-Napoca area aeronautical servitude.

- To reduce or at least to keep to a minimum the noise exposure of populations in the vicinity of the International Airport Cluj , either on an annual basis, concerning the completion of aircraft movement forecasts , either when significant differences occur in the number of flights scheduled in the timetable, will be carried out simulations and forecasts of noise to be able to be determined the optimal distribution of aircraft movements in the directions of flight and If possible on different time scales.

The motivation of the proposal these measures is based on the fact that, in the context of the work of the strategic noise mapping for the year 2016 as well as within the simulations carried out for the NAP and noise level prediction in 2017-2022 period level, were identified situations in which are recorded the maximum permitted exceedances of the values for indicator Lden and especially Ln for residential areas in the vicinity of the airport.

- Permanent updating of strategic noise maps and making them available to the public concerned. The reasons for this measure consists in the necessity of informing those concerned about the noise level on a particular location targeted, before starting an investment in construction or purchase of houses
- Transmission to local authorities (Mayoralties and local councils of neighbouring localities, particularly the Mayor of Cluj-Napoca) strategic noise maps drafted for Cluj

airport, with a focus on the contours of the conflict, in order to enable the use of these data and in the development and approval of projects for residential developments in the vicinity of the airport. Last but not least, the provision of information on related indicators contours of Lden and Lnight noise resulting from strategic noise mapping will provide local authorities with an extremely useful tool in the regulatory process construction of the system in the vicinity of the airport.
- Implementation of a noise monitoring system to manage the problem of noise and long-term assessment of the real-time values of noise generated by the airport activity;

Operations

- Currently 2018 NAP requires the use of preferential runways during departures and arrivals. According to a detailed simulation study performed during 2013 and repeated in 2018, it resulted that the use as much as possible the RWY 07(from the City towards the airport) for departures and RWY 25 (from the Airport towards the City) for arrivals should reduce the both the area and the total exposed population even considering the increased traffic forecasted for the period 2017-2022.

It will pursue-particularly at night-use in the fullest possible measure of flight directions supplied by flight control equipment which will lead to a significant reduction in the number of aircraft flying over the city of Cluj; The reasons for these measures is based on the concentration of flying above the surface areas least inhabited

- -As a long-term measure in order to reduce the number of people exposed to high noise values, in collaboration with the ROMATSA (Romanian ANSP), will try to improve the SID/STAR procedures in establishing flight paths image, as far as possible, avoid overflights of Cluj, as presented above.

Operational restrictions

There are no operational restrictions on noise considered within NAP apart from the aircraft type which are allowed to operate. Even so the NAP recommends:

- maintaining the minimum possible number of flights at night through the scheduling of new races, so far as practicable, outside the range (23:00-07:000), in order not to exceed a period of one year the number of aircraft movements 4500 at d It's night;
- As a long term and particularly at night the use as much as possible of flight directions supplied by flight control equipment which will lead to a significant reduction in the number of aircraft flying over the city of Cluj; The reasons for these measures is based on the concentration of flying above the surface areas least inhabited

Public Consultations

These have been done according to Law no. 52/2013 regarding the decisional transparency in the public administration, with further modifications and updates.
In order to ensure transparency in decision-making, suggestions, recommendations and proposals can be sent to an e-mail address, by specifying the articles from the Action Plan that are referred to, which is available on the website of the airport at the same time when the announcement is made. The announcement for the official meeting have been published on the website and also in local newspapers.
The participation to the public consultation requires an a priori registration which can be done online or at the airport.

All proposals and observations discussed during the public consultation are included in the official minute and further analysed in order to establish what can be included in the Action Plan.
The minute of the public consultation, the recorded recommendations, an updated version and the final version of the Action Plan and other relevant documents are published and available on the website of the airport, respectively at the airport.

Identification of any trends and overarching processes and internal systems that underpin BA implementation

Costs associated with the measure of reducing to a minimum the possible associated Cluj-Napoca are unavailable at this point information on the direct cost involved due to the implementation of measures to avoid as far as possible associated Cluj-Napoca, measures included in the action plan. However, it can be estimated that modifying the landing and takeoff paths, by extending the flight paths, could lead to an increase in costs for the airlines. Also reducing or capping the number of flights operated at night, will lead to an increase in operating costs for airlines. In these circumstances, there is a possibility that these companies reduce the number of flights on Cluj Airport -either by waiving certain destinations, either by reducing the frequency of flights.
An important factor to consider is the SPICE project where Cluj Airport is involved. The European Project SPICE (Synchronized PBN Implementation – Cohesion Europe) is part of the implementation phase (2014-2024) of SESAR (SES) that seeks the increase of Air Traffic Management (ATM) efficiency and of Air Navigation Services (ANS) through decreasing the fragmentation level of the European airspace. Through its nature, this initiative is Pan-European. Predicted advantages through the application of SES (Single European Sky) estimate a triple increase in airspace capacity, a 50% reduction in ATM costs, a 10% safety increase and a 10% impact reduction of aviation on the environment.
SPICE involves the implementation of a navigation system based on PBN performance, exploiting RNAV (Area Navigation Systems) advantages of modern aircraft in order to support an efficient design of the airspace and the systematization of air traffic routes, in pursuit of optimizing the available airspace.
The implementation period of the project is from 2016 to 2020 and is coordinated by EUROCONTROL. Partners range from air carriers (Aegean, Blue Air, Regional Air Service, SATA, Tap Portugal), to air traffic service providers (DCAC, HCAA, LPS SR, NAV Portugal and ROMATSA), including also the Romanian Civil Aviation Authority (AACR) and the Romanian Airports' Association (AAR) including Cluj Airport.
At the Romanian level, the project implies a series of activities to design, approve and operate RNAV SID/STAR systems and procedures (RNP APCH LNAV, LNAV/VNAV, LP and minimum LPV) through the use of the GNSS signal (EGNOS). The tasks of the project include data collection through the development of obstacle studies for all participant airports, as well as the design, encoding and authorization of the equipment for PBN implementation. The application of the project activities will assist the progress of controlling operations inside the Romanian airspace through PBN, thus facilitating safer and more efficient trajectories, altogether with reducing the rate of missed approach and redirection.

<u>Complaints</u> regarding Airport noise are less than 20 /year and are addressed to the Airport, local ROMATSA, Environmental Agency or Municipal local Police. It should be mentioned that there is no clear regulated path for handling these noise complaints.

Flight Procedures (e.g. SID/STARs)

RNAV SID and STAR procedures within NAPOC TMA are based on DME-DME sensors and designed in accordance with RNAV-1 (P-RNAV) criteria. RNAV-1 (P-RNAV) approval is required to conduct these procedures without additional restrictions. RNAV-1 (P-RNAV) approved aircraft operators fill-in accordingly the flight plan. There are expected direct routing/shortcuts by ATC whenever possible (especially during off-peak hours). The turn to final approach is usually performed by radar vectors to expedite traffic handling and for separation reasons.
Tactical points for non-standard shorter approach are established: IXORI for CL RWY07, VIBUD for CL RWY25. These points may be used only after request/approval of air crews.
Vertical planning information: air crews should plan for possible descent clearance in accordance with vertical restrictions specified on STAR charts. Actual descent clearance will be as directed by ATC.
In case a published climb gradient cannot be respected, air crews should request non-standard departure before start-up.

2.3.2 Obstacles

The exact location for the main obstacles are presented within LRCL AD2.10 and presented below.

LRCL AD 2.10 AERODROME OBSTACLES

In approach / TKOF areas			*In circling area and at AD*		*Remarks*
1			2		3
RWY/Area affected	*Obstacle type Elevation Markings/LGT*	*Coordinates*	*Obstacle type Elevation Markings/LGT*	*Coordinates*	
a	b	c	a	b	
07/APCH 25/TKOF	Tree 325M/1066FT	464656.45N 0233953.11E	Building 510M/1673FT	464837.78N 0233841.49E	
	Building 325.4M/1066FT	464654.70N 0233951.82E	Geodetic point 513M/1683FT	464837.48N 0233834.80E	
	Building 331.2M/1086.6FT	464659.13N 0233940.93E	Geodetic point 478.2M/1569FT	464833.12N 0234018.69E	
	Building 384.2m/1260FT	464620.64N 0233747.85E	Hill 440.8M/1446FT	464855.44N 0234242.93E	
	Antenna 386.5m/1268FT	464613.50N 0233726.10E	Hill 476.7M/1564FT	464940.91N 0234151.53E	
	Antenna 382M/1253FT	464610.62N 0233705.69E	Hill 451.2M/1480FT	464617.44N 0234336.52E	
	Antenna 391M/1283FT	464607.70N 0233656.40E	Hill 458.9M/1505FT	464510.31N 0233907.80E	
	Church 401.6M/1319FT	464619.06N 0233547.06E	Hill 438M.2/1438FT	464539.68N 0234206.29E	
	Church 428.7M/1407FT	464612.44N 0233522.68E	Hill 446.6M/1465FT	464538.90N 0234258.75E	
	Antenna 406.7M/1335FT	464547.23N 0233458.72E	Hill 536M/1759FT	464637.12N 0232910.91E	
	Antenna 480.2M/1575FT	464520.20N 0233436.56E	Hill 550M/1806FT	464912.61N 0233704.15E	
	Hill 442M/1449FT	464517.55N 0233430.29E	Forest 456.8M/1499FT	464443.27N 0234318.02E	
	Building 521.2M/1710FT	464526.70N 0233545.91E			
	Building 526.7M/1728FT	464442.01N 0233528.13E			
	Crane 552.3M/1812FT	464444.39N 0233527.37E			
	Antenna 351.5M/1153FT	464710.67N 0233926.74E			
	Church 359.5M/1179FT	464706.62N 0233927.32E			
	Antenna 349.9M/1148FT	464711.88N 0233932.42E			
	Building 322.6M/1058FT	464657.54N 0234012.09E			
	Building 323.6M/1062FT	464657.36N 0234011.12E			
	Building 325.5M/1068FT	464657.51N 0234007.97E			
	Church 346.6M/1137FT	464705.42N 0233923.30E			
	Building 324.7M/1065FT	464657.61N 0234010.33E			
25/APCH 07/TKOF	Asphalt plant 335.9M/1102FT	464737.33N 0234317.85E			
	Hill 460M/1509FT	464906.13N 0234709.41E			
	Hill 465M/1526FT	464805.48N 0234645.58E			

Figure 8.10 - Cluj Airport obstacles [3]

However, the Airport is surrounded by river Somes and agricultural land in the Northern part. The rest are residential areas towards West, South and East. The most important is the city of Cluj located towards the Western part.

Further relevant airport information

Bird-strike is not a risk around the airport due to relatively densely populated area and natural conditions. However, flight trajectories after departure and before arrival takes this issue in consideration by avoiding some areas within Cluj vicinity.
There is a small airfield South-East from the Airport which have to be considered for flight trajectories planning.

Use of preferential runways for noise mitigation

Introduction

The intervention consists by the use of preferential runways for departures and landing as much as possible in order to avoid Cluj city overflight. This intervention was proposed during the first NAP from 2014 and after a subsequent SNP from 2015 based on traffic data from 2014. At that time the new runway RWY 07/25 was opened to the public and became the only operational one as the older 08/26 is now used for ground operations. Specific requirement of the intervention was to use RWY 07 (from Cluj towards the Airport) for departures and RW25 (from Airport to Cluj) for arrivals as much as possible limited only by safety reasons and considering the economic impact.

Detailed Process

Identification of environmental needs

Cluj Airport is the second largest Romanian Airport and has a very fast growth rate. This is the result of the rapid economic development of Cluj area(especially after Romania joined EU) and the need of fast transportation for people and cargo . These aspects were recognized early by regional , local authorities and airport management and resulted in some important investment plans for the Airport development: building a new terminal (2007), a new longer runway 07/25(first part opened in 2013) instead of the older08/26, new parking slots and an Intermodal station for cargo operations. The new 07/25 runaway is of particular importance for further development of the airport.
The final runway will have a length of 3500 m but it was executed in two stages. The first stage of 2100 m was opened to the public during 2013. The second stage up to 3500 m is still waiting for environmental approvals and financial support. The project was more difficult to be achieved since it requires a correction of Somes river over a distance of 7 Km. This means more environmental approvals and financial implications. One aspect regarding the new runway 07/25 is that it changed a bit the orientation compared with the older 08/26. This was mainly due to the fact that it was the only practical solution in order to build it longer. The old direction 08/26 could not be further extended due to the proximity of Sanicoara community right at the end of the runway. The new orientation 07/25 allows the extension at 3500 m since avoids the residential area but it needs important corrections for Somes river.

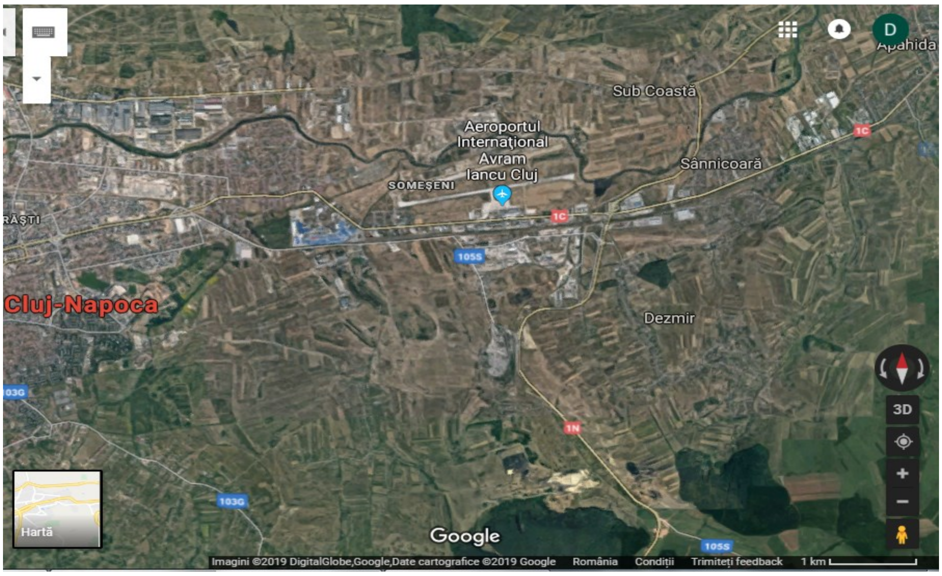

Figure 8.11 - Location of Cluj Airport with the two runways (07/25 on the top) [1]

Considering noise issues the new runway 07/25 has the advantage to be able to avoid the direct overflight of Sanicoara and Apahida communities, a fact which was considered during impact studies. However, if the runway is used as RWY 25 for departures and RWY 07 for arrivals the overflight noise represents a problem for the much bigger community of Cluj especially during night.

In 2014, the international airport of Cluj-Napoca registered 13,335 (arrivals plus departures) aircraft movements. Forecasts for 2017 estimated 23,000 landings and take-offs, and their number will double up in 2022 and eventually become a major airport before 2030. The Airport makes plans in anticipation of significant air traffic growth in the coming years, and for this they consider issues arising from airport noise. Stakeholders as Cluj Airport, Local Authorities and community became aware of the importance of introduction of noise mitigation interventions especially after the SNMs and NAPs became compulsory.

Selection of the intervention 'Selected options in response to environmental needs'

The first NAP issued after the new runway 07/25 was opened, was based on noise studies considering 2014 and 2015 traffic data and 2016 forecasts.

Experts proposed at that time establishing smaller percentages of use of flight tracks which overflights Cluj city and setting a maximum number of aircraft movements at night as it will be technically possible. Since 2014 and 2015 the use of RWY 07/25 for departures and arrivals were completely different in percentage, comparative data showed the importance of the use of the landing and take-off directions on the number of people exposed to noise generated by the operation of the airport. It was recommended that whenever possible the programming of the Cluj airport movements to be made using for landing runway oriented from the airport to the city, and for takeoff runway to the airport from the city-oriented. The 2014 traffic orientation as percentage was considered a good practice and technically achievable for the future even considering the high growth rate of operations. From economic point of view, the action plan states that introduction of this intervention by altering landing and take-off routes and reducing the number of flights operated at night will end up to an increase in operating costs for airlines with as these companies reduce the number of flights Cluj airport either by waiving certain destinations, either by reducing the number of flights. An economic impact study was also recommended for the proposed intervention design.

Several other positive factors have been considered to help the efficacy of the proposed intervention in the future. Firstly, the new aircraft gradually come into use are much quieter and much less noisy. Secondly, with the expansion of the track toward Apahida with 1,200 meters, the city will be much less affected by the noise as Mr David Ciceo, the Airport Manager considers.

Implementation processes

The success criteria for the intervention implementation was considered the number of people affected by noise during day and night and especially the people affected beyond the max limit or long-term limit values. Noise simulations or monitoring should be performed periodically or whenever traffic deviates from normal established distribution.

The implementation of the proposed intervention was not fully completed until 2017 when airport representatives have commissioned a new noise study for the new 2018 NAP. Some reasons for this delay seemed to be: the short period of time if we consider that other economic and technical aspects needed to be considered; a technical issue

since the runway has VOR and GNSS stations just towards the city, the other direction has an ILS.
One important factor for the delay is the yet unknown cost associated with the intervention. However, it can be estimated that modifying the landing and take-off paths, by extending the flight paths, could lead to an increase in costs for the airlines. Also reducing or capping the number of flights operated at night, will lead to an increase in operating costs for airlines. The implementation process will continue during the next period as stated within the new 2018 NAP since the Airport and the whole community started to understand more about the importance of noise issues for a durable development. This perception resulted from several interviews with important stakeholders during the development of this study beside some local newspaper articles.

Post-implementation evaluation 'Evaluation of results. Post-implementation changes. Mitigation actions'

During the commissioned 2017 noise study for the new 2018 NAP experts revealed that in 2016 has grown "significant" percentage of use for take-off runway which is oriented towards the city from the airport-74.6% in 2016 as compared to 34.9% in 2014, and in terms of landings on the runway to the airport from the city-oriented they had suffered a fall-7.5% in 2016 as compared to 13 percent in 2014. From the analysis of noise maps according to the predictions of traffic generated for the 2017-2022 there will be a large number of people exposed to noise indicator values at night in excess of the limit value of 60 decibels. The new proposed distribution (almost similar to 2014) within the intervention revealed significant reduction (over 10 times) in the number of people exposed to the values of the Lnight in excess of the long term target of 50 dB and 60% decrease of the number of persons exposed to Lnight exceeding 60 dB (max limit). This may be achieved without raising the number of people exposed to values that exceed the maximum allowed value of 70 dB and the value of the long-term target of 65 dB for Lden. The figures for the new proposed intervention are presented in the below Tables for day and night movements distribution considering the 2017-2022 forecast.

Directia / Tip operațiune		*Anul 2014 %*	*Varianta Plan Acțiune %*
RWY 07	ARR*	*13*	*13*
	DEP	*65,1*	*70*
RWY 25	ARR	*87*	*87*
	DEP*	*34,9*	*30*

Day and evening movements proposed for the new intervention [2]

Directia / Tip operațiune		Anul 2014 %	Varianta Plan Acțiune %
RWY 07	ARR*	13	5
	DEP	65,1	90
RWY 25	ARR	87	95
	DEP*	34,9	10

Night movements proposed for the new intervention [2]

The new proposed movement distribution for 2017-2022 for the adopted intervention is even more important since the traffic forecast show to double the number of aircraft movements at the level of the year 2022 in relation to the situation existing in the year 2016.
This data reinforced the decision to speed up the implementation of the proposed intervention in conjunction with limited number of flights during the night.
The 2018 NAP also states the proposed intervention should be closely monitored by new noise simulations and eventually monitoring whenever the traffic deviates from normal figures.

Use of metrics/trials/modelling/monitoring/interdependencies etc. 'Method and tools. Interdependencies. Other relevant information'

The results of the proposed intervention are easy to evaluate by the use of number of people exposed to a certain noise level. This require the use of noise mapping. Data used for the development of Strategic Noise Maps include: airport coordinates (AIP); runway dimensions and physical characteristics (AIP); airport plan (AIP); air traffic data (airport); data regarding the flight paths and flight profiles (AIP); data regarding the number of population, number of residencies and statistical distribution of population; data about the level curves; the map with cities; building types and heights. Data regarding the flight paths and flight profiles (AIP) include the Aerodrome Obstacle Chart, Precision Approach Terrain Chart, Standard Departure Charts and Instrument Approach Charts. All the aforementioned are further processed through the use of BaseOPS (v 7.363) software pack (calculus and prediction) for noise mapping. In addition, NoiseMap – Washmer Consulting (v 4.969) is the software pack used for editing and visualizing airport GIS data.
Traffic data is provided by the airport and demographic data by local authorities.

Conclusions

Cluj international Airport is the second largest airport in Romania and is supporting a fast growing traffic due to a strong economic demand. Noise was not a concern in the past but the creation of SNMs and NAPs starting with 2012 showed the necessity to take it into account for a durable development. The proposed intervention as the use of preferential runways for takeoffs and landing looks to be an effective solution for noise mitigation considering the next five years traffic forecast. Several other factors like the finish of the longer runway, the use of much modern and quieter aircrafts and the mandatory use of NADP1 procedures starting with 2019 will help noise mitigation for the airport area.

Recommendations and lessons to learn

The intervention for using preferential runways for departures and arrivals ,was proposed during the first NAP in 2014 and agreed by all stakeholders. Several factors affected the proper implementation until the 2018 NAP. A subsequent study included in the new NAP reinforced the implementation process and the full support from the main stakeholders. However clear responsibilities and monitoring plans are still under development but there is a firm determination from the Airport management to implement the intervention after considering also the financial and economic impact.

References

[1] Google Maps https://www.googlemaps.com/

[2] Website Cluj Airport https://www.aeroportcluj.ro/

[3] AIP Romania httsp://www.aisro.ro/

[4] Environmental Noise Directive (Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise – Declaration by the Commission in the Conciliation Committee on the Directive relating to the assessment and management of environmental noise) http://ec.europa.eu/environment/noise/directive_en.htm https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32002L0049

[5] HOTARARE nr. 321 din 14 aprilie 2005 privind evaluarea si gestionarea zgomotului ambiental (MONITORUL OFICIAL nr. 358 din 27 aprilie 2005) The Ministry of Environment: http://www.mmediu.ro/app/webroot/uploads/files /2012-02-24_Hotarare321din2005.pdf) http://legislatie.just.ro/Public/DetaliiDocumentAfis/61215

[6] HOTARARE nr. 674 din 28 iunie 2007 pentru modificarea si completarea Hotararii Guvernului nr. 321/2005 privind evaluarea si gestionarea zgomotului ambiental (publicat in MONITORUL OFICIAL nr. 485 din 19 iulie 2007) http://legislatie.just.ro/Public/DetaliiDocument/83733

[7] HOTARARE nr. 1.260 din 12 decembrie 2012 pentru modificarea si completarea Hotararii Guvernului nr. 321/2005 privind evaluarea si gestionarea zgomotului ambiant (MONITORUL OFICIAL nr. 15 din 9 ianuarie 2013) http://legislatie.just.ro/Public/DetaliiDocument/144470

[8] HOTARARE nr. 944 din 15 decembrie 2016 pentru modificarea si completarea Hotararii Guvernului nr. 321/2005 privind evaluarea si gestionarea zgomotului ambiant (MONITORUL OFICIAL nr. 1.056 din 28 decembrie 2016) http://legislatie.just.ro/Public/DetaliiDocument/185147

[9] LEGE nr. 52 din 21 ianuarie 2003 (republicata) privind transparenta decizionala in administratia publica (MONITORUL OFICIAL nr. 749 din 3 decembrie 2013) http://legislatie.just.ro/Public/DetaliiDocument/41571

[10] LEGE privind evaluarea si gestionarea zgomotului ambient http://www.mmediu.ro/articol/mm-supune-dezbaterii-publice-proiectul-de-lege-privind-evaluarea-si-gestionarea-zgomotului-ambiant/2655

[11] Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council (Text with EEA relevance) https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1551229574056&uri=CELEX:32015L0996

[12] Aircraft Noise. Balanced Approach to Aircraft Noise Management, ICAO https://www.icao.int/environmental-protection/pages/noise.aspx

[13] Regulation (EU) no. 598/2014 of the European Parliament and of the Council of 16 April 2014 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC

8.9 Case Study 9 – Arlanda Airport

Introduction to the airport

Stockholm Arlanda Airport located in the Sigtuna Municipality of Sweden approximately 37 kilometres north of Stockholm and nearly 40 kilometres south-east of Uppsala. It is the largest airport in Sweden and the third-largest airport in Scandinavia. The majority of international air traffic within Sweden was in 2017 carried out by approximately 27 million passengers, including 21.2 million international and 5.5 million domestic travellers [2].

The airport has three runways: Runway 1 (01L/19R), Runway 2 (08/26) and Runway 3 (01R/19L). Runway 1 is 3.301 m long and can handle take-offs and landings of the heaviest, currently used aircrafts. Runways 2 and 3 are 2.500 m long. Runway 1 and 3 are parallel runways that can be operated independently of one another. Two runways (01L/19R and 08/26) were built in 1958 and 1959. At the end of 1980´s/beginning of 1990´s Stockholm Arlanda Airport started to plan to build an additional third runway (01R/19L).

Noise complaints at Stockholm Arlanda Airport were not much of an issue before 2003. There was not even the need to have a special organisation at the airport to handle noise complaints. The residential community living close to those two runways accepted the air traffic over their houses. When the third runway was built, the airport participated in meetings with the authorities, municipal leaders and representatives of the surrounding residential areas. Concerns regarding the noise exposure of densely populated areas south of the airport were discussed. New and improved ways and technologies for navigating the air traffic with the new runway were presented by the airport. The possibility to apply a curved approach instead of using a straight approach to the new runway was discussed as one option to reduce the noise exposure for the residential areas [3].

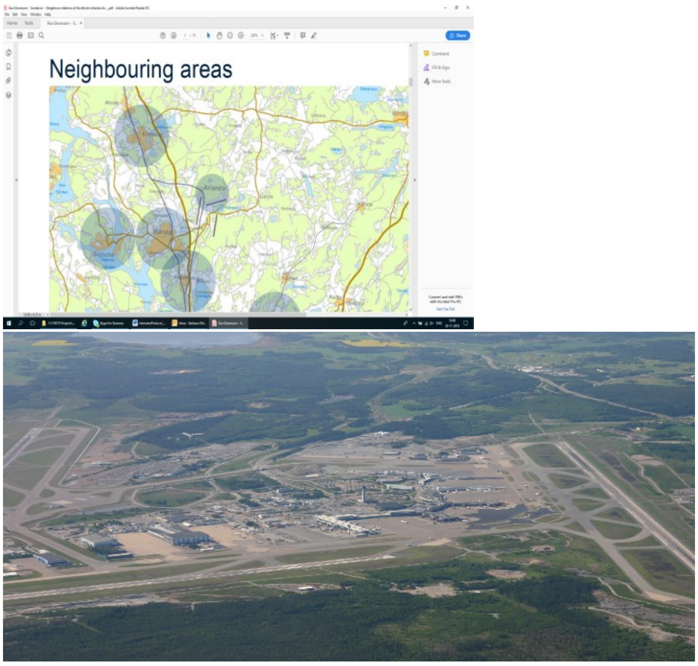

Figure 9.1 – The Stockholm Arlanda Airport is located close to a densely populated area in Sweden

To operate an airport in Sweden an environmental permit is required. The applied noise regulations at Stockholm Arlanda Airport are applied according to the environmental permit, granted in 2015. This permit is in operation since January 2016 and includes technical development conditions, noise insulation conditions for residential buildings and premises for care and education [5]. Figure 9.2 shows the permitted traffic volume with respect to the environmental permit for the Lden noise contour of 55 dB(A).

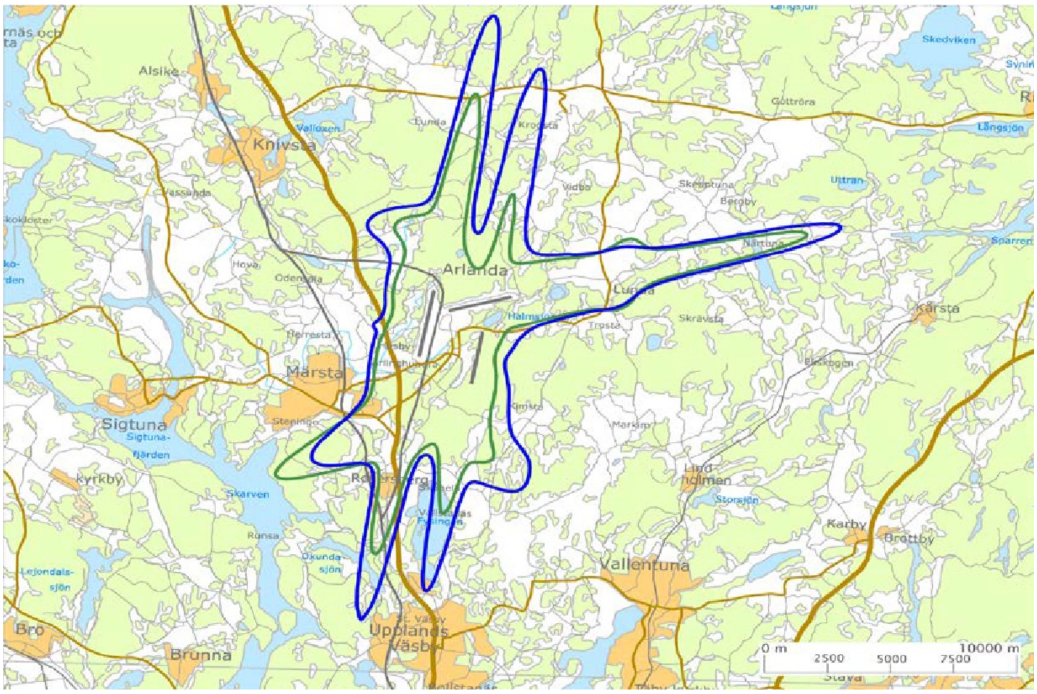

Figure 9.2 – Noise contours for Lden 55 dB(A) for Stockholm Arlanda Airport

Approach to the Balanced Approach

a. Essentially a summary of national regulations and how these have been implemented by the airport.
The airport has an environmental permit containing a number of terms regulating the airport´s activities. Among the terms are several that regulate how the traffic should be handled when it comes to flight paths, use of runway combinations, noise levels, noise disturbed areas to be avoided when possible, noise insulation, etc. The environmental permit has been determined in proceedings in the environmental court.
b. Review of NAPs and previous BA interventions.
c. Identification of any trends and overarching processes and internal systems that underpin BA implementation.

Stockholm Arlanda Airport compiles annually a Noise Management Plan (NMP), containing all activities regarding aircraft noise that they will work on during the year. The activities are spread over different departments of Swedavia (airport owner). In the NMP it is stated that the airport follows the Balanced Approach and that the activities are in correlation to this. Besides points 1-4 in the Balanced Approach the airport has added two extra – Follow up and control and Communication. Follow up and control is done through noise mapping, noise calculations and noise measurements by our department for flight acoustics. Communication is basically the handling of noise complaints and communication with neighbours and surrounding communities.

Introduction to the intervention

With the aim of reducing the noise levels, steeper glide approach angles were applied. Two scenarios with different glide slope approaches were presented for the most commonly used type of airplane.

Delve into the processes behind the case

Identification of the 'need'.

The Stockholm Arlanda Airport started to use the 3rd runway (01R/19L) in April 2003. The flight paths ran over densely populated areas south of the airport were additional residents were exposed to air traffic noise. A large amount of noise complaints was submitted to the airport almost immediately after they started to use the third runway. The sudden and high amount of complaints was a surprise for the airport and handling the complaints became a big challenge.
It was difficult to get the curved landing approach for the third runway approved by the Swedish Transport Agency as many conditions and the international flight safety regulations had to be fulfilled. In the end the curves approaches could not be used in practise. The requirement of special education of the crew, the requirement of very nice weather and that it was not usable during peak traffic. The only option left was to fly straight over the residential area. This was especially problematic because runway 3 was mainly used during the peak traffic hours in the early morning and early afternoon. The residential community thought that the airport had lied to them and the unexpectedly high aircraft traffic made the community angry. The reasons for flying straight over the residential area were shared publicly and even discussed in court. The community seems not to forgive, and the Airport has been in court with respect to noise complaints many times during the previous years.

The design of options.

There was no choice for another comparable approach due to requirements within the environmental permit and technical limitations. However, the project is still ongoing, and a final selection has not been made yet.

The selection of the intervention.

The operational priority was originally to use a curved approach at Stockholm Arlanda Airport. The technical requirements for a curved approach could not be fulfilled in the way that Stockholm Arlanda Airport initially intended. An alternative project approach that would be in line with Arlanda's environmental permit was designed. The idea was to reduce the noise levels by having the aircraft fly at a higher altitude for a longer time. The motivation to apply the VCNS was to provide the opportunity to personally experience differences between operational procedures. The effect of a steeper glide slope angle was investigated. The operational changes were part of the airport environmental permit.

Implementation

During a kick-off meeting, the representatives of the neighbourhood were informed about the different glide slope angles. Parameters of the setup were explained and discusses. A joint decision was made on the selection of the location and the flight procedure [6]. The chosen measurement location is shown in Figure 9.3.

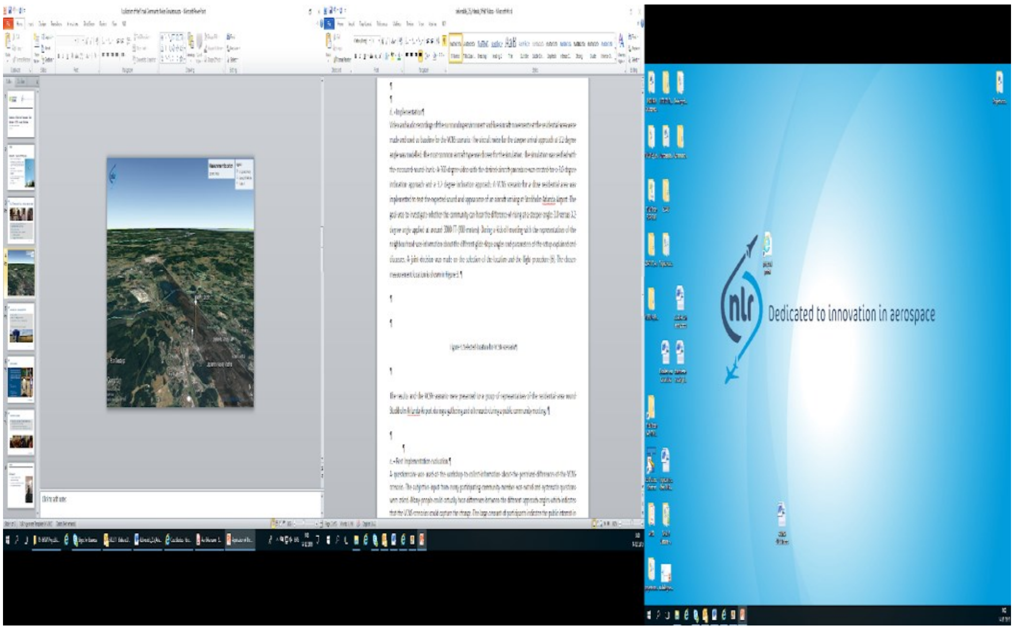

Figure 9.3 – Selected location for VCSN scenario

Video and audio recordings of the surrounding environment and live aircraft movements at the residential area were made and used as baseline for the VCNS scenario. The aircraft noise for the steeper arrival approach at 3.2 degree angle was modelled. The most common aircraft type was chosen for the simulation. The modelled results were verified with the measured sound levels. A 360 degree video with the desired aircraft procedure was created for a 3.0 degree inclination approach and a 3.2 degree inclination approach. Local measurements were carried out to collect video data of the surrounding environment and the aircraft movement at four locations (see Figure 9.4). Acoustic measurements of the surrounding sound environment including cars, schoolyard, bird etc. was carried out too.

Figure 9.4 – Setup for 360 degree video recordings of the environment and the aircraft movements

A VCNS scenario for residential area close to the airport was implemented to test the expected sound and appearance of an aircraft arriving at Stockholm Arlanda Airport. The goal was to investigate whether the community can hear the difference of rising at a steeper angle: 3.0 versus 3.2 degree angle applied at around 3000 FT (900 meters). The results and the VCSN scenario were presented to a group of representatives of the residential area round Stockholm Arlanda Airport during a gathering and afterwards during a public community meeting.

Post-Implementation evaluation.

A questionnaire was used at the workshop to collect information about the perceived differences of the VCNS scenario. The subjective input from every participating community member was noted and systematic questions were asked. Many people could actually hear differences between the different approach angles which indicates that the VCNS scenarios could capture the change. The large number of participants indicates the public interest in participation and engagement.

The use of metrics, trials, modelling, monitoring, interdependencies etc. will be discussed throughout these sub-sections.
The metrics used within this project are modelling, acoustic measurements, video recordings, a workshop and meetings for community engagement. For the VCNS scenario included audio recordings of locally measured air plane noise [6]. The tested flight procedures were a glide angle approach with 3.0 degrees and 3.2 degrees inclination. The measured noise levels were used to verify the calculated noise levels from models.

Conclusions

The goal of applying the VCNS for the community around Stockholm Arlanda Airport was to improve the public opinion about the airport. Swedavia, which is the umbrella organization of Swedish Airports, aimed to reduce levels of air traffic noise or to keep them within an acceptable range. During a workshop for residents around the airport the VCNS was applied to test whether people can perceive changes in the glide approach angle. It is difficult to say whether the project was successful. Not only the subjective perception but also the distrust of the residents played a role. This project reflects the importance of engaging the community in the processes of decision making instead of presenting decisions once they are made. Any change of a flight path or procedure will often not make the noise disappear but move it to another area. It is important that people understand why a certain change has to happen, what the consequences and motivations were.

References:

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3. ESSA – Stockholm Arlanda (2015), www.lfv.se;
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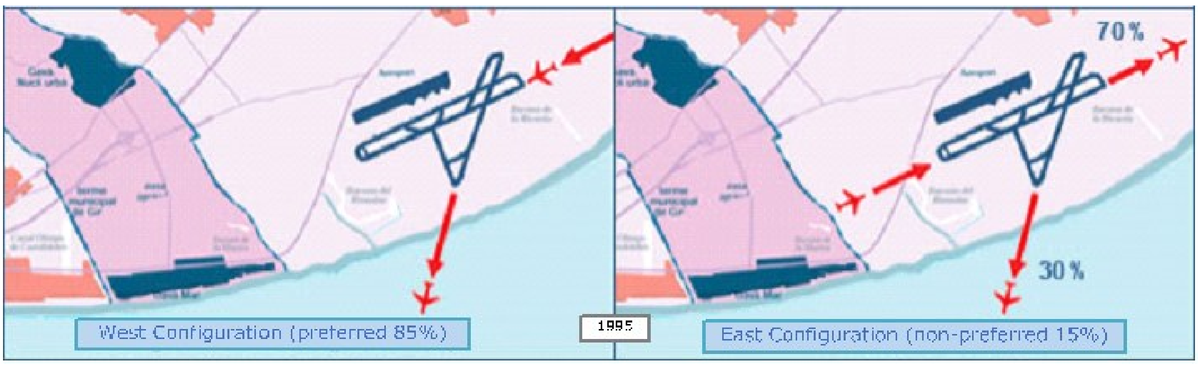
5. Swedavia Airports (2016), Neighbour relations at Stockholm Arlanda Airport, ANNA Conference
6. Wennberg, L., Veerbeek, H. (2018). Application of the Virtual Community Noise Simulator (VCNS) around Stockholm.

8.10 Case Study 10 – Barcelona Airport

Background

In 2018 Barcelona airport saw the record figure of 50,172,457 passengers, 6.1% more than the previous year, as well as 335,651 operations and 172,940 tonnes of cargo. The airport is open 24 hours a day and can handle 90 operations/hour (78 slots/hour currently). The airport can process 55 million passengers/year (Terminal T1: 33 million pax + Terminal T2: 22 million pax). A new Masterplan is needed for this airport in these moments, new challenges for all stakeholders.

It is the 7th busiest airport in Europe and 17th in the world. Located in "El Prat de Llobregat", 15 km Southwest of central Barcelona, the airport is the main driver of the Catalonian economy.
The airport is operated by AENA, the world's leading airport operator by number of passengers. AENA is a state-owned company that manages general interest airports (46) and two heliports in Spain. Through its subsidiary company Aena Internacional it also participates in the management of 17 airports abroad.
In 1948, runway 07-25 was built –the one currently used as the primary runway– crossing over the runway that existed at the time.
In 1963, Barcelona-El Prat airport reached its first million passengers, while in 1965 two new extensions were carried out on runway 07-25.
Between 1965 and 1970, runways 07-25 and 02-20 took on their current configuration and the apron expansion was completed. In 1977, passenger traffic was over 5 million.
In 1994, departure point 25, for instrument (ILS) approaches, became fully operational. From that moment on, the airport implemented a basic operations configuration based on landings on runway 25 and take-offs on runway 20, which made it possible to increase the capacity of the airfield progressively from 38 operations per hour to 50.

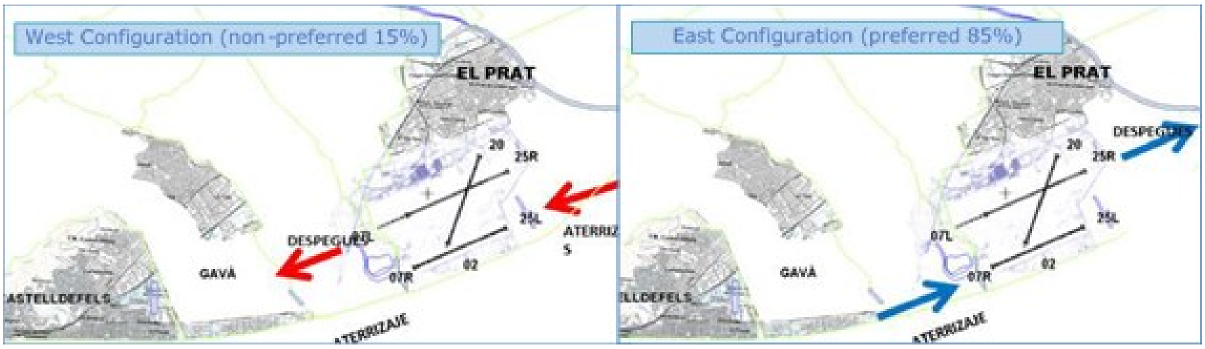


From 1995, Barcelona-El Prat Airport was consolidated as one of the top 15 airports in Europe and one of the top 50 in the world.

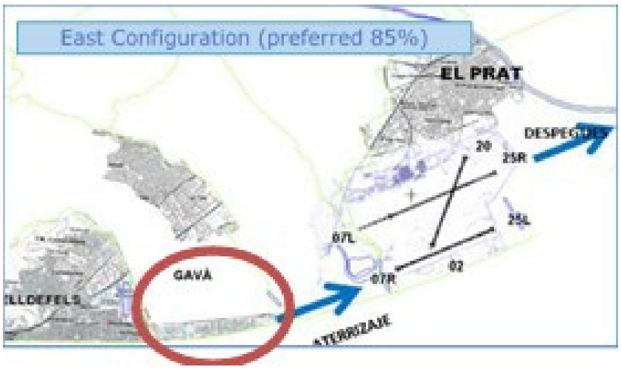
In 1999, the Ministry of Public Works approved the Master Plan for Barcelona-El Prat Airport, formally implementing the Barcelona Plan, the third great transformation operation of the airfield was inaugurated in September 2004 and brought the third runway, parallel to the main runway, into service.

This new infrastructure is equipped with the maximum category runway lighting facilities (ILS Category II/III systems in each departure point). This enables its use in both directions and in foggy conditions. Runway 07L-25R has also been lengthened to 3,743 metres and widened to 60 metres.

The construction and introduction of the third runway in September 2004 and the extension to the primary runway were decisive steps to increase the airport's capacity to reach 90 operations per hour.



The whole project of the new Master Plan was approved, and got an **Environmental Impact Statement** as the result of a complex and participatory process in 2002 (lengthy discussions with the territory to preserve certain sites of Community Importance). The third condition of this statement was to establish measures to protect the population affected by the noise impact, and a New Commission on Environmental Monitoring of the Airport Expansion Works (CSAAB) had to approve all these measures (Local Authorities with airport noise issues were members). For two years all the noise studies prescribed by the Environmental Impact Statement were done and were approved by the Commission, even with positive votes from the Local Authorities, except Castelldefels (affected by take offs on West configuration).



However, in October 2004 the new runway, the third one, started to operate. This immediately caused a lot of complaints, mainly because of the overflights on Gavà in the East configuration.
In order to resolve this situation and after the request of the local councils, and even the Spanish Congress, the Barcelona Technical Working Group of Noise (GTTR) was created at the beginning of 2005.

Barcelona Operational Procedure Case: *Switching the role of each runway during the day (the ones that would be used for take offs, should be used for landings and vice versa), and new flight configuration during the night.*

This is a relevant example for the ANIMA project because the environmental benefit in terms of people affected over $LAeq_{day}$ 65dB and $LAeq_{night}$ 55dB (annual indicators) were non-existent. The benefit of this solution was for the people under these levels (insulation levels) and depending on the airport configuration.

The scenarios and noise studies that the CSAAB approved up to 2004 were based on LAeq annual indicators till 65dB for the day and 55dB during the night (established on the Environmental Impact Statement as a limit to be insulated). They approved the best solution for those indicators, nevertheless, the people were claiming at all levels (legal claims, administrative claims, social media claims). Why?
It is always difficult to try to convince somebody about something that they cannot see or even imagine. Since 2002 there has been a Noise Directive with an Annex 3 (assessment methods for harmful effects) empty of content. The State Law does not cover issues such as noise annoyance either. With that in mind, the CSAAB Members could not see or imagine the noise problem, but they could see the urban problems that limited their freedom to develop new residential areas.
Barcelona airport was an infrastructure close to the sea and therefore didn't use to have significant noise problems. The planes could take off or land using tracks over the sea or over the industrial area of Barcelona to the East. Only Western areas like Castelldefels that had experience with airport noise were used to and were aware of the problem.
The main problem was the noise impact due to a non-preferred operation configuration. There were people really affected by "normal" airport noise in less frequent flight paths (non-preferred configurations). There are non-preferred tracks of use of each airport but still within "normal" operation. Most airports operate with a preferred configuration for take offs and landings (usual tracks and runway ends for departures and landings most of the time throughout a year). Depending on the orientation and intensity of the wind, it is sometimes necessary to change to an alternative configuration (normally this alternative configuration involves switching the roles of the runways, in other words the ones used for take offs are used for landings and vice versa) in which aircrafts use tracks

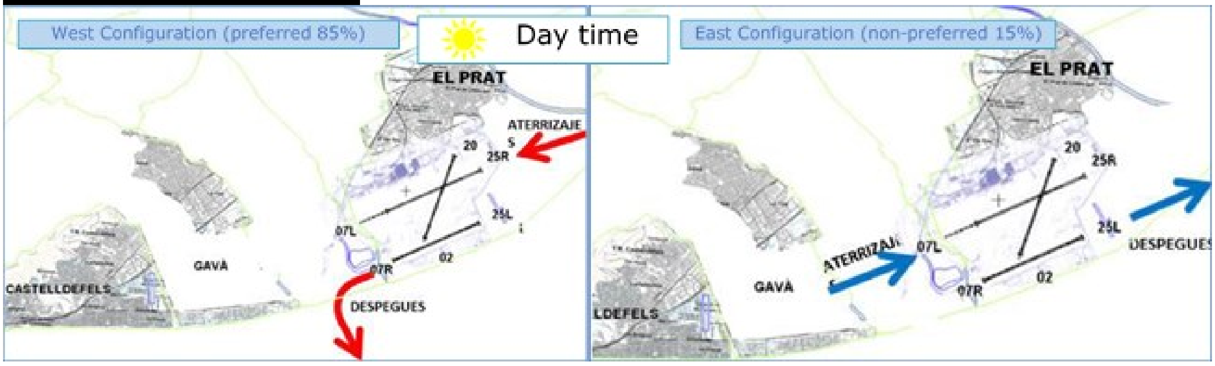
that are not as common but perfectly well-known and "normal". These are not emergency tracks (which sometimes exist) or unexpected tracks. These are "normal" tracks with a significant use (15% in Barcelona) that don't have a sufficient annual value to require corrections (noise insulation) or compensation following the acoustic regulations in most of the countries in EU, because most of them (Barcelona included) use annual (long term) noise indicators to represent a noise footprint that are an average of the use of tracks in different weather conditions over a year.
These situations (non-preferred configurations) usually last for a few hours, although sometimes they are extended for days.

A daily indicator in these areas for these days, has similar values to the daily indicators in areas under the preferred tracks most other days. Both cases can cause annoyance, but the areas under preferred tracks have usually been provided with insulation and so on. By contrast, the areas under non-preferred configurations may only be affected for a few days in the year rather than most of the year, and therefore don't usually have compensation or insulation.
Most of the complaints in 2004 were from non-preferred configuration areas. This was the main problem in Barcelona, after a few days with the airport operating in a non-preferred configuration, the people under the track (Gavá Mar) were seriously annoyed. Firstly, they had never had an airplane overflying this area before the new runway's operation. And secondly, because it was a non-preferred configuration and consequently noise insulation programs had not been established there.
The affected communities were the main drivers in creating the GTTR (dependent on the CSAAB). All the options to solve the situation were discussed inside this technical group (GTTR). In legal terms, the previous process and the Environmental Impact Assessment had been done properly and the noise was under legal limits (even with measurements). But there were new tracks, new people feeling the aircraft noise for first time without being used to it and there were a lot of people under 64 -63 levels (annual average, really close to 65dB and with more than 65dB in days of non-preferred configurations-East). The inputs from the people, claims at all levels, were the trigger in creating the GTTR and to get the resources to do the studies to look for a new solution in record time.

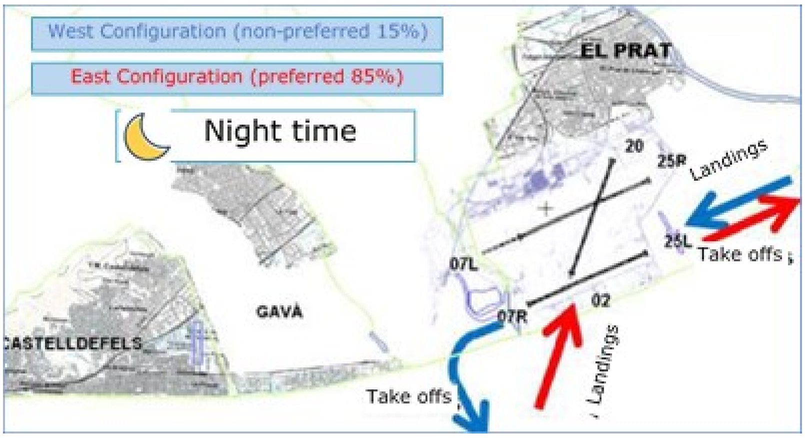
The new Technical Working Group of Noise (GTTR), dependent on the CSAAB, was constituted as a technical forum where the different interest groups could present technical proposals and studies to minimise the noise impact.
The first ideas of solution presented by some airline pilots and air traffic controllers from Gavá and Castelldefels was thoroughly studied from different points of view. The definitive solution was submitted to the CSAAB, and finally approved in November 2005. This was the best solution until 2009-2010. This solution required new investments and works in record time and the capacity was guaranteed only until 2009-2010. It was a lot of work and money for only 3-4 years. It was a short time but enough to develop new technologies/regulations to get better capacities after 2009-2010, thus the GTTR must continue working.

The Solution

Switching the role of each runway during the day: The longest runway should be used for departures, and the shortest for landings (for safety reasons). The GTTR studied switching the role using the shortest for take-off and the longest for landings and some take-offs that required more length for take-off (depending of the kind of aircraft).



Night configuration change: Avoided the demolition of the previous cross runway (02-20) and used it during night periods and East configuration with less capacity. Permanently limited the night capacity in Barcelona airport for the West configuration during the night.



When speaking about operational measures, **technical/constructive studies** (radio interference, new runway exit, new access to apron, and so on), **operational studies** (air traffic controller point of view), **capacity studies** (in the air and on the ground) and **environmental/sustainability studies** are required. The technicians had to assess cost/benefit of each option from all perspectives (safety, sustainability, capacity, budget, time frame…).
In this case, from an environmental/sustainability point of view there were:

1. Emissions study: It was a taxi time study associated with capacity ground studies for each option. There was an optimization of it.
2. Noise study: There were three new options to be evaluated against a reference option. Then the study had for each option and for the reference:
   - Daily indicators (Lday, Levening, and Lnight) with people and areas affected (from 75dB till 40dB). It is worth mentioning that all the calculations were done for each configuration (West and East) and with different fleets, tracks, % of use, and so on, per each period of time (night/day/evening).
   - Number of overflights in different points of populated areas and an average of SEL and LAmax in those points. Moreover, the hardest part of the work was taking some working hypotheses and repeat all the calculations for the future horizons 2010 and 2025 like for example:
   - The rate of population growth (in areas under 60dB of LAeqday or 50dB night where new residential areas are permitted under Spanish law).
   - Forecast of new fleet and runway length required for takeoff.

- Expectations of PRNAV development (legal) and implementation. New tracks (less dispersion).
- Forecast of demand Vs capacity.
- New works like a new passenger terminal in 2009-2010 or a new bypass for greater taxi capacity
- And so on.

In the Barcelona case we are speaking about the noise **over** the noise law limits (65dB $LAeq_{day}$ and 55dB $LAeq_{night}$), environmental outcomes were prioritised. **Under the noise law limits, noise annoyance had to be reduced.** Firstly, they had to have a better option in terms of noise against the reference option, to consider it as an option. Later they had to get enough positive outcomes in technical/constructive, operational (safety) and capacity studies. The budget was also important, but only if the solution was a temporary solution without continuity in time.
There were at least eleven options that were rejected (a lot of technical, constructive, capacity and operational studies in record time), sometimes because of a ground capacity study, sometimes due to technical issues, sometimes because of air capacity studies, and in the end, they had 3 options (+reference option) and the Commission (CSAAB) decided on one because of the environmental outcomes of each one exclusively.
Regarding metrics and other techniques used to ensure comprehension of environmental issues, they knew that L_{den} was not the solution, they used L_{day}, $L_{evening}$ and L_{night} per each configuration (different maps for West and East and per period of time with all curves dB by dB from 75 till 40dB) in terms m^2 of areas exposed and in terms of number of people exposed on each level. The second metric was an overflight study assessing number of overflights in different points of populated areas and an average of SEL and LA_{max} in those points. The participants in GTTR were technicians, there were some explanations about technical noise concepts during the meetings at the beginning of the studies, but not much was necessary.
The debate inside the GTTR throughout those months was focused on the option solution possibilities, the noise technicians were agreeing from the beginning about which kind of noise studies were needed. The main problem was the technical solution (from an aeronautical point of view).
The core issues in the discussions of the GTTR were the comfort of the passengers inside the planes, the comfort of pilots and the comfort of air traffic controllers Vs ICAO recommendations. If a new runway is designed (included in the 1999 Master Plan), all ICAO recommendations should be respect. If something different needs to be done, a serious study must be carried out, notify the change, and so on. For example, a command like "turn left as soon as possible" was written in one of the options and technicians representing Local authorities tried to limit it at 500ft to avoid some overflight (much more noise than the reference option in some points). Spanish law did not permit it, because it was an ICAO recommendation, and the group had accomplished everything necessary to change the law with all safety studies and systems that were needed.
During the previous design and EIA process, nobody thought about it, nobody was willing to change a law (with a solution with noise levels under legal limits). After two months of the new runway operating, with noise claims to all levels (institutions, public bodies, courts, son on), everybody was willing to work as hard as was needed.
In this case the GTTR had on one hand professional pilots, air traffic controllers and technicians affected and on the other hand similar professionals working for AENA (AENA + ENAIRE today) or for other Airlines. They argued for hours and hours sometimes, about the comfort of the passengers (one track could be possible but what about the passengers' comfort). They were designing SIDs at the limit of the ICAO recommendations.

The same happened with air traffic controller parameters to put one take off between two arrivals. At this point they had more problems because of air traffic control trade unions. The controllers affected said: "in London they manage X miles of distance between aircrafts. Why does our law say X+1000?" And changing a law based on ICAO recommendations is not easy! You must demonstrate the safety of your solution before to changing the law.
In conclusion, **the main issue was designing new SIDs "stretching the ICAO recommendations" to get better environmental solutions for a period of 4 years and keep working inside the group to extend the solution in time.**
The option finally adopted in 2005 had been rejected during the previous EIA process because of all these technical issues. And that was precisely the reason for rejecting it at the end of 2004 as well, when the pilots and air traffic controllers affected presented it as an idea.
But after some months of working hard hand in hand, the GTTR got a "provisional solution" for 4 years.
It was in 2010 when AENA and the Spanish government announced that they could extend the solution approved in 2005 until the next master plan of the airport (2020 approximately), many professional stakeholders had been working on new developments to allow this option to continue after 2009.
To inform CSAAB about decision-making, they used the report of the GTTR published as a summary of 6 months of hard work. Simple language, with graphics and all options on a one-page summary.

Implementation

The implementation of the solution took almost one year, and it was a complete success. The solution had been designed by a group of technicians from different stakeholders and authorities involved Local, Regional and State, working together to get the best solution. The CSAAB published a press release before the implementation and the Local Authorities, and the rest of the stakeholders disseminated the information as well, each one about its competences. New information was disseminated after the implementation. All the noise measurements were accessible for the public.
Many difficulties were encountered in implementing the intervention: Legal problems, delays with works, weather conditions, technical problems, political problems with trade unions and so on. All of them were solved on time.
The general perception was good. Always conscious of the timeframe of the measure (it was a provisional measure for 4 years). Some small groups made some claims, even court procedures, preferring that other areas (affected previously and more populated) continue to experience more noise instead of them.
To assess the effectiveness and efficiency of the measure, there was a noise monitoring system before, during and after the switching of runway roll to control noise levels. During the process two more noise monitoring terminals were installed and two more were relocated. Moreover, some temporary measurements in different points for two or three months were done. The location of each NMT was discussed inside the technical group (GTTR). Some characteristics considered were:

- Place for reallocated and new NMT was determined technically (populated areas inside/outside curves), affected by different configurations.
- The NMT was to be in a public/accessible place (maintenance problems).
- The place could not be contaminated by other noise sources of similar characteristics like roads, industry, wind turbines, trains. Protected as much as possible from animals/birds/vandalism. It is not always easy to get a good location for the NMT.
- Some measurements must be deleted sometimes because of these kinds of problems.

A new sanction system according to the law was established. Aeronautical Circular Note 1/2006 of May 23, of the General Directorate of Civil Aviation, by which the air traffic discipline procedures for noise are determined for the Barcelona Airport. It was a new disciplinary procedure (control and sanction) to follow the tracks during take-off and landing.

- The procedure started with the daily control of noise and tracks. The possible infringements were sent to the aviation authority to initiate a sanction procedure if there was not a safety reason for the infraction.
- The statistics of infringements were analysed by the technical group (GTTR) to look for a better technical solution if it was needed. After the implementation of the measures, the GTTR continued working for a permanent solution and it is still working with 4 meetings per year. They must study each proposal or initiative on possible actions aimed at improving noise exposure around the airport. In 2010, when AENA announced that they could extend the solution approved in 2005 until the next master plan of the airport, in addition to the noise monitoring system, a new webtrack system started to run to provide replay of aircraft operations around the immediate area of the airport for the general public. WebTrak can show both recent and past aircraft operations around the airport. It shows the path taken by aircraft and as much information about them as is permissible. In addition, it can show measurements of noise taken at specific monitoring locations. These measurements allow the noise made by aircraft operations in an area to be compared and whether operations have made unusual amounts of noise.

Lesson learned

- The political commission required a technical group with all kinds of specialists on which to base their decisions. **Collaborative groups** are always the best solution.
- Beyond the 60dB footprint, there is the 59dB footprint, and beyond 59 there is the 58. The noise persists after the line of 60dB, even though you will not have insulation rights. All the **airport noise studies should consider values under the insulation levels** and land use planning restriction levels (political concerns), and should consider annoyance levels (at least till 40dB L_{night}).
- People under non-preferred tracks have a significant percentage of time L_{day} and L_{night} levels (daily indicator) over insulation levels. Even though they are not under insulation levels (in terms of annual indicator), obviously they will be annoyance. All the noise studies should consider as a complement, daily values per each "normal" configuration of the airport, to at least be aware of the people annoyance.
- **L_{den} is a good indicator in global terms** to see the global annoyance throughout a year, to compare different noises from different sources, to add all of them in global terms for global comparisons. Nevertheless **to be aware of the annoyance**, you **should complete** this indicator **with** other **daily indicators per configuration and a noise event (L_{Amax}) analysis**.
- Safety rules are always a priority, nevertheless **OACI recommendations can be restudied** for each particular case, **even for environmental purposes**.
- **Reliable control systems** increase people's trust.
- **Lack of transparency and information make people feel ignored and unprotected**.

Barcelona Operating restrictions Case

The ICAO Balance Approach was collected by European Law under directive 2002/30/EC of 26 March 2002 of the European Parliament, Royal Decree 1257/2003 of 3 October, adapted this Directive to the Spanish legal code.

Following this Royal Decree, the Resolution of 31 May 2011 of the Spanish Air Safety Agency (AESA) was published, introducing operating restrictions in El Prat Barcelona Airport, following the Balance approach procedure. The content can be found in item 21 of AIP ESPAÑA AD2-LEBL.

What is Balance approach?

Aircraft noise is the most significant cause of adverse community reaction related to the operation and expansion of airports. The main overarching ICAO policy on aircraft noise, is the Balance Approach to Aircraft Noise Management (ICAO Doc 9829, Guidance on the Balance Approach to Aircraft Noise Management).

The Balance Approach consists of identifying the noise problem at a specific airport and analysing various measures available to reduce noise through the exploration of various measures which can be classified into four principal elements:

- **Reduction of Noise at Source.** Controlled by the setting of noise limits for aircraft in the form Standards and Recommended Practices contained in Annex 16 to the Convention on International Civil Aviation (the "Chicago Convention").
- **Land-use Planning and Management.** ICAO guidance on this subject is contained in Annex 16, Volume I, Part IV and in the ICAO Doc 9184, Airport Planning Manual, Part 2 — Land Use and Environmental Control. The manual provides guidance on the use of various tools for the minimization, control or prevention of the impact of aircraft noise in the vicinity of airports and describes the practices adopted by some States on that.
- **Noise Abatement Operational Procedures**, ICAO assists on the development and standardization of low noise operational procedures that are safe and cost-effective. The possibilities include noise preferential runways and routes and noise abatement procedures for take-off and landing. The appropriateness of any of these measures depends on the physical lay-out of the airport and its surroundings, but in all cases the procedure must give priority to safety considerations. ICAO Doc 9888, Noise Abatement Procedures review of research
- **Operating Restrictions**, apart from phase-out, other possible operational restrictions include curfews, night time restrictions, noise quotas/budgets, cap rules, non-addition rules, and restrictions related to the nature of flight. ICAO Assembly in 2001 urged States not to introduce any operating restrictions at any airport before fully assessing available measures to address the noise problem at the airport concerned in accordance with the balance approach. Any restriction should be based on the noise performance of the aircraft and should be tailored to the noise problem of the airport concerned, and the special circumstances of operators from developing countries should be taken into account. The goal is to address noise problems on an individual airport basis and to identify the noise-related measures that achieve maximum environmental benefit most cost-effectively using objective and measurable criteria.

How was "A Balance approach" deployed into European legislation?
Firstly, by Directive 2002/30/EC of the European Parliament and of the Council of 26 March 2002 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports.

The report from the Commission of 15 February 2008 entitled 'Noise Operation Restrictions at EU Airports' pointed to the need to clarify in the text of Directive 2002/30/EC the allocation of responsibilities and the precise rights and obligations of interested parties during the noise assessment process so as to guarantee that cost-effective measures are taken to achieve the noise abatement objectives for each airport After 12 years, an update was necessary of how to use operating restriction measures in order to enable authorities to deal with the current noisiest aircraft and to improve the noise environment around Union airports within the international framework of the Balance Approach. Thus, a new Regulation (EU) Nº 598/2014 of the European Parliament and of the Council of 16 April 2014 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balance Approach and repealing Directive 2002/30/EC.

Noise Management at Barcelona-El Prat Airport

Reduction of Noise at Source

Since 2007 the noisiest aircrafts have to pay a charge for landing, the extra cost depends on the cumulative margin of the acoustic certification limits. Airport charges are determined according to the maximum take-off weight (MTOW), and vary depending on the type, class of flight, and the noise level of the aircraft. The amounts resulting from the application of the regular rates shall be increased by the following percentages according to the noise level of each aircraft and to the schedule of the landing or take off:

The criterion applied to determine the noise category for each aircraft is as follows:

- Category 1: Aircraft with accumulative margin up to 5EPNdB.
- Category 2: Aircraft with accumulative margin between 5EPNdB and 10EPNdB.
- Category 3: Aircraft with accumulative margin between 10EPNdB and 15EPNdB.
- Category 4: Aircraft with accumulative margin over 15EPNdB.

Land use planning and management

Planning instruments

In 1999, a new concept was introduced into the Air Navigation Law to protect land planning around the main airports: "Servidumbres aeronáuticas acústicas" = "Aeronautical acoustic easements". This was a new kind of aeronautical space limitation with a right of way. In order to comply with this law, the DGAC (Spanish Directorate General for Civil Aviation) must issue a favourable report about each urban plan under a noise contour: 55dB $LAeq_{day}$ 16h / 45dB $LAeq_{night}$ 8h contour around the civil airports. Generally, they do not allow new housing, schools and hospitals inside this contour. All the land use plans around Barcelona airport inside these noise contours have been informed by DGAC in order to avoid new residential, educational or healthcare areas.

Mitigating instruments

Aena carries out Acoustic Insulation Plans (PAA), aimed at minimizing the disturbance caused around airports, the noise produced by aircraft during take-off, landing, taxiing, engine tests and any other operations.

To achieve this goal, Aena soundproofs homes and buildings that are used for sensitive purposes (residential, educational, healthcare and cultural centres which require special protection from noise pollution) and that are located within the noise footprint of the airports (isophones 60dB $LAeq_{day}$ and $LAeq_{evening}$/50dB $LAeq_{night}$).

Depending on the noise levels to which these buildings are subjected, the soundproofing projects characteristically entail installing double-glazed windows, insulating façades and soundproofing roofs.

Through its Acoustic Insulation Plan Office, Aena provides anyone who may be interested with all the advice they need about the execution of Acoustic Insulation Plans.

Financial instruments
In 2010, compensatory measures were introduced into the Air Navigation Law in order to compensate the noise impact over some areas. It needed a new regulation to develop the law and clarify the measures.

Operational procedures
Noise abatement flight procedures

- Continuous Descent Operations (CDO), referred to in the past as Continuous Descent Arrival or Approach (CDA); During night hours (between 23:00-07:00), arrival procedures in continuous descent (CDA) are authorized for noise abatement reasons. This procedure avoids the stage flight segments that occur during a conventional landing and has a lower noise impact as well as reduction of fuel and emissions.
- Noise Abatement Departure Procedures (NADP); Published in the AIP and must be followed by all aircrafts, except for safety reasons or air traffic control (ATC) instructions:
  - Take off (RWY 25L): in order to avoid excessive noises at the runway centre line extension, the initial turn prescribed in the standard instrument departure (SID) shall begin no later than reaching 500 ft. altitude.
  - Aircraft must follow the nominal trajectory of SID until they have reached 6000 ft., unless they are over the sea, above 3500 ft, in ascent and moving away from the coastline or at more than three nautical miles from the coast and in parallel to it.
- Modified approach angles, staggered, or displaced landing thresholds; Some heads of runway have a displaced threshold to allow an increase of the altitude of the flights over the surrounding areas of the airport.
- Low power/low drag approach profiles; According to each aircraft manual for SIDs 25R
- Minimum use of reverse thrust after landing: Reverse use restrictions during night time hours.

Spatial management

- Noise preferred arrival and departure routes; Airplane flight paths are constantly monitored by the airport's Environmental Division, which analyses any potential procedural or regulatory violations and reports potential non-compliances to Spain's Aviation Safety Agency, as appropriate.
- Flight track dispersion or concentration; RNAV (Area Navigation) for departure procedures to optimise the paths and to minimise the dispersion around the nominal track. It makes for an optimal path. So as to gradually decrease the number of non-compliances and improve operations, thereby reducing noise levels in surrounding communities, individual meetings are held with specific airlines to discuss improvements to follow standard routes, analysing specific points of contention and coordinating follow-up actions to improve flight procedures.
- Noise preferred runways; Whenever the traffic demand, weather and operational conditions permit, the preferential night time configuration may be extended beyond 7 a.m. or to advance before 11 p.m. ATC follows the preferential configurations and the preferential runway use in order to reduce noise annoyance.

Ground management

- Hush houses and engine run up management (location/aircraft orientation, time of day, maximum thrust level): Engine tests higher than idle regime may be carried out at the engine test area established for such purposes.
- Auxiliary power-unit (APU) management: There are limitations on the use of auxiliary power units (APU): it depends on the kind of aircraft, and also on the stand (contact or remote), each aircraft is allowed to make use of APU for a specific time.
- Taxi and queue management; Towing; Taxi power control (taxi with fewer than all engines operating). Depending on the air company procedures. *Operating restrictions*

Specific bans
Gradual reduction of aircraft having Marginal Conformity levels, up to 28 September 2012, in compliance with resolution of Resolution of 31 May 2011 of the Spanish Air Safety Agency. Any marginally compliant aircraft has not operated in this airport since May 2015.

Night flight
Prohibition of night-time (between 23:00 and 07:00) operations of aircraft with noise levels of 4 or higher.

Community engagement
The Commission for Environmental Monitoring of the Airport Expansion Works (CSAAB)
It was created in February 2003, according to the environmental statement of the Barcelona airport expansion; it includes members of the Ministry of the Environment, Civil Aviation Authority, Aena, ENAIRE, the Generalitat de Catalunya and the surrounding town councils. Its aim is to monitor and control the compliance of the preventive, corrective and off-setting measures, developed during the construction and operation phase of Barcelona Airport's expansion, as well as to approve the studies and previous investigations indicated in condition 13 of the environmental statement such as:

- The studies of prediction and design of the network of monitoring stations of air quality;
- The study on measures to control the emissions of volatile organic compounds;
- Programme of emissions of pollutants from aircraft, ground support equipment (GSE) and APU;
- Noise studies;
- Acoustic insulation plan;
- Other corrective measures in relation to noise produced by aircraft operations;
- Design of the network of noise meters;
- Operational programme for monitoring and control of noise, in the terms established in the environmental impact statement (EIS). So far, the periodicity of the meetings is linked with the presentation of new studies or measures, which have to be approved.

Noise Technical Working Group (GTTR)
It was created in 2005 and is composed of technicians, appointed by the members of the CSAAB belonging to the Ministry of Environment, Civil Aviation Authority, Aena, the Government of Catalonia and representatives of the town councils. Its purpose is to study proposals and initiatives on possible actions aimed at improving noise exposure around the airport. Until now 59 meetings have been held on a quarterly basis. Both commissions are linked, and all members are being informed promptly about

noise data, configuration changes or exceptional situations that arise at the airport. To provide all the necessary information to these groups, Aena and Barcelona airport have a **noise monitoring system** which receives information of flight plans and radar paths, correlates them with the measurements taken by the noise monitoring terminals (NMTs), allowing the system to evaluate the data from the general airport system. The characteristics of each sound event and all the data related to the aircraft responsible for an event are recorded: aircraft identifier, position, altitude, airline, destination, etc. The locations of the NMTs are selected in order to measure the environmental noise levels in the points that are most exposed to aeronautical noise, close to air routes, and also to improve the measuring and control of the level of noise pollution caused by aeronautical operations in towns that could be affected. All this information can be consulted by citizens, since 2010, through the interactive noise map (WebTrak system), which provides reliable and transparent information on aeronautical operations, and the acoustic levels they generate. This information includes flight numbers, aircraft type, altitude and the flight path used by the aircraft. In addition, this tool allows the identification of which flight has caused the noise, and to send a complaint to be answered by the corresponding department of the airport.

Complaints channels
Additionally, Aena has a virtual environmental office on its public website, where anybody can fill in a complaint, environmental request or suggestion.

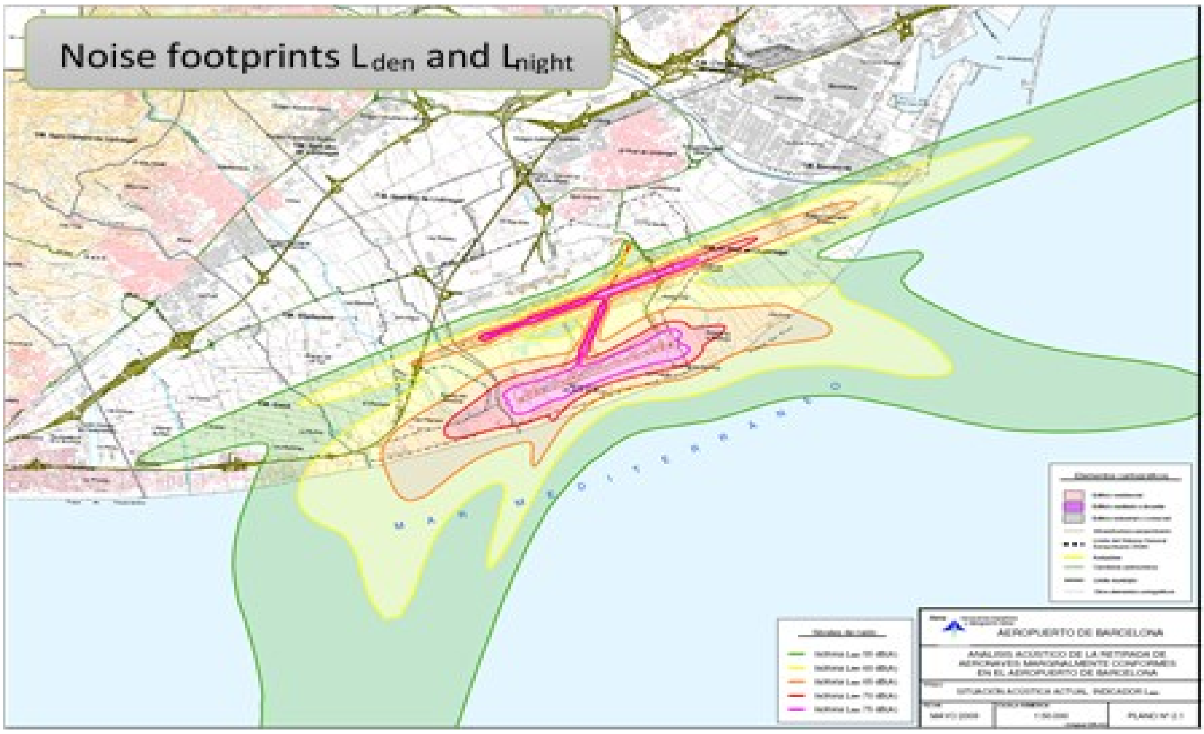
Collaborative environmental management (CEM) concept
Even if Aena have different operational coordination mechanisms, it is necessary to pool the experience with the different actors involved, and to address the different environmental challenges through collaborative actions. In this regard, on the basis that no one can resolve the environmental challenge of the aviation sector alone, in June 2018, Barcelona airport (along with the Madrid airport) launched the first meeting with ENAIRE in the framework of the most significant airlines setting the collaborative environmental management (CEM) working arrangement based on the EUROCONTROL specifications.
They have just begun to work with this collaborative working group, and the main aim is to find common solutions to minimise noise impacts and protect the environment.

In this context, what was the process of introducing the operating restriction in 2011?
This case study is framed in the previous regulation, directive 2002/30/EC, the new Regulation 598/2014 came into force in June of 2016. As we mentioned before, Royal Decree 1257/2003 of 3 October, adapted this Directive to the Spanish legal code. The process started with a detailed study with a comprehensive examination into the current inventory of measures, noise and objectives, secondly the expected evolution with several scenarios, later the assessment of new measures and finally the conclusions.

1. Current inventory and objectives
    - Airport description
    - Physical configuration
    - Operational configuration
    - Environment and implemented measures
    - Acoustical description
    - Acoustic modelling
    - Indicators

The first chapters of this case study summarized the Barcelona airport description, physical configuration (two parallel runways and other one crossing, TWR and terminals), operational configuration (after switching the role of each runway), the Environment and implemented measures adopted always after their study by the GTTR. As it was explained in point 1.3.3, Barcelona airport had been worked through the first three balance approach pillars.

About acoustical description, modelling and indicators, this study was looking for the benefits of an operating restriction, consequently, the study must characterise the global noise in terms of number of people exposed and m2 of exposed areas to each L_{den} and L_{night} levels, and moreover the study must characterise properly the noise from the noisiest aircraft with its influence in general noise.

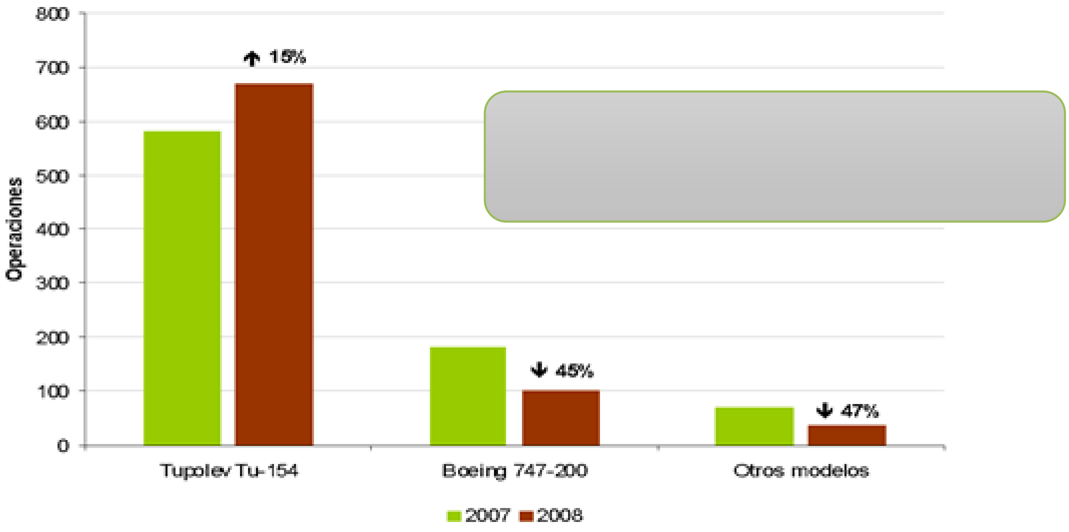


Current Situation	Indicator L_{den} (dBA)				
	55-60	60-65	65-70	70-75	>75
Area (ha)	*4.914*	*1.781*	*698*	*246*	*164*
People	*2.727*	*442*	*19*	*11*	-
Current Situation	**Indicator L_{night} (dBA)**				
	50-55	**55-60**	**60-65**	**65-70**	**>70**
Area (ha)	*2.457*	*909*	*357*	*131*	*95*
People	*8*	*8*	*19*	-	-

Areas affected and number of people affected by aircraft noise

For general noise: Lden and Lnight indicators for a complete year of operation with the assessment of area and people exposed to each level of noise per each indicator.

A deep analysis of Marginally compliant operations at Barcelona airport, hour by hour to characterise properly the noise from the noisiest aircraft with its influence in general noise. In 2006-2008 there was not a global data base with noise certificate data. The study was not easy to do because of the lack of reliable noise aircraft data.



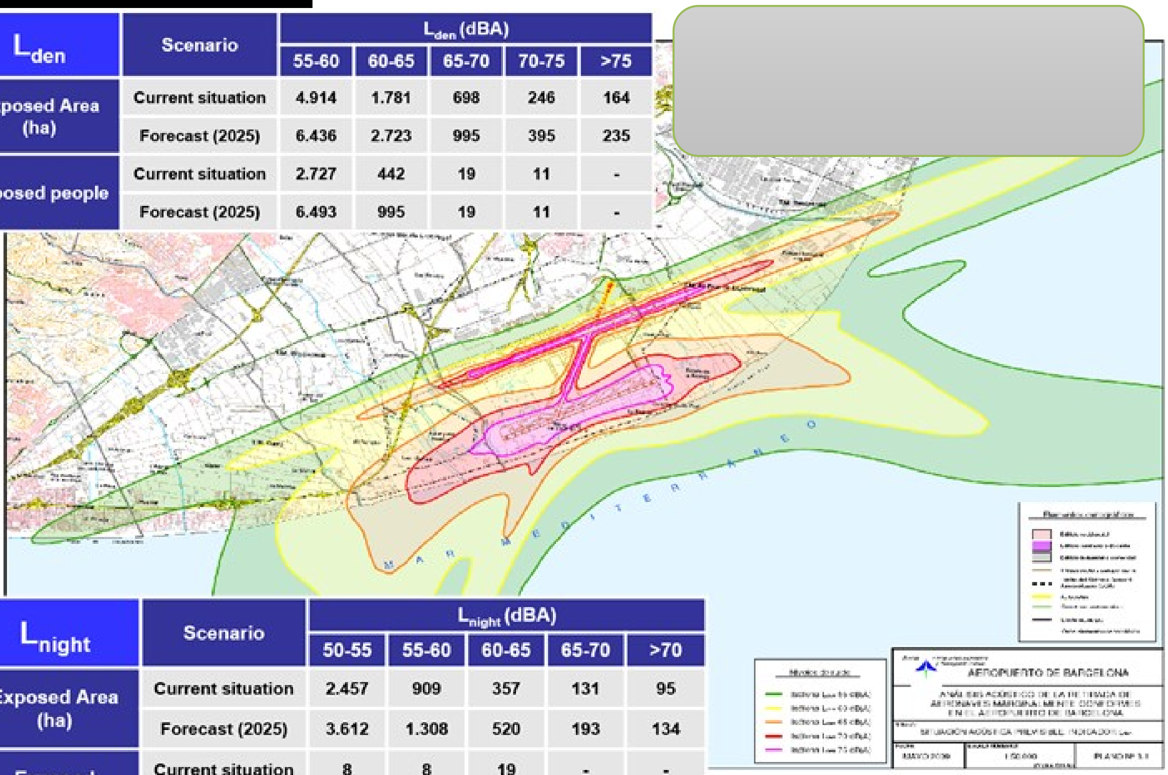
Recertification issues like some aircrafts with different certificates for winter or summer, other aircrafts with new engines and new certificates… Until 2007 it was not mandatory in Spain to present a certificate to the airport operator, then there was not an official noise acoustic data base.

Compañías aéreas	%ops./tot op 2007 MC	Compañías aéreas	%ops./tot op 2008 MC
Rossiya Airlines	23,7	Rossiya Airlines	33,8
Transaero Airlines	20,1	Ural Airlines	16,2
Vladivostok Air	10,8	Transaero Airlines	11,8
Aeroflot - Russian Airlines	6,0	Globus	9,2
Aviaprad Airlines	4,6	Tatarstan Air	8,5
Belavia Belarussian Airlines	4,6	S7 Airlines	5,2
S7 Airlines	4,3	Belavia Belarussian Airlines	4,6
Otras	25,9	Otras	10,7

After a deep study of the current situation it was necessary to characterise the future. What would happen to the airport development for the next 5-7 years, the noise action program, the fleets, the traffic evolution and so on.

2. Evolution: Scenarios
   - Airport development
   - Programmed actions
   - Expected benefits
   - Traffic evolution
   - Acoustic development
   - Acoustic modelling
   - Indicators

L_{den}	Scenario	L_{den} (dBA)				
		55-60	60-65	65-70	70-75	>75
Exposed Area (ha)	Current situation	4.914	1.781	698	246	164
	Forecast (2025)	6.436	2.723	995	395	235
Exposed people	Current situation	2.727	442	19	11	-
	Forecast (2025)	6.493	995	19	11	-



L_{night}	Scenario	L_{night} (dBA)				
		50-55	55-60	60-65	65-70	>70
Exposed Area (ha)	Current situation	2.457	909	357	131	95
	Forecast (2025)	3.612	1.308	520	193	134
Exposed people	Current situation	8	8	19	-	-
	Forecast (2025)	165	8	21	-	-

3. Assessment of additional measures
    - Measure definition
    - Measure assessment (with/without operating restrictions)
    - Cost-Benefit analysis

The noise objective of the ENV is to keep or reduce noise emitted by the major sources (that include major airports), and the evolution presented an increase number of people and areas affected.
The third part of the study defined and assessed different scenarios with and without marginally compliant aircraft, in terms of L_{den} and L_{night} and areas and people exposed to each level.

Nevertheless, those assessments were not enough to implement a restriction and the study selected some points in populated areas to be analysed more deeply.

On each singular point (1,2,3,TMR1, TMR7 and TMR8) the study calculate the Noise energy contribution of each aircraft type into L_{den} and L_{night}.

Furthermore, a L_{max} study per operations and per each singular point.

Aircraft type		Operation's number 2008		Singular points					
				1	2	3	TMR1	TMR7	TMR8
Marginally Compliant (MC)	*Tupolev TU-154*	*Day*	*178*	*106*	*103*	*101*	*82*	*102*	*92*
		Eve	*54*						
		Night	*3*						
Chapter 3 no MC	*Mc Donnell Douglas MD-88*	*D*	*14*	*90*	*88*	*87*	*72*	*87*	*82*
		E	*20*						
		N	*-*						
	Airbus A320	*D*	*1.491*	*83*	*76*	*74*	*63*	*78*	*70*
		E	*573*						
		N	*107*						

Conclusions

- Clear benefits in terms of number of people affected by noise annoyance (under noise insulated levels) and less awakeness.
- Lack of data from some airlines to be solved during the hearing procedure.
- Only one airline affected at significant levels.
  The study was presented firstly to the GTTR, and after its approval started the legal process to implement the operating restrictions:

Legal Processing

- Hearing procedure
- Necessary adjustments
- Stakeholders communication
- BOE publication
- AIP publication
  The lack of noise data certificates from some airlines were solved during the hearing procedures. In general, most airlines understood the measures and made their best efforts to re-schedule aircrafts (other times, other aircrafts less noisy). Some problems with some International Agreement (Cubana for instance) and some State flights were managed, and some exemptions applied.

Implementation

- Operations reduction according to the directive's rules and exceptions
- Inspection and Control
  After all the efforts the environmental department started to receive less complaints because of awakeness. In 2014 Barcelona had not marginally compliant flights.

Lesson learned

- Assess different scenarios with and without marginally compliant aircraft, in terms of L_{den} and L_{night} and areas and people exposed to each level, are not enough to implement a restriction and **the study should select some points in populated areas to be analysed more deeply** in terms of L_{Amax} (and frequency) and in terms of the noise energy contribution of each aircraft type into L_{den} and L_{night} in those points.
- **Clear benefits** in terms of number of people affected by noise annoyance (under noise insulated levels) and **less awakeness during the night period**.
- The **lack of noise data certificates** from some airlines were solved during the hearing procedures. In general most airlines understood the measures and made their best efforts to re-schedule aircrafts (other times, other less noisy aircrafts). Nevertheless this is still missing in many airports. EASA has a database without registration numbers, and there are still some issues to be solved.
- **Inspection and Control**, giving detailed information to the companies and following the infringements.

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8.11 Case Study 11 – Catania Airport

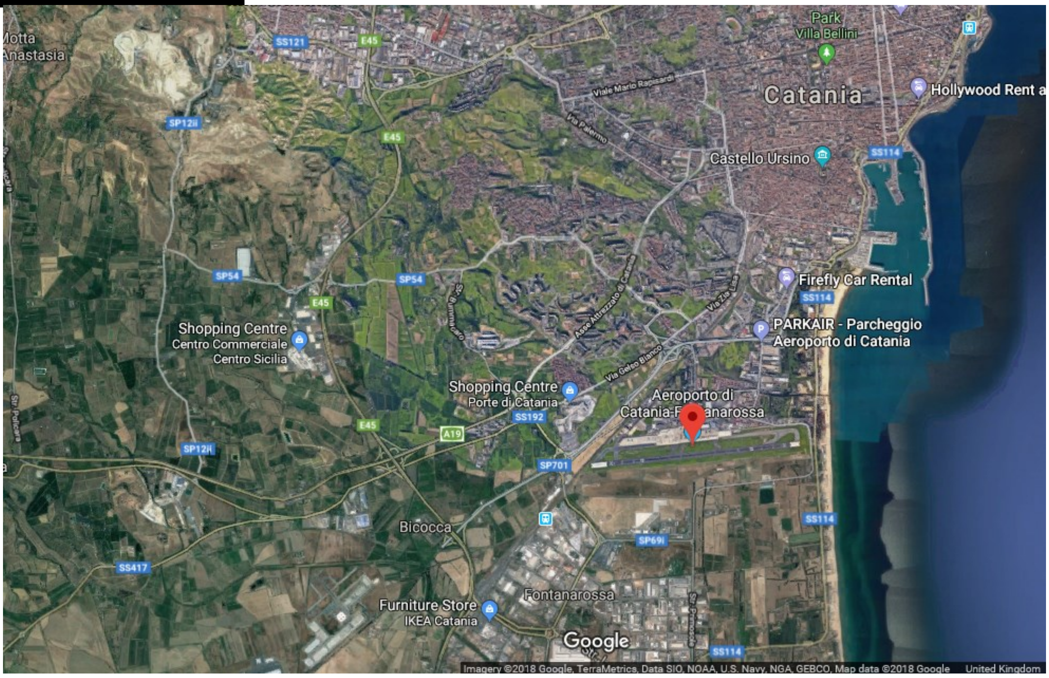
Background

Catania Airport is the 6th largest airport in Italy for passenger movements, with over 9 million in 2017 and 6700t of goods, and 68000 flights (http://www.assaeroporti.com/statistiche_201712/).
The Airport has only one track (08-26) with orientation east-west and it is located very close to the sea and approximately 5kn south to the City of Catania.

Airport Characteristics	
Airport Name	Catania
ICAO Code	LICC
IATA Code	CTA
Geographic Coordinates	37°28'00'' N 15°03'50'' E
Altitude	12 m
Tracks number	1
Type of Track	08-26 Strumentale di precisione
Helicopters	NO – AD (Aerodromo) open, with restrictions, only civil helicopters but after authorisation only.
Airport surface	≈230 ha
Type of management	As a whole
Managing/Responsible Entity	S.A.C. S.p.a.

The whole airport surface is within Catania City council remit, however the Aeronautical activities (departure and landing) are over another Council territory, Misterbianco, where no residential buildings are present.
For completeness, the urban areas closest to the Airport and its activities are:

- North, the residential areas of Catania between San Giuseppe da Rena St. And Santa Maria Goretti St.;
- West, the village of Librino (between motorway A19 and SS 192 road);
- South-South West, the villages of Fontanarossa and Torregalliera (Industrial areas);
- East, mainly turistic activities/beach.



In the wider areas around Catania Airport are present other noise sources from transport systems, such as the rail line west to the Airport, in proximity of the end of track 08, the SP55 road, going in parallel to the rail line and the military heliport "Mario Calderara".

From a legislative point of view, the noise zoning system with noise maps approved in 2005 by the Commission ex Article 5 of D.M. 31/10/1997 in 2005 and the Catania Council acoustic classification plan approved on the 04/03/2013.

Noise monitoring network

The Noise monitoring network at Catania Airport is constituted by monitoring system of three fixed and 1 mobile noise monitoring sites, and located within the Airport land, as per figure below. The whole Airport complies with the ARPA guidelines ("Linee guida per la progettazione e la gestione delle reti di monitoraggio acustico aeroportuale") and the table below illustrates the characteristics of the noise monitoring network.

ID number	Site name	Location	Coordinates	Related Weather station
P1 - 1301	Testata 26	Inside (B)	37° 27' 58.94" N 15° 4' 56.59" E	SI "Vaisala Weather Transmitter WXT533"
P2 - 1302	Testata 08	Inside (A)	37° 27' 47.28" N 15° 2' 59.00" E	SI "Vaisala Weather Transmitter WXT533"
P3 - 1303	Pista lato sud	External	37° 27' 43.77" N 15° 3' 54.25" E	NO
P4 - 1304	Mobile	N.D.	N.D.	NO

Other Information

The responsible authority is SAC S.p.A. and the main legislative reference for the noise impact assessment are the following:

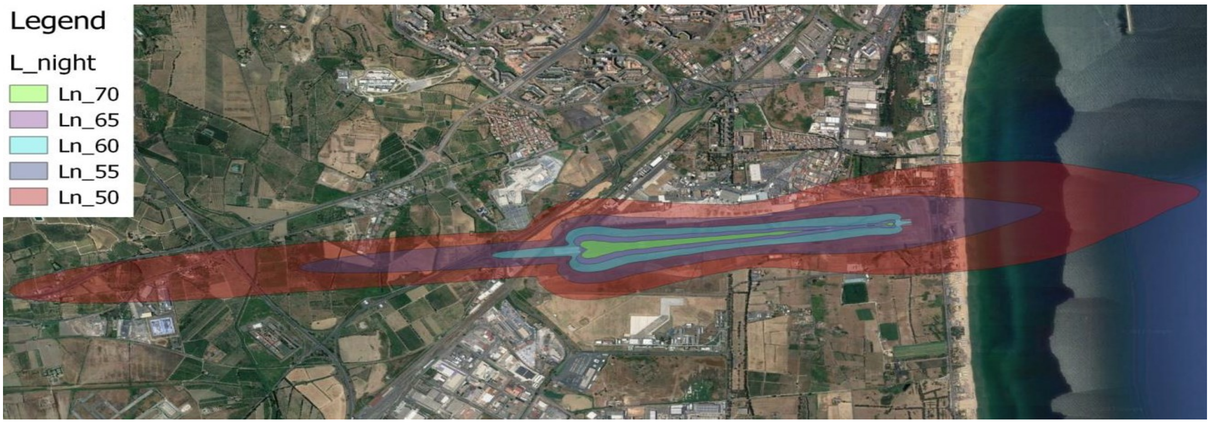
- **Legge 447 del 26/10/1995**: "Legge Quadro sull'inquinamento acustico".
- **D.M. 31/10/97**: "Metodologia di misura del rumore aeroportuale".
- **D.P.C.M. 14/11/97**: "Determinazione dei valori limite delle sorgenti sonore".
- **D.P.R. 11/12/97 n. 496**: "Regolamento recante norme per la riduzione dell'inquinamento acustico prodotto dagli aeromobili civili".
- **D.M. 16/03/1998**: "Tecniche di rilevamento e di misurazione dell'inquinamento acustico".
- **D.M. 20/05/1999**: "Criteri per la progettazione dei sistemi di monitoraggio per il controllo dei livelli di inquinamento acustico in prossimità degli aeroporti nonché criteri per la classificazione degli aeroporti in relazione al livello di inquinamento acustico".
- **D.P.R. 09/11/99 n. 476**: "Regolamento recante modificazioni al D.P.R. 11/12/97 n. 496, concernente il divieto dei voli notturni".
- **D.M. 3/12/1999**: "Procedure antirumore e zone di rispetto negli aeroporti".
- **D.M. 29/11/2000**: "Criteri per la predisposizione, da parte delle società e degli enti gestori dei servizi pubblici di trasporto o delle relative infrastrutture, dei piani degli interventi di contenimento e abbattimento del rumore".
- **D.lg. 17/01/05 n. 13**: "Attuazione della direttiva 2002/30/CE relativa all'introduzione di restrizioni operative ai fini del contenimento del rumore negli aeroporti comunitari".
- **D.lg. 19/08/05 n. 194**: "Attuazione della direttiva 2002/49/CE relativa alla determinazione e alla gestione del rumore ambientale".

At Regional level, current applicable legislation for noise assessment is:

- **D.D.L. n. 457 del 23/05/97**: "Norme per la tutela dell'ambiente abitativo e dell'ambiente esterno dall'inquinamento acustico".
- **Decreto Assessoriale del 11/09/07**: "Linee guida per la classificazione in zone acustiche del territorio dei comuni della Regione siciliana".

Noise Maps

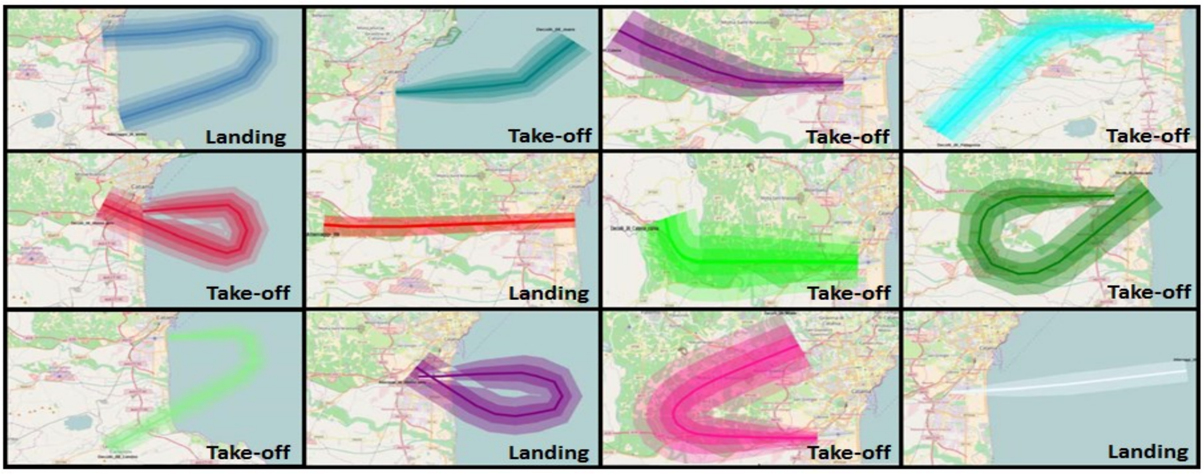
Noise maps have been generated in 2017 using a specific software, Integrated Noise Model (INM).



Noise abatement measures

Operating restrictions
allowed only Chapter 3 (Annex 16 ICAO) aircraft or above; restricted night flights

Operational Procedures
departure NAPD 1; Approach CDA; Distribution of the flights during the day.



Land use case study

Noise Zoning:

Italian legislation for land use planning of Local Authority defines the uses for each parcel of land depending on the level of noise exposure. It generally consists of a zoning ordinance which specifies land development and use constraints based on certain noise exposure levels. Noise zoning is applied in nearly all surveyed countries as a physical planning measure to prevent new noise-sensitive developments near the airport. Ideally noise zoning should be established for all airports. Noise zoning should be used constructively to increase the value and productivity of the affected land. Changing zoning primarily for prohibiting a use which is already in effect is generally not possible. Therefore, zoning is most effective at airports that have not yet felt the impact of buildings. Noise Zoning around airports is applied in nearly all surveyed countries as a physical planning measure. However, it is sometimes only applied to the larger or national airport.

Airport binding zones

According to the Article 707, 1st comma, of the "Codice della Navigazione del Regolamento per la Costruzione e l'Esercizio degli Aeroporti" (2nd Edition of 21.10.2003, amendent 5) binding zones are defined when in proximity of airports and to prevend obstacles and danger for both airport operations and public safety. As a result, binding maps are generated to govern and manage safely the land and the flight operations.

In line with International Technical Legislation Chapter 4 (Rules for construction and operation of airports), Catania Airport has adopted a binding (or incompatibility) zoning system (figure 11.1), following two main rules:

Absolute incompatibility land **–** Footprint of encrochment, landing and departure contour and of the ATZ "Aerodrome Traffic Zone"

Valuation dependent incompatibility land **–** Every zone between the external boundary of the ATZ and a radius of 15km from the Airport Reference Point –ARP airport

In figure 11.1 below is reported an example of the zoning.

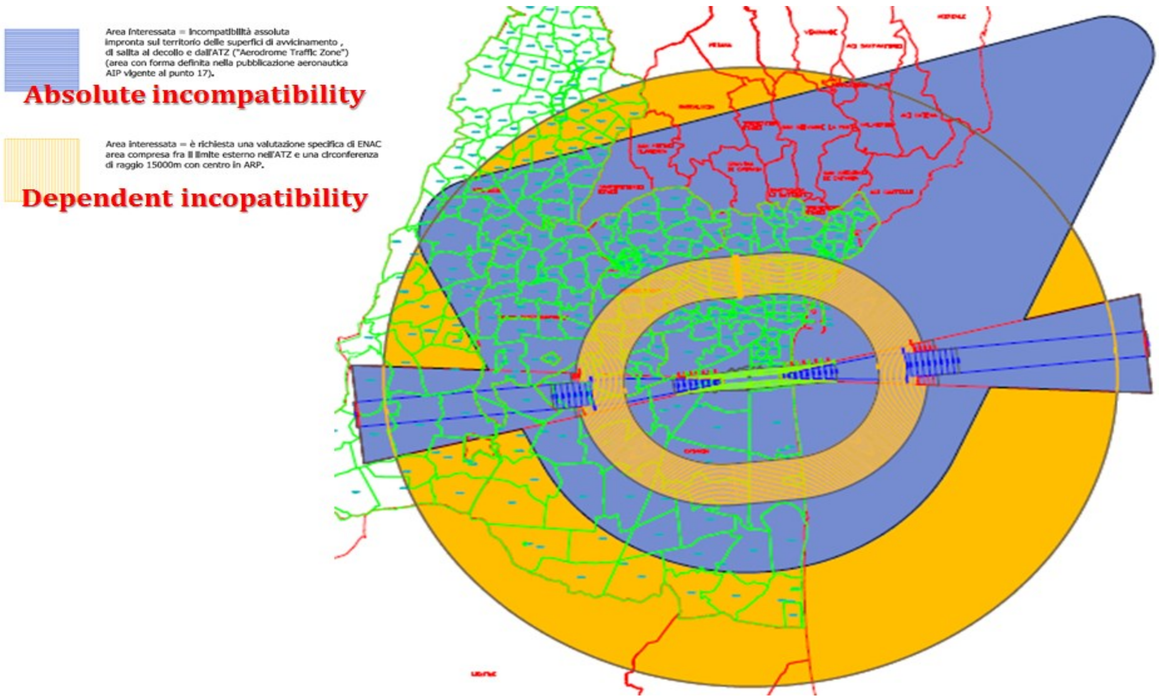


Figure 11.1 – Airport binding zones of absolute and dependent incompatibility [1]

The process followed the indication of the Act 15/03/2006. Specifically, based on the instructions of the art. 707, comma 1 of the Act it is necessary to develop adequate binding maps around airports, to be published and make executable by an Italian procedure developed by ENAC (31/05/2007 protocol 0034982/AOC/DIRGEN).
The ENAC procedure is organised in different phases, described in detail by guidelines developed by ENAC with the main objective to create a standardisation from a graphical as well as application point of view, to allow a unitary digitalisation and centralisation of the data. Also, ENAC based on experience and Airport operators' feedback has updated the guidelines recently.
The procedure consists in developing binding maps that take into account of the land registry information (dati catastali) and other geographical information, building height, etc.

Barriers and gaps: During the implementation period there have been some gaps especially in the identification of all necessary land registry information particularly some disallignment of consecutive maps creating some gaps or duplication in the land information.

Detailed matching building vs zoning:

A detailed study has been carried out for the different residential properties located at the edge of the noise zones between 60 and 65dBA (Figure 11.2). This was necessary as several building fall at the boundary or very close to the relevant noise contour and the Airport wanted to be sure to truly assess the level of noise for those specific building and their destination of use.

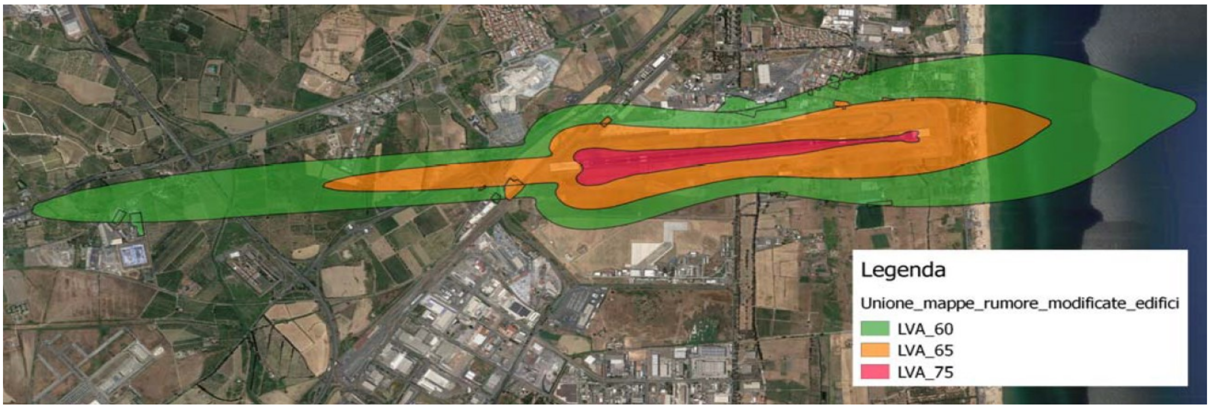


Figure 11.2 – Noise maps of Catania Airport and location of sensitive buildings [2]

For few buildings, according to modelling results (noise maps, Figure 11.3) a more detailed study using site specific monitoring was required. Also, from the destination of use a sub-set appears to be not residential use but only day activities (such as offices).
Results from the detailed monitoring activity has revealed lower levels of Noise than those modelled, providing evidence that those building were not subject to restrictive legislation.

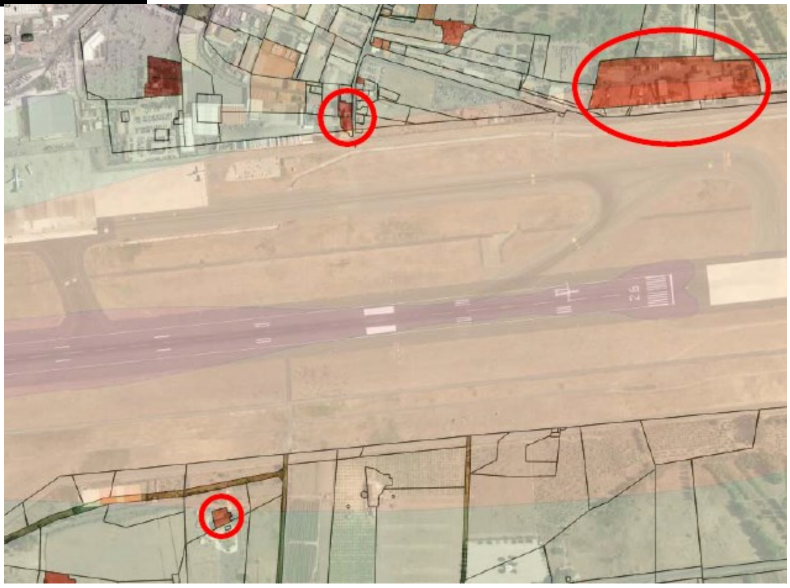


Figure 11.3 – Buildings identified as requiring a more detailed monitoring exercise [2]

Conclusions

This case study shows the importance of accurate input data, to refine and improve modelling results, as well as the important role of site-specific monitoring activities.
As a result of this initial case study, Catania Airport does now regular site monitoring using mobile systems to make sure modelling results are constantly validated.
There is also plan for extending the monitoring systems with new equipment to be located permanently on those areas and in proximity of buildings within the Zone B (65dBA).

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8.12 Case Study 12 – Helsinki Airport

Introduction to the airport

Background information on Movements/pax/growth/noise data and applicable noise regulations. Helsinki airport was originally built for the Summer Olympics in 1952. Meanwhile, approximately 1500 companies operate at the airport providing 25000 jobs. Helsinki airport became the largest airport in Finland and the fourth busiest airport in the Nordic countries. About 90% of Finland's international air traffic passes through Helsinki Airport [1]. In 2018 approximately 21 million passengers were handled, including almost 18 million international passengers and 3 million domestic passengers [1]. On average, the airport handles around 350 departures a day. Two terminals include a total of 29 gates with jet bridges and 80 remote aircraft parking stands.

Runway number	Direction and code	Length [m]	Notes
1	04R / 22L	3500 m	First runway
2	15 / 33	3901 m	Direction 15 used for propeller and low visibility departures. Direction 33 only used during strong winds from northwest.
3	04L / 22R	3060 m	Introduced in 2002

The airport makes use of three runways. The runway characteristics are shown in the above table and an overview of the three runways is shown in Figure 12.1.

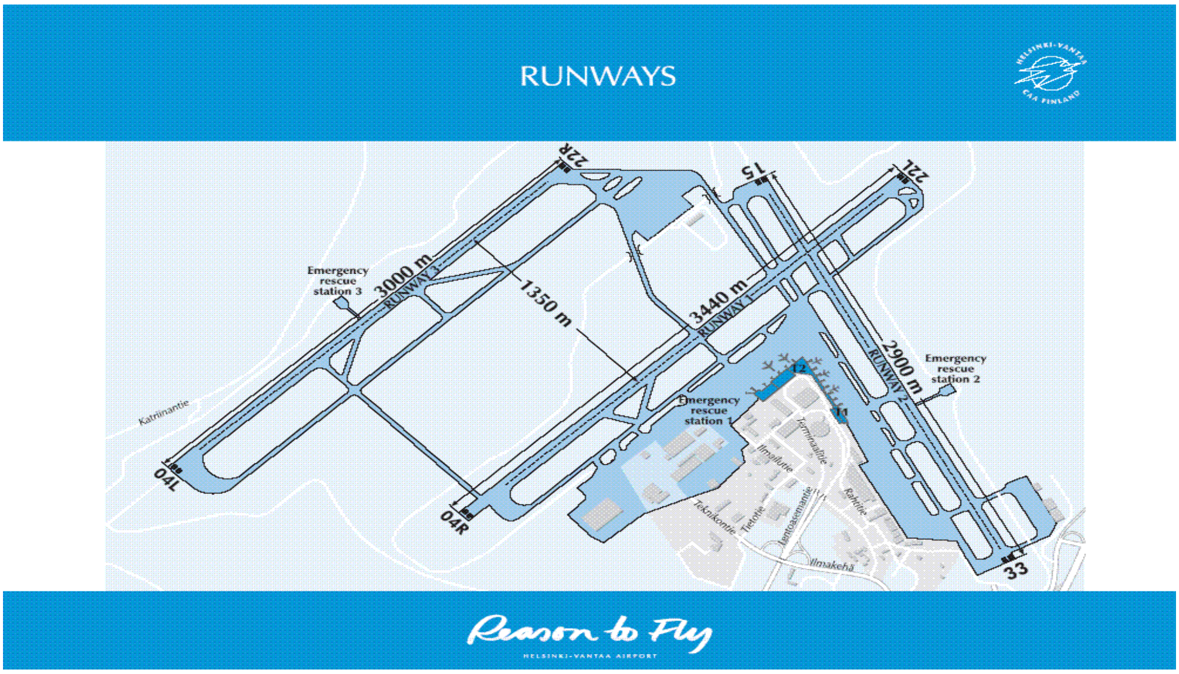


Figure 12.1: Map showing the three runways used at Helsinki Airport [3]

Approach to the Balanced Approach

a. Essentially a summary of national regulations and how these have been implemented by the airport

EU Regulation 598/2014, national Aviation Act 864/2014 and government decree 401/2016 form the regulation basis of the implementation of the Balanced Approach in Finland. Based on those regulations the Ministry of Transport and Communications has established a working group on noise management at Helsinki Airport. The working group is led by Finnish Transport and Communications Agency that is also the designated competent authority according to EU Regulation 598/2014. The working group is participated by the airport, ANSP, relevant ministries, environmental and aviation authorities, regional council, municipalities and major airlines. As a technical co-operation framework referred to by EU Regulation 598/2014 the CEM working arrangement (Collaborative Environmental Management) for the Helsinki Airport was established in 2018. It's formed by major airlines, ANSP and the airport.

b. Review of NAPs and previous BA interventions

In 2015 Finnish Transport Safety Agency, as the competent authority in accordance with the Directive 2002/30/EC, decided on noise-related operating restrictions at Helsinki Airport. Operating restrictions had been requested by an application submitted on the basis of the environmental permit requirement. In its decision Finnish Transport Safety Agency rejected to impose any noise-related operating restrictions at Helsinki Airport as it could not find any ground for them for the time being. The process involved establishment of the noise management objective for the airport and none of the proposed operational restrictions was found necessary for achieving the objective.

Previous BA interventions include CDO implementation and continuous monitoring of the performance, NADP1 implementation for runway 22L departures, departure route design minimizing the noise impact to residential areas and noise level restrictions on certain departure routes. In 2017 effective noise abatement strategies for high-weight aircraft were applied in the same way as for low-weight aircrafts. The regulations are in line with the International Civil Aviation Organization's (ICAO) recommendations (Chapter 14). The overall goal is a reduction of the total land area exposed to aircraft noise by 2%. In other words, 500.000 people will be removed from the noise zones [4]. Different cooperation's with the land-use planners were undertaken to look closely at the population density around the airport. The departure tracks have been fine-tuned according to the geography and location of suburbs. This has been stepwise implemented during the past 15 years and is meanwhile well optimised. Finavia maintains effective cooperation with Vantaa's local government, which has led to a consensus forming on route-planning and runway use.

The runway usage preference principle includes approximately 20 different combinations. The primarily preferred runway for landings is runway 2 (15) from the northwest. Depending on weather and capacity conditions runway 1 (22L) is used from the southwest. For wind conditions from the north or east, runway 3 (04L) or runway 1 (04R) are typically used for landings. Take-offs are made from Runway 1 (04R) in northeastern direction. The runway usage during the night time differs and certain combinations are avoided. Restrictions include jet airplane landings on runway 2 (33) from the southeast and take-offs from runway 2 (15) towards the northeast. Landings are primarily carried out on runway 2 (15) from the northwest. For take-offs runway 3 (22R) is used towards the southwest. The airport is located close to a large rural tract to the north, which it can use for night-time approaches, orienting flights away from the suburbs of the capital to the south.

Airspace and SID changes as well as the NADP1 implementation were published in the Aeronautical Information Publication (AIP) and taken into use in accordance with the Aeronautical Information Regulation and Control (AIRAC) system.

c. Identification of any trends and overarching processes and internal systems that underpin BA implementation

A noise area forecast has been included in the Helsinki Region Land-Use Masterplan defining housing restrictions to noise areas. CEM working arrangement promotes active co-operation of the major airlines and ANSP to find operationally feasible solutions to further improve arrival and departure procedures supporting the noise management. Noise charges and other economic incentives were implemented to encourage avoiding night time operations and supporting the use of quieter aircraft types.

Introduction to the intervention

Implementing an increased amount of departures at the runway RWY-22L was complex and brought several concerns. One concern was that using the runway RWY-22L more intensively causes that more air traffic will fly over noise sensitive residential areas. Therefore the noise level based departure procedure (by ICAO) Noise Abatement Departure Procedure (NADP1) was introduced to prevent more intensive noise exposure for the residents. This implies that the airplanes climb higher with constant speed before acceleration is applied. This means that airplanes are flying slower but with higher altitude. The result is a lower noise level due to a higher flight altitude. The altitude difference between NADP1 and Finavia's ("Baseline") regular procedure is schematically sketched in Figure 12.2.

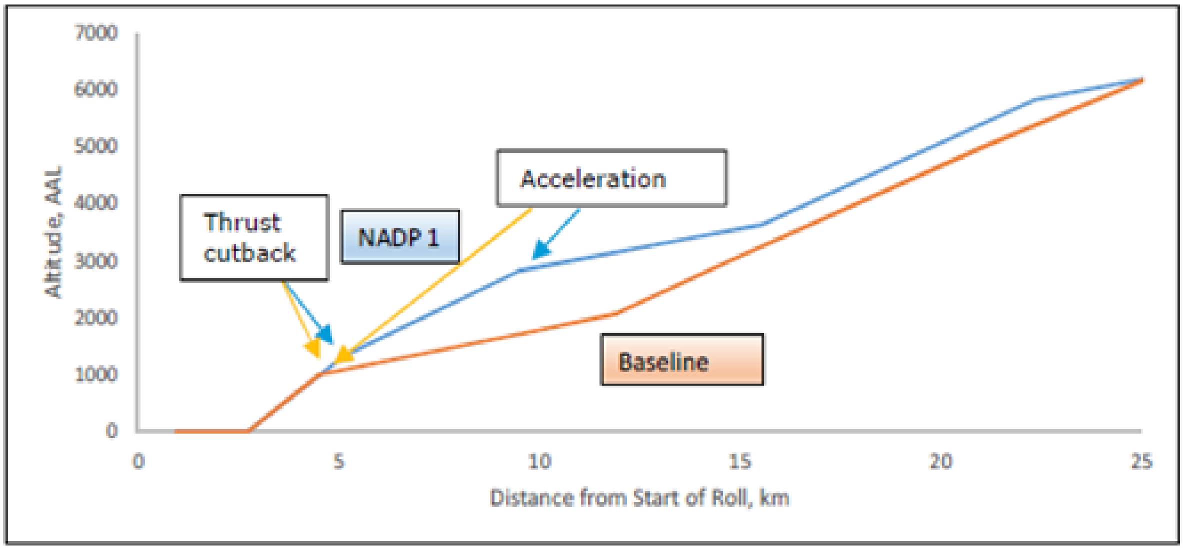


Figure 12.2: The NADP1 procedure enabled a reduction of the noise level due to higher flight altitude and longer noise attenuation distances.

Delve into the processes behind the case

a. Identification of the 'need'

The departure demand at Helsinki Airport increased during the last years. It was foreseen that the usage of the primary departure runway RWY-22R would reach its limits especially during the afternoon peak hours between 4 pm and 6 pm. Figure 12.3 shows the most typical runway configurations at Helsinki Airport.

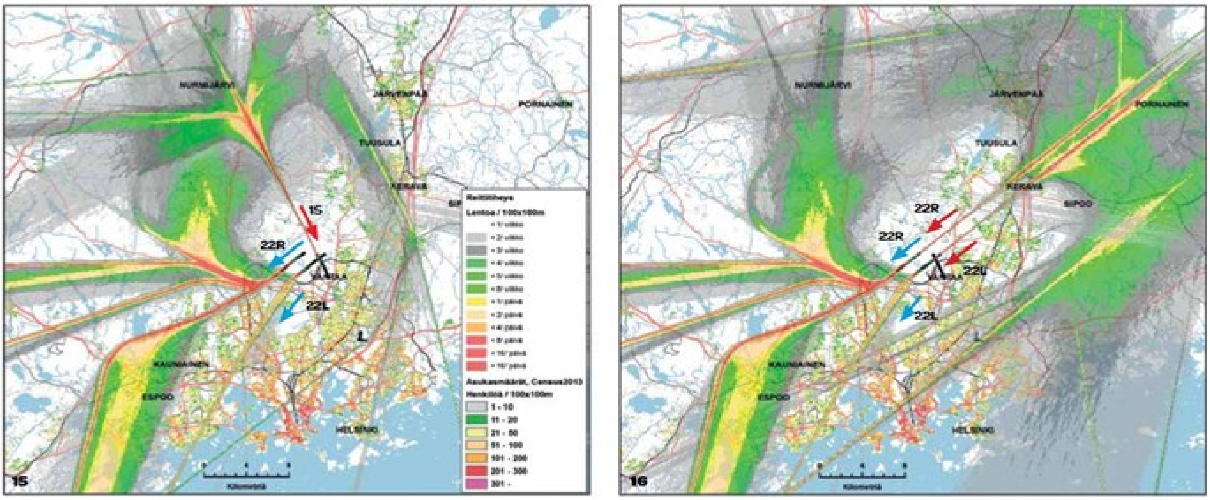


Figure 12.3: Typical runway configurations at Helsinki Airport.

An additional departure runway was required to handle the increased capacity of aircraft departures. One possible solution to increase the departure capacity was to use runway RWY-22L more intensively within the already implemented noise restrictions. Until April 2018 only one exit point (DOBAN) was used for the traffic to the south. Increased airplane traffic from RWY 22L that fulfilled the security requirements was enabled by splitting the DOBAN exit point into two separate exit points (KOIVU and VALOX), as shown in Figure 12.4.

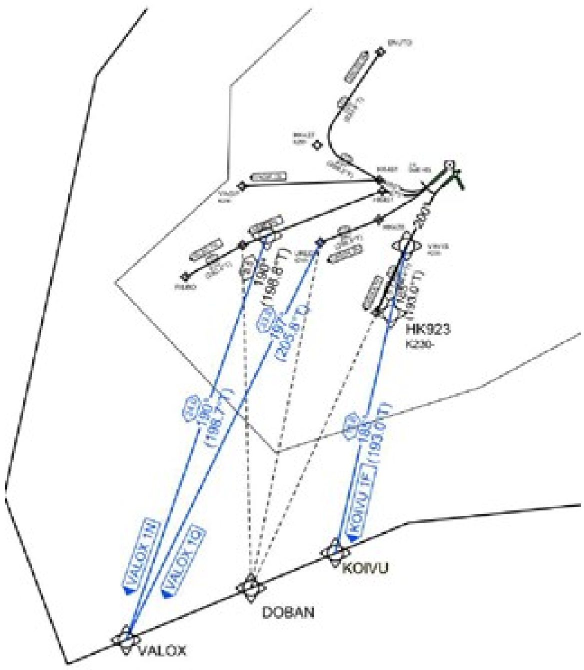


Figure 12.4: Splitting the DOBAN exit point into the two separate exit points VALOX and KOIVU.

b. The design of options
There was only one option to increase the flight capacity and that was using the runway RWY-22L. The NADP1 departure procedure was chosen at it appeared as the best solution for the populated areas.

c. The selection of the intervention

It was expected that the runway RWY 22L would be used more intensively in the future due to the increased air traffic demands. The Integrated Noise Model (INM) was used to calculate the estimated noise abatement for the usage of runway RWY 22L. A flight profile was created for the changed departure procedure. The estimated noise levels for departures using runway RWY 22L were compared with the estimated noise levels for the NADP1 departure procedure. A reduction in maximum noise levels (Lmax) was expected based on the calculations. Measurements proved that the application of the NADP1 departure procedure resulted in a reduction of the Lmax levels of approximately 3 dB. Summing up, the results for decision making were less noise exposure and emissions, less taxi time and air times.

Implementation

The airspace was changed by replacing the exit point DOBAN with two new exit points KOIVU and VALOX. In the same context, the Standard Instrument Departure (SID) route was adjusted to better avoid certain residential areas. The traffic flows are further managed by Estonian Air Navigation Service Provider (ANSP) by using the Route Availability Document (RAD). The airspace changes were planned and implemented in cooperation between ANS Finland (Finnish ANSP), EANS (Estonian ANSP) and Finavia. The RAD was updated by Estonian ANSP as the traffic flows towards south proceed to Estonian airspace after leaving the Terminal Manoeuvring Area (TMA). The gradual traffic increase from RWY 22L was enabled by splitting the DOBAN exit point to KOIVU and VALOX points, as shown in Figure 2.

Post-Implementation evaluation.

A post-implementation evaluation was not as such carried out. The comparison of multiple track flight departure profiles between Finavia's regular used departure procedure and NADP1 in practise is shown in Figure 12.5. For NADP1, the aircraft is required to climb with constant speed to a higher altitude before acceleration (green circle) as compared to Finavia's regular procedure (red circle). Reduced noise levels were enabled because the attenuation distance is longer for an aircraft flying at higher altitude.

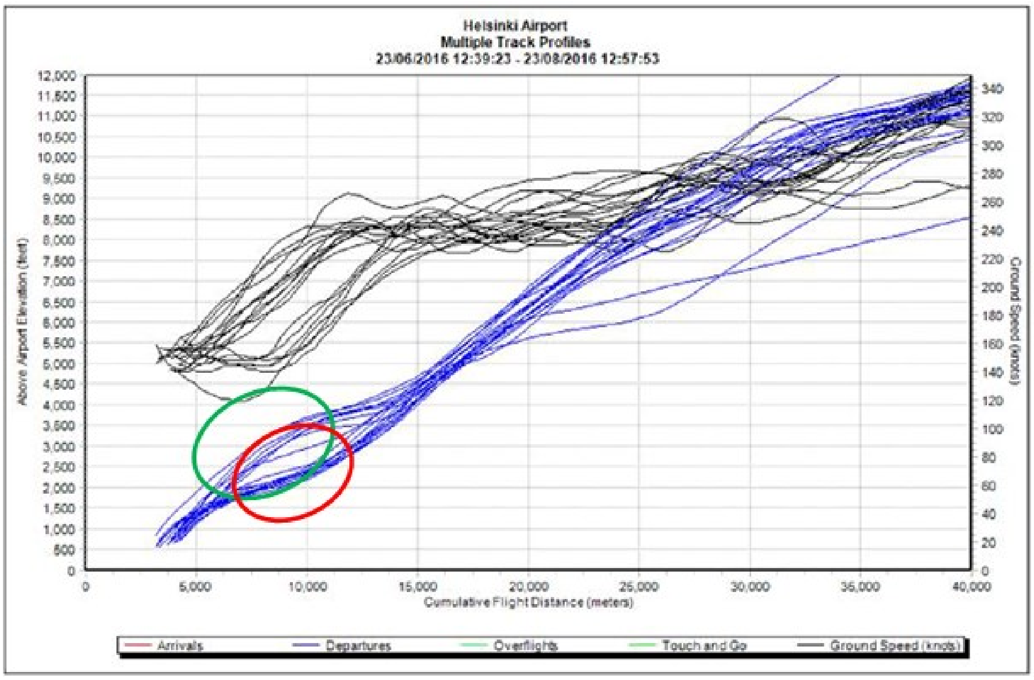


Figure 12.5: Departure profile comparison between commonly used departure procedure and NADP1.

Noise measurements at the Runway RWY22L confirmed the reduced noise levels by applying NADP1 as compared to the commonly used departure procedure. In the below the measured maximum noise levels (LAmax) are shown for the commonly used aircraft types.

Airplane type	Commonly used departure procedure		NADP1		Delta dB
	LAmax	Movements n	LAmax	Movements n	
A319	74.6	37	71.3	10	-3.3
A320	75.3	33	73.4	9	-1.9
A321	75.8	13	72.5	3	-3.3

Measured LAmax noise levels for the airplane types A319, A320 and A321 for varying amounts of air traffic movements.

Summary (of the whole airport case)

Departures were split up between RWY-22L and RWY-22R. This lead to fuel, time and emission savings, due to shorter taxi and flight route distances. The safety and capacity situation at Helsinki Airport was improved due to the divided traffic flow. The noise exposure was reduced by applying the NADP1 departure procedure. The greatest difficulty was the actual implementation of the changed operational procedure. The avionics data houses did not recognize the changes at the time that the implementation became applicable. The consequence was that the implementation of cockpit charts took extra time and effort. Finavia implemented a note into their flight preparation software to specify departures from the RWY 22L runway. The overall perception of the benefit of the intervention was positive and for the airport and the airlines worth the effort. There was only a small number of noise related complaints from the nearby residential community. The increased number of flight operations has not significantly increased the annoyance of air traffic noise.

References:

[1] Helsinki Airport is designed for smooth travelling (2016). Finavia
[2] Helsinki Airport Runway 22L departures noise management (2018). Finavia
[3] Helsinki Airport Information - https://helsinkiairport.org/#/searchcars
[4] A balanced approach to noise abatement Helsinki and Lisbon (2016). Futureairport: http://www.futureairport.com/features/featurea-balanced-approach-to-noise-abatement-helsinki-and-lisbon-5724240/

8.13 Case Study 13 – ACNUSA (French Airports)

Background

The ACNUSA (Autorité de contrôle des nuisances aéroportuaires / Airport Pollution Control authority) was founded in 1999 at a time of sharp growth in air traffic and yet a standstill in dialogue between stakeholders.

It is a public body, without formal regulatory powers, but it carries considerable moral ascendant as it is allowed to undertake studies, provide opinions, and contribute to debates. Last, but not least ACNUSA also manages the system of administrative sanctions (ie, fines) in the cases where existing environmental regulations are being breached. The mandate of ACNUSA encompasses noise pollution and was more recently (2010) expanded to air quality. ACNUSA covers some of the busiest airports in the country.

Actions undertaken by ACNUSA

There four pillars to ACNUSA's activities :

Enabling debate through knowledge and information

ACNUSA is tasked with providing stakeholders with a common foundation of sound technical, objective and scientific information, indicators and data, and convincing targets. Without this foundation, the conditions for consensus-building dialogue would not be present and there would be no due consideration for each form of pollution resulting from air traffic.

Noticeable progress has been made in harmonising information and ensuring that it is both more transparent and more accessible. In particular, the Authority has initiated or championed a number of studies, with the aim of yielding accurate and recognised information and, thereby, facilitate decision-making on increasingly-difficult societal issues such as night flights or the effects of airplane noise pollution on the local community's health.

Difficulties remain in certain areas, however, such as the verification of noise measurement systems or the working principles of certain coordination bodies. Beyond the essential part it plays in providing information, the Authority has brought back to players' minds the importance of making concrete proposals and embarking on a process of consensus-building dialogue and active management of environmental issues.

Examples of activities undertaken to restore trust and foster dialogue:

ACNUSA has worked on establishing trust on the existing information, notably through the promotion of harmonised indicators, and by making the existing information available to residents. For example airport managers are now required to provide residential populations with all four of the indicators recommended by the ACNUSA: lAmax, lAeq (day, evening and night), lden and lAeq (planes/evening). ACNUSA also verifies the quality of the noise monitoring systems in place.

The Authority is also extremely attentive to disseminating the most transparent and accessible information possible, ACNUSA has called for the development of *trajectory visualisation tools*. The availability, mostly via internet, of visualisation systems is vital

Due to the lack of precise and reliable information on night flights and noise impacts on health, it was not possible to embark on constructive, disimpassioned debate with the parties involved For this reason the Authority strived, over the past years, to make this information available. It commissioned and funded report to encompass figures and details on night flights across the "ACNUSed' airports (subject to ACNUSA mandate).

ACNUSA had also set up a working group on which all of the stakeholders were represented, in order to take stock of the situation jointly, at the national level, perform international benchmarking of the restrictions in effect at the main airports and, if possible, to set a 5-year target to lower pollution due to night flights. A newly created group now has a similar mission (benchmarking) but this time related to air quality.

ACNUSA also works on governance of public inquiries and public consultation and encourages public authorities and airport managers to embark into both upstream and continuous consultations of residents, and into more innovative interaction with all of the partners in (comparable to sustainable development days, job fairs, etc.) so that resident populations can be more involved in the decisions affecting them.

Supporting a better management of airport related pollutions

Because they are increasingly subject to noise pollution resulting from air transport and concerned about the impact of noise on their health, the populations residing around airport are demanding solutions capable of limiting all forms of pollution.

ACNUSA, is aware that there is no panacea answer to this growing concern, and –through its opinions- it encourages a holistic approach, addressing all of the factors to better manage airport-related pollution. This is true in the air, through the measures geared toward air navigation (CDOs etc) , and it is also true on land, with controlled urban management and grants for soundproofing.

This is a gradual approach, and one that requires time. It is also an approach that highly-technical and complex given that solutions need to be experimentally tested before being deployed on the ground Continuous descent approach procedures, an increase in ILS intercept attitude, limits on helicopter traffic in zones with high population density, etc. are just a few of these.

Through the discussions it holds and the recommendations it issues, the Authority has supported and sometimes triggered the environmental advances seen in the past few years, both in air navigation and on the regulatory front. It has also made managing noise pollution due to night flights one of its priorities and emphasised that this is a major issue for the years to come.

Preventing and repairing

The Authority has consistently reiterated that better acceptance of air transport will also require strong-willed action from public authorities – action that recognises the real disturbance undergone by the population, fits into the timetables set and preserves the future. Air transport demand has risen relentlessly, as a result of developing exchanges and greater mobility, for recreational purposes in particular.

However, the announced expansion of air traffic in the years to come is coming up against the growing environmental aspirations of the local populations. In this context, new solutions must be considered in order to better manage urbanisation around airports.

The aim is, in particular, to reconcile the urban renewal needs of certain municipalities and protection for the local populations from airport-related disturbances. It also appears vital that the economic benefits of airport activity be more equitably shared. To foster acceptance, it is necessary to solve the dilemma that sometimes the municipalities subject to pollution from air traffic and to pauperisation phenomena, do not benefit from the economic and fiscal trickle-down effects of airport activity, whilst being also subject to severe urban planning constraints stemming from the airport proximity. The solution cannot be found by the State alone and a better governance across airport communities is needed.

Driven by these principles, the Authority continued its efforts to better protect the local populations from airport-related disturbances and observed that most of its recommendations had been adopted.

With regard to management of urban development, the Authority continues to advocate full compliance with construction regulations in the zones delineated in the noise exposure plan (Plan d'Exposition au Bruit, PEB), all the while requesting that the current difficulties experienced by certain municipalities be taken into account. As far as grants for soundproofing are concerned, its action has paved the way for notable progress, but unfortunally and due to some funding issues, the grants no longer covers 100% of the costs incurred, only 80%.

Administering penalties

The law that created the ACNUSA empowers it to fine undertakings in in case of non-compliance with the existing environmental measures adopted by the Ministry in charge of Civil Aviation. The ACNUSA is one of the few independent administrative authorities that have power of sanction, even though it does not hold any regulatory powers and issues only advisory opinions.

This power enables the Authority to issue an administrative fine that may reach €1,500 for individuals and € 40,000 for legal entities. The instances of non-compliance entailing a penalty are defined by restriction orders. The said orders establish permanent or temporary restrictions on the use of certain types of aircrafts or certain activities, on special take- off and landing procedures, rules on engine tests and maximum noise and air pollutant emissions levels not to be exceeded

Fines in 2014
140 airlines
387 decisions for a total amount of 2,342,200 Euro
97 infringements have not been fined
290 infringements have led to a fine
8077 euro= the average fine

<u>How does it work</u>

There are two criteria used to determine ACNUSA affiliation for airports. one is that they must have posted more than 20,000 movements of aircraft with maximum-mass equal to or greater than 20 tonnes upon take-off, within the last five civil years.

The mandate of ACNUSA covers 11 of the busiest airports in the country

- Basel Mulhouse
- Bordeaux Mérignac
- Lyon Saint Exupéry
- Marseille Provece
- Nantes Atlantique
- Nice Côte d’Azur
- Paris Charles de Gaulle
- Paris Orly
- Toulouse Blagnac
- Beauvais Tillé
- Paris le Bourget

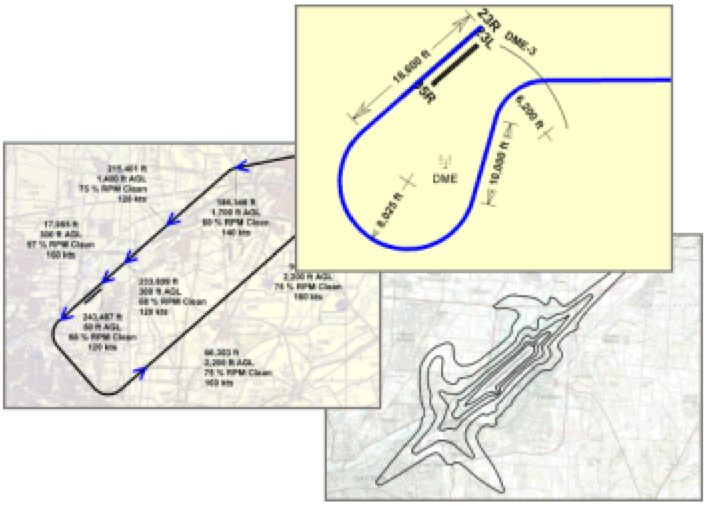
The ACNUSA is lead by a board of 10 members. They are experts coming from various horizons, airports, airlines, research, medical world etc. They are assisted by a team of 11 staff members. ACNUSA is funded by the general budget of the country. The fines levied by the ACNUSA go back to the general budget of the country.

8.14 Examples of Modelling and Communication Tools

<u>Noise Modelling/Mapping Tools</u>

<u>i. BaseOps (Noise Calculus and Prediction; Noise Mapping)</u>

BaseOps is a software pack displayed as a graphical user interface for aircraft noise models. Its main application is in performing airport noise analyses, e.g. input aircraft operational data, run noise models and create noise contours. The entire software suite (Noisemap) includes an Advanced Acoustical Model (AAM), in-flight noise from next-generation aircraft, a model of in-flight aircraft (Nmap) together with run-up noise near air bases, a model of subsonic aircraft noise (MRNMap) from Military Operations Area (MOA) together with Military Training Route (MTR) operations, a model of noise for airborne weaponry operations (AGM) and a Rotorcraft Noise Model (RNM), the latter being the model of NASA Langley for noise from helicopters and tilt-wing aircraft noise.



Example of BaseOps features
https://wasmerconsulting.com/baseops.htm

Features of BaseOps include the option to modify data related to noise analysis cases, i.e. flight tracks, flight profiles, runways and static profiles, displaying and editing noise analyses in both text-based formats and graphical maps, creating alternative scenarios of air traffic operations, develop noise contours and customised reports and many others.

<u>ii. IMMI (Aircraft Noise Calculation/ Noise Mapping)</u>

IMMI is a software tool that operates in the field of emmission control, ensuring the necessary means to calculate sound propagation outdoors, propagation of air pollutants and noise exposure in workrooms. It can be used for various calculations of different types of environmental issues, such as: commercial noise, traffic noise, workspace noise, air traffic noise, air pollutants, room acoustics. In addition, IMMI can support the development of noise maps and action plans.

IMMI Noise Map Example
https://immi.eu/

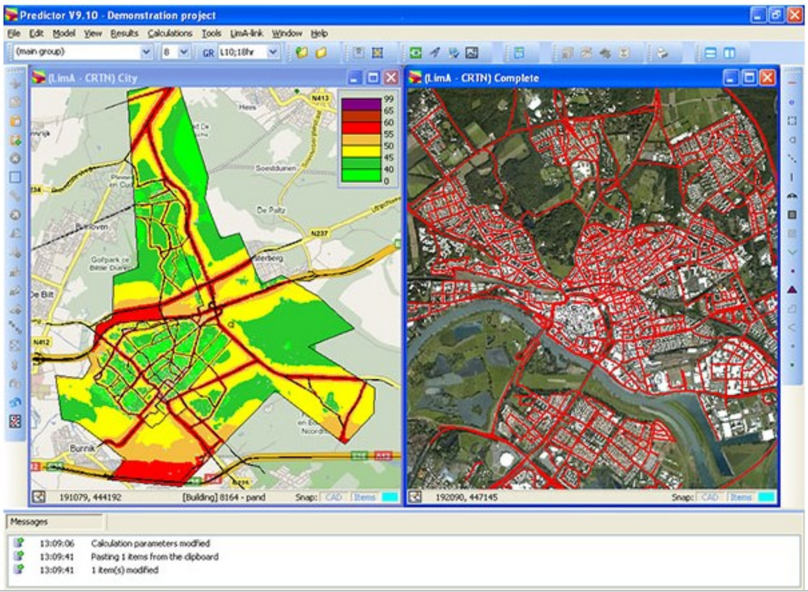
IMMI has an aircraft noise module developed particularly for offering support to compliance to requirements of aircraft noise prediction.
The European method used for aircraft noise calculation is ECAC. CEAC Doc. 29.
Its features include the definition of runways used for departures and arrivals, modelling aircraft/helicopter flight tracks and traffic circuits, the integration of aircraft movements (day, evening, night), an emission data base, the calculation of various indicators (Lden, Lday, Levening, Lnight, Lday(16h), NAT, Nawr - awakening reaction) and others.

iii. Isobella Model (Civil Aircraft Noise Model)

Isobella Model is a tool that supports the development of noise maps for various environmental noise sources, based on statistics and the number of movements of any airport. Other input data include information regarding the fleet mix, expected changes for the current fleet configuration (e.g. fleet renewal, scrapping aircraft etc.), expected airspace changes (e.g. opening/closing flight paths) and others. By considering all input data, as well as other strategic/ business development criteria and infrastructure changes, predictive noise maps are developed. Scenarios vary from 5 to 10 or 15 years and additionaly include a case of the aerodrome maximum operational capacity based on the model of runway capacity in terms of aviation safety.

iv. Other similar available tools

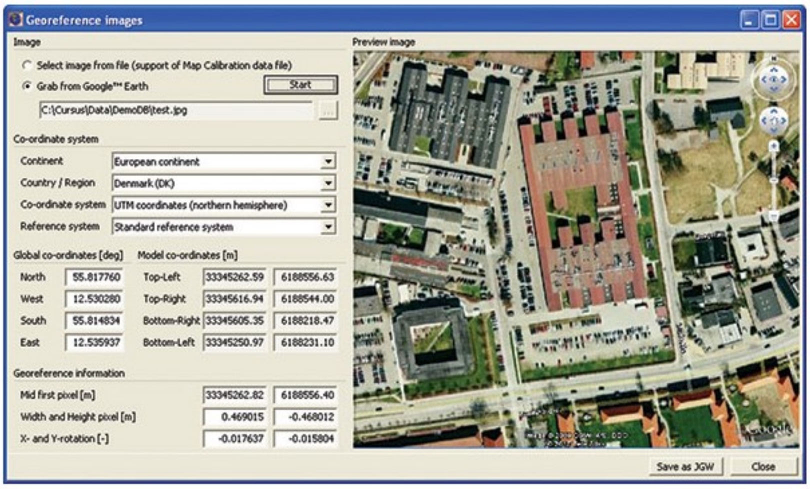
Predictor – LimA (Environmental Noise Modeling and Mapping Software)
Environmental Noise can be assessed through the support of this software tool, enabling the development of a prediction of future levels, together with the comparison of distinct noise reduction scenarios. Noise levels can be assessed even in sound contaminated areas, i.e. with high background noise (road, rail, industrial etc.) and noise contour maps can be developed from one or more sources (road, railway, industry, construction, airport).



Example of Predictor – Lima
https://www.emsbk.com/predictor-lima/

This tool has a manifold purpose, being used for modelling, calculating, mapping and predicting environmental noise.

Acoustic models can be constructed through geometrical processing, supporting an efficient prediction and reporting on environmental noise pollution through result analysis, as well as through what-if scenarios.



Example of Predictor – Lima
https://www.emsbk.com/predictor-lima/

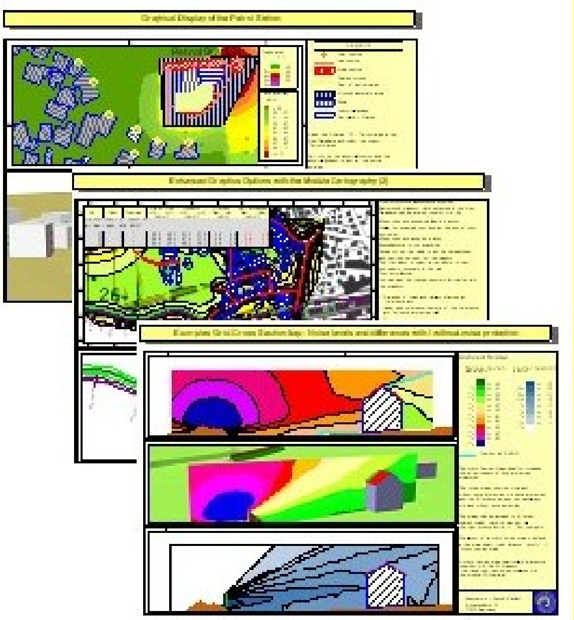
Predictor-Lima has been developed in compliance with the Environmental Noise Directive (2002/49/EC) and the IPPC Directive (2008/1/EC).

GIS data has to be integrated within this software in order to access the 2D/3D modelling options offered by Predictor – Lima.

Complex situations can be analysed and assessed, including uneven terrain, bridges, fly-overs, both indoor and outdoor calculations and others, which can be further transposed into a noise map.

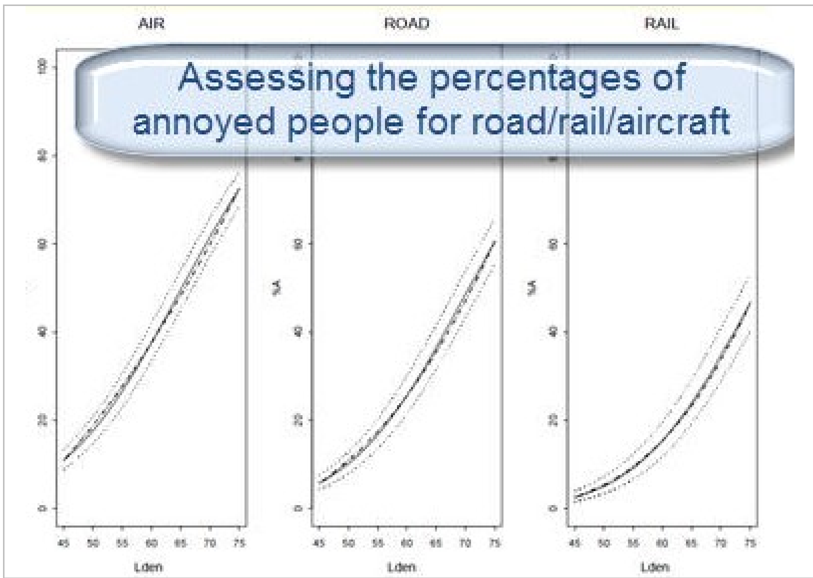
v. SoundPLAN

SoundPLAN is a simulation software that supports both air pollution calculations and noise modeling. Its features can be adjusted according to several noise regulatory frameworks for road, train and aircraft noise, as well as for industrial noise and indoor noise. Other features include an advanced planning tool that can highlight critical noise issues and offer suggestions for mitigation.



Example of Graphics from SoundPLAN
https://www.soundplan.eu/

The Aircraft Noise Module operates in compliance with ECAC CEAC Doc. 29 and can differentiate various types of noise: flyover, taxi, engine tests/run-ups, auxiliary power units, air conditioning, luggage handling and transportation noise from and to the airport.
Noise Contour Maps can be developed for both existing or planned airports, for which contour variations dependant on future types of aircraft, different types of operations and noise abatement operations/restrictions can be studied. Additional to Noise Contour Maps, the software can develop Meshed Maps, Cross-Sectional Noise Maps and Facade Noise Maps.



Example of dose-response curves
http://www.soundplan.com/

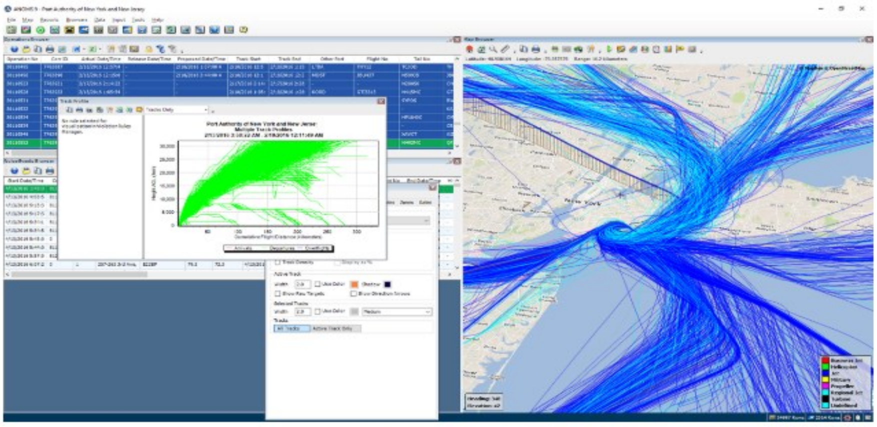
Within this tool, noise from various sources can be evaluated separately and further assessed in terms of annoyance, offering the possibility to understand the non-acoustical differences between different noise sources. A total number of people expressing annoyance can be further generated, information that will further support the development of different aircraft noise scenarios for noise management.

SoundPLAN has also been used in other aircraft noise studies, such as NORAH (Study on Noise-Related Annoyance, Cognition and Health) in the Frankfurt Area, comparing the influence factors from aircraft noise to the factors from other noise sources.

Noise Monitoring/ Management Tools

i. ANOMS (Airport Noise Monitoring and Management)

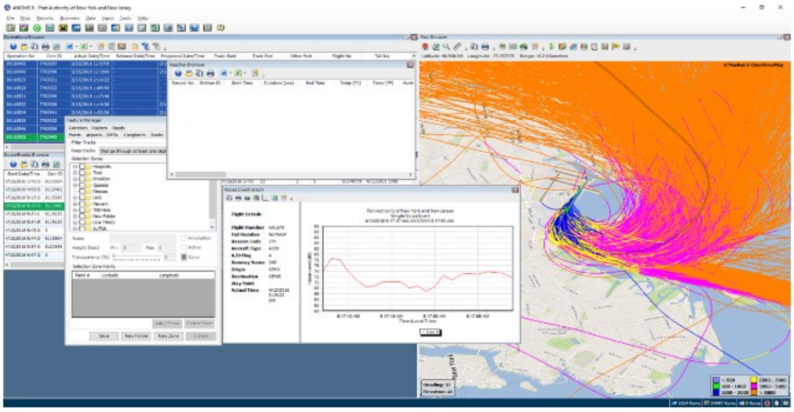
ANOMS is a management system for airport noise and operations, designed as a support tool for ensuring accurate monitoring and management of both noise on airports worldwide (e.g. Heathrow, Chicago, LAX, Eindhoven, East Midlands and others), while maximising operations within environmental constraints. In this respect, the main purpose of such a tool is to reduce operating costs and at the same time improveme the noise situation, whilst ensuring regulatory compliance, and increasing community trust and tolerance for airport operations and expansion.



Example of ANOMS
https://www.emsbk.com/anoms/

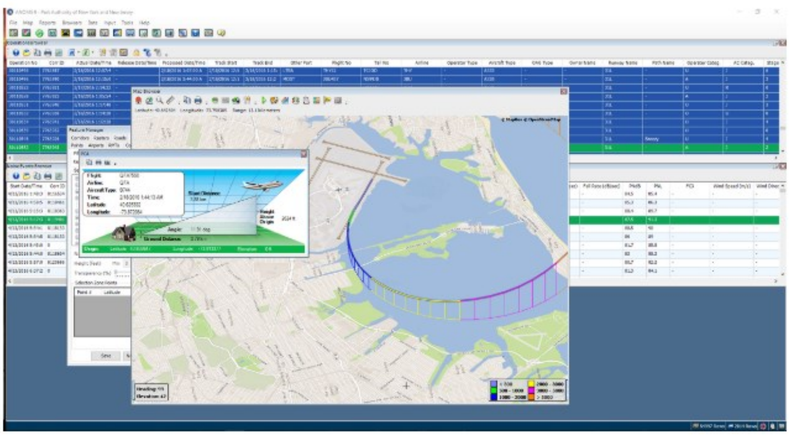
The advantages of such tool include the ability to model and investigate the fesibility of noise abatement proposals in order to reach an in-depth understanding of operational compatibility with environmental needs.

Therefore, this tool can be an aid in developing future measures, processes and policies that contribute to a better noise management.



Example of ANOMS
https://www.emsbk.com/anoms/

Through its features, ANOMS can visually transpose both past and proposed noise mitgation initiatives, thus contributing to a more reliable reporting of the noise situation and to more transparent and easy-to-understand communication means with the residents near airports.

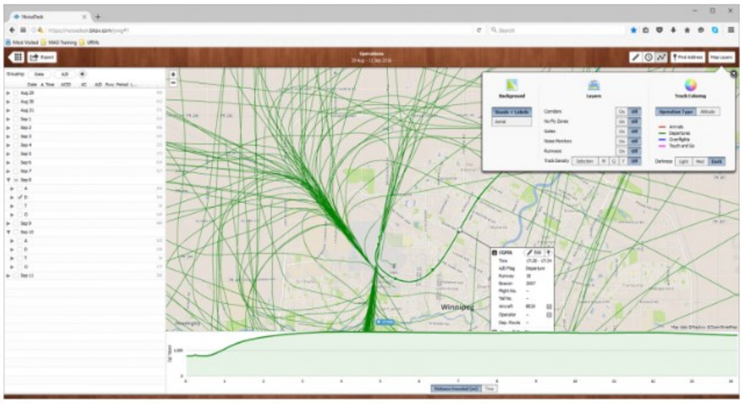


Example of ANOMS
https://www.emsbk.com/anoms/

Non-standardard operating procedures, apart from standard ones, can be analysed and assessed in terms of noise.
ANOMS platform includes an Automated Line for Complaints in order to facilitate a timely transcription of vocal complaints, a Scenario Builder to shape noise contours based on real flight data and others.

ii. NoiseDesk (Airport Noise Monitoring)

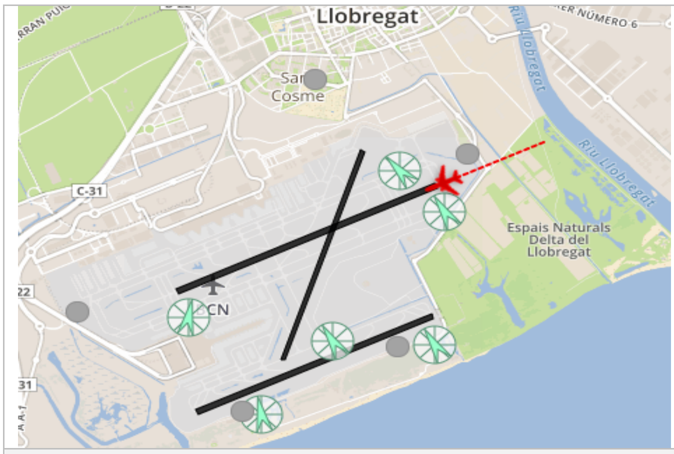
NoiseDesk is an airport noise monitoring web-based application that supports a better understanding of the noise situation around a specific airport and assists both experts and non-experts to assess the environmental impact of aeronautical operations.



Example of NoiseDesk
https://www.emsbk.com/noisedesk/

Based on ANOMS system, its features include noise limits, complaint handling, data provision for noise INM contour generation, no fly zones, curfew management, flight track compliance, running routine reports, reporting noise compliance and others. The main advantage of NoiseDesk resides in the easiness of its operation by non-experts, by processing data on its own.

iii. WebTrak (Airport Community Engagement)



Example of WebTrak use for Barcelona Airport
https://webtrak.emsbk.com/bcn3

WebTrak is a tool developed as a measure of ICAO Balanced Approach, to support Airport Community Engagement.
Such systems have been implemented by many major airports in order to ensure and support an online communication interface between airports and communities. Locations of Noise Monitoring Stations (NMS) are selected such that they measure the environmental noise levels in points where residents are most exposed to aeronautical noise, i.e. in the proximity of air paths.

This is generally a measure used to improve both measuring and control of noise determined by aeronautical operations in locations exposed to aircraft noise. All such information is available online in a transparent manner, such that any resident can obtain information regarding aeronautical operations and generated acoustic levels. Other information is available, such as the flight number, the aircraft type, the height/altitude and the flight path that the aircraft follows, weather, locations of Noise Monitoring Stations (NMS) and others. In this respect, this tool is helpful in identifying which aircraft/flight has determined a specific noise level that can influence an increase in the noise exposure of communities surrounding the airport. Therefore, complaints can be filed to the airport department dealing with complaints, based on this information, as this interface can be integrated within airport websites.

Webtrak data includes both radar data and information from flight plans, the latter being provided from the Air Navigation Service Provider (ANSP). In addition, noise data is provided from Noise Monitoring Stations (NMS), located in relevant areas of the communities surrounding the airport. The Webtrak system colour code displays departures in green and arrivals in red, while unknown aircraft and trajectories are in amber/grey/others. Airports worldwide use Webtrak or a similar tool to ensure transparency in communication with communities in their proximity.

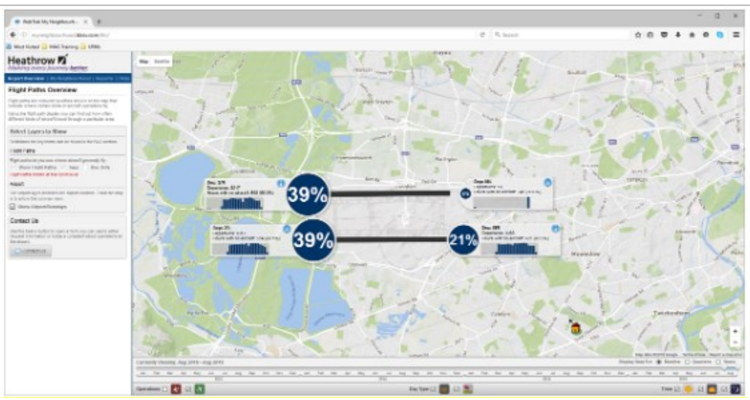
List of Airports using WebTrak

Australia	Adelaide International Airport Brisbane International Airport Cairns International Airport Canberra Airport, Coolangatta Airport Melbourne International Airport Perth International Airport Sunshine Coast Airport Sydney International Airport
Canada	Toronto City Airport Toronto Pearson International Airport Vancouver International Airport YUL Aeroport International Montreal-Trudeau
Denmark	Copenhagen Airport
Finland	Finavia Airport
Iceland	Keflavik International Airport
New Zealand	Wellington International Airport
South Africa	Cape Town International Airport King Shaka International Airport O.R Tambo International Airport
Spain	Aeropuerto de Alicante Aeropuerto de Bilbao Aeropuerto de Malaga Barcelona Airport Gran Canaria Airport Madrid Airport Palma de Mallorca Airport Valencia International Airport
Sweden	Angelholm Airport Are Ostersund Airport Gothenburg-Landvetter Airport Jonkoping Airport Karlstad Airport Kiruna Airport Lulea Airport Malmo-Sturup Airport Ronneby Airport Skelleftea Airport Stockholm Arlanda Airport Sundsvall/Harnosand Airport Umea Airport Visby Airport
The Netherlands	Eindhoven Airport
UK	Bournemouth International Airport East Midlands Airport Gatwick Airport Glasgow Airport Heathrow Airport

	London Biggin Hill Airport Manchester International Airport Stansted Airport
USA	Bob Hope Airport Centennial Airport Chicago Department of Aviation FAA – LA Basin Fort Lauderdale Executine Airport Honolulu International Airport Long Beach International Airport Los Angeles International Airport McClellan-Palomar Airport Oakland International Airport Ontario International Airport Palm Beach International Airport Port Authority of New York & New Jersey (PANYNJ) Port Columbus International Airport Portland International Airport Reno-Tahoe International Airport Ronald Reagan Washington National Airport Sacramento International Airport San Diego International Airport San Jose International Airport Santa Monica Airport Southwest Florida International Airport Torrance Municipal Airport – Zamperini Field Van Nuys Airport Washington Dulles International Airport Westchester County Airport

iv. WebTrak MyNeighbourhood (Sharing Airport Noise Trends)

WebTrak MyNeighbourhood is a tool that offers online support in sharing airport noise, as well as tracking trends as an aid in building community tolerance within sustainable airport growth. The objective of such tool is to display a friendly and simple to understand display of flight tracks in order to share information transparently and educate communities on aeronautical operations, therefore build trust.



Data displayed by WebTrak MyNeighbourhood
https://www.emsbk.com/webtrak-myneighbourhood/

This tool can be integrated within the website of the airport to display both noise and flight trends in order to increase community knowledge. In addition, in order to facilitate non-expert understanding, the public is able to delve into changes of noise levels and overflight patterns in specific areas.

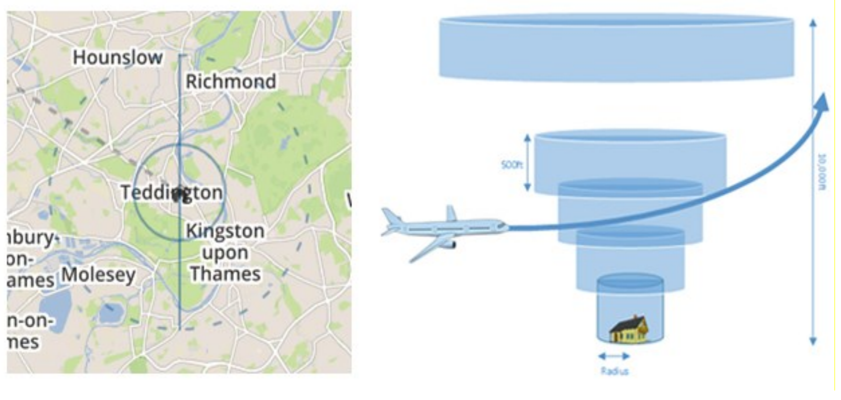
Therefore, community trust is expected to be supported as this tool is able to answer to various community concerns, i.e. if aircraft overflying a certain area are louder, if the number of overflying aircraft increased etc.

Example of Flight Paths - WebTrak MyNeighbourhood
https://www.emsbk.com/webtrak-myneighbourhood/

Its features include an illustration of airport noise trends that extend to actually displaying the long-term impact. Data used by this tool is extracted from ANOMS noise management system. The interface can display an overview on the impact of aeronautical operations over all relevant communities, illustrating both seasonal and long-term noise exposure.

v. xPlane

xPlane is a tool that displays specific flight information for a particular location and facilitates the development of individual flight analyses in selected areas that offer information regarding the type, number, height/altitude and position of aircraft. Locations that can be accessed are limited within 60 km (37 miles) from the airport. Input data is obtained from the Noise and Track Kepping system installed and operated by the airport, which collects data from the air traffic control radar. Only aircraft operating on the airport, i.e. departures and arrivals, can be displayed. Stored data offers the possibility to access information from the past six years. New entries are logged with a 3 days delay.



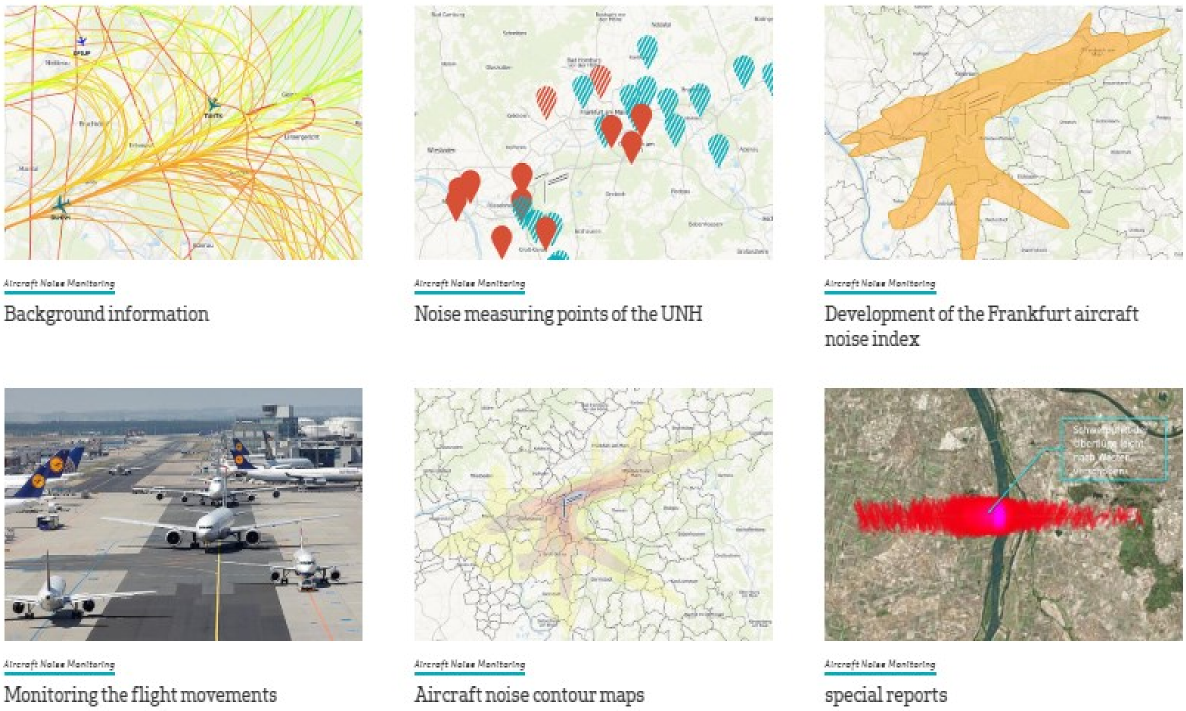
Operating Principles of xPlane
http://xplane.bksv.com/how-to-use-xplane/

The difference between the solid and dashed circles is that the first represents the home zone at the ground level, while the second is the top of the home zone.
Noise data is not yet included, but this tool is representative for community engagement.

Aviation Noise Forums

i. Airport and Region Forum (Forum Flughafel und Region, FFR)

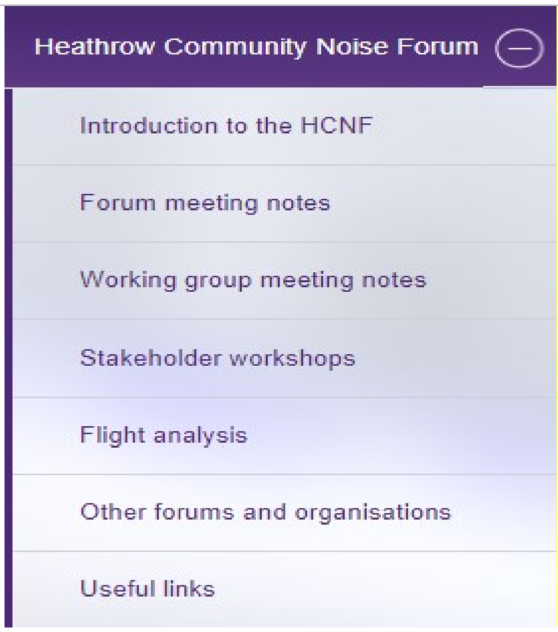
This forum was established in 2008 as a continuation of the former Regional Dialogue Forum (RDF), bringing together relevant stakeholders (aviation industry experts, muncipality representatives, relevant authorities, researchers and practitioners) to discuss noise abatement measures. The main goal of this initiative is defined around sharing and communicating information in a correct, transparent and neutral manner, while enhancing collaboration between the airport, its users and residents in the surrounding area. In this respect, the Forum is oriented on three main monitoring directions: noise, environmental and social.



Example of categories of data/information shared online
https://www.umwelthaus.org/fluglaerm/fluglaermmonitoring/

The Expert Group responsible for 'Active Noise Abatement' is actively engaged in various activities related to the identification of suitable, sustainable and ICAO compliant noise abatement measures, as well as for noise impact calculations. Criteria to be met by such measures include safety and capacity requirements, the condition that noise reduction can be achieved, technical and operational fesibility on the airport, together with the exclusion of any legal approval in advance. Examples of such measures include alternate use of runways, noise reducing departure and approach procedures, as well as financial incentives that support the use of quieter aircraft. After the implementation of any measure, comprehensive monitoring is performed for validation and mitigation of outcomes. Post-implementation monitoring results are further published online.

ii. Heathrow Community Noise Forum (HCNF)



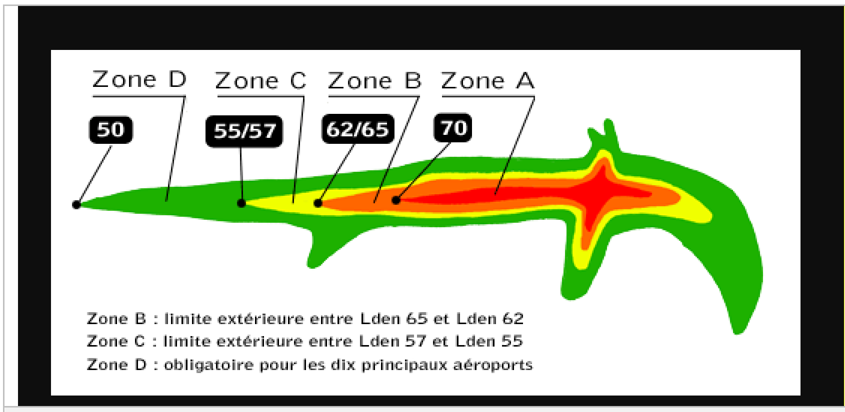
HCNF available information https://www.heathrow.com/noise/heathrow-community-noise-forum

Established in 2015, HCNF responded to local concerns regarding airspace changes established by the Governmental Airspace Modernisation Strategy which pursued the optimisation of airspace management through more efficient technology, focused on reduced carbon emissions and noise.
Relevant stakeholders include representatives from local authorities representing the areas surrounding the airport, from the Air Navigation Service Provider (NATS), from airlines (BA), from the Transportation Department (DfT), from the Civil Aviation Authority (CAA), as well as from the airport itself. Noise discussions are held on a bi-monthly basis and include community reactions resulted from airspace changes.

Aviation Noise Publications

i. The Noise Exposure Plan (PEB) and the Noise Disturbance Plan (PGS)

Based on an acoustic database, PEB and PGS are the two planning documents that have the ability to establish forecasts regarding air transport trends, which further contribute to establishing the areas that are exposed to noise. PEB development is focused on managing the effects of urbanisation, while PGS is used to specify the areas eligible for soundproofing funding.
PEB is an urban planning document establishing the necessary conditions for using the areas exposed to aircraft noise, as it is designed to limit/prohibit constructions with the purpose of avoiding an increase in the number of people exposed to noise pollution. This forecast has a 15-20 timespan and includes aerial activities, changes in air traffic procedures and infrastructure development.



PEB Example (https://www.acnusa.fr)

The PEB includes a map of 1:25000 scale and an Overview Report. The map displays the noise restriction zones. The curves are developed through the use of short, medium and long – term assumptions of traffic, also accounting for infrastructure changes such as a new runway.

The zones exposed to noise are highlighted and the extent of exposure is marked by letters from A to D, meaning: ZONE A – Very high exposure to noise; ZONE B – High exposure to noise; ZONE C – Moderate exposure to noise; ZONE D – Low exposure to noise. These are the zones in which the residents are expected to experience noise disturbance in the next 10-15 years.

A mathematical model is used to determine sound pollution, accounting for the number of aircraft movements in 24 hours, the sound emitted by each aircraft, as perceived from the ground and the differences in perception between day and night activities, where it is considered that night-time flights generate 10 times higher disturbance rather than day-time. Outcomes are depicted using Lden, where the higher is the index, the greater is the disturbance. Results include an isopsephic curve, obtained by connecting all points having the same value.

PEB is an urban planning document, to which territorial consistency plans, local urban planning plans, sector plans, conservation and optimisation plans, as well as municipal plans must be compliant with. An interactive tool that integrates available PEB can be found on https://www.geoportail.gouv.fr/donnees/plan-dexposition-au-bruit-peb.
PGS is used for establishing the zones where residents can be eligible for soundproofing funding. Such grants can be accessed only under certain conditions and in France only 12 main airports have such PGS.

PGS Example
https://www.acnusa.fr

The content of PGS includes a report and a 1:25000 scale map that depicts 3 types of zones: ZONE I – a very high noise pollution level (within the Lden 70 index curve); ZONE II – a high noise pollution level (between 70 and 65/62 Lden curves); ZONE III – a moderate noise pollution level (between 65/62 and 55 Lden index curves).

PGS map development includes an estimation of air traffic, the applicable air traffic procedures, together with the in-use infrastructure for the year following the publication of the map.
The values recommended for the Zones I, II and III (PGS) are similar to Zones A, B and C (PEB), i.e. Zone I is within the 70 Lden index curve, Zone II is between the 70/62 and 65/62/70 Lden curves and Zone III is between 65/62 and 55 Lden.

ii. Sustainability Reports – the Matrix of Materiality

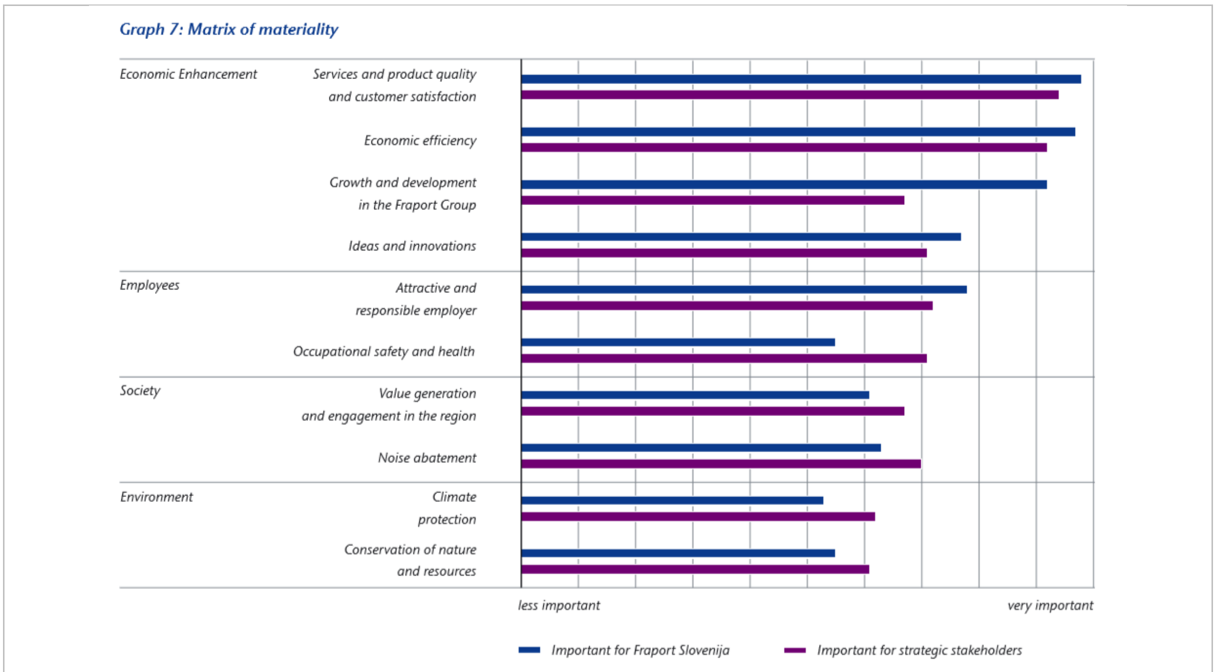
Based on regular meetings with local municipalities and recorded complaints, the airport concluded that noise is an important issue for communities, followed by local air pollution and climate change.
All initiatives originated from the implementation of the Environmental Management System in compliance with ISO 14001 requirements. Further steps led to the development of Sustainability Reports (since 2016), in compliance with GRI (Global Reporting Initiative) Standards, in order to ensure and promote Sustainable

Communication, i.e. the quality of the information, together with the transparency of processes while delivering reliable data.

The development of Sustainability Reports was focused on achieving and maintaining sustainable communication both internally and externally, such that the performance of internal day-to-day operations can be assessed against environmental impacts. Objectives established in this respect provided a definition of sustainable communication such that it could approach a planned and systematic in-house and external communication, while pursuing the principles of being proactive, honest and transparent when engaging with the public. In addition, a non-discriminatory communication style, together with providing timely responses were outlined as highly important.

Various aspects regarding the daily operations of the company are presented and described in a transparent manner, together with their implications to the overall environment, including communities. Benefits are highlighted, together with all past, current and proposed efforts to overcome negative effects that can result from such operations, including noise management. The objectives established for communication are: enhancing reputation and credibility of the company, raising awareness of the identity and benefits of the company, building trust in the company, establishing a direct relationship with the service users, based on dialogue and highlighting advantages, by positioning the company as an advanced, well-regulated and development oriented organization which intensively monitors trends in the field of aviation and cares for the needs and wishes of all users by providing them a comprehensive care.

An important approach to promoting Sustainable Communication was the use of the Matrix of Materiality. This is a tool that supports the company in identifying and managing opportunities and risks, in relation to the strategic public. The matrix contributes to an in-depth understanding of the company in terms of sustainable development, having together all relevant areas, from environmental issues to economic and wider social aspects.



The Matrix of Materiality
https://www.fraport-slovenija.si

The key areas in communication have been established by the airport through the use of GRI Guidelines and through interactive dialogue with representatives from relevant stakeholder groups. In this respect, the airport with the strategic stakeholders work continuously towards ensuring effective protection against noise.

In order to establish effective means of communication, the strategic stakeholders were clearly defined, in line with the output data from the Matrix of Materiality. Furthermore, the airport was able to establish goals according to the needs of each stakeholder, as well as methods and tools to contribute to the accomplishment of each goal.