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The Role of Communication and Engagement in Airport Noise Management

Graeme Heyes [1,*], Paul Hooper [1], Fiona Raje [1], Ian Flindell [1], Delia Dimitriu [1], Fabio Galatioto [2], Narcisa E. Burtea [3], Barbara Ohlenforst [4] and Olena Konovalova [5]

1 Ecology and Environment Research Centre, Department of Natural Sciences, Manchester Metropolitan University, Manchester M1 5GD, UK; p.d.hooper@mmu.ac.uk (P.H.); f.raje@mmu.ac.uk (F.R.); i.flindell@mmu.ac.uk (I.F.); D.Dimitriu@mmu.ac.uk (D.D.)
2 Modelling and Appraisal Unit, Connected Places Catapult, Milton Keynes MK9 1BP, UK; Fabio.galatioto@cp.catapult.org.uk
3 National Research and Development Institute for Gas Turbines COMOTI, 220D Iuliu Maniu Blvd., District 6, OP76, CP174, 061126 Bucharest, Romania; narcisa.burtea@comoti.ro
4 Royal NLR-Netherlands Aerospace Centre, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands; Barbara.Ohlenforst@nlr.nl
5 Faculty of Ecological Safety, National Aviation University, Kosmonavta Komarova ave. 1, 03058 Kiev, Ukraine; ekon@nau.edu.ua
* Correspondence: g.heyes@mmu.ac.uk

Abstract: Research suggests that non-acoustic factors can have a considerable effect on community attitudes and opinions towards aviation noise and that these can be influenced through processes of communication and engagement. This paper reviews literature from various fields to identify the key elements of effective practice, using them as a lens through which to assess case study noise management actions conducted at European airports. This analysis found that communication and engagement holds significant potential for noise management, but that this remains largely unfulfilled due to such methods being used as an ancillary management activity, rather than as a powerful tool to aid in the design and delivery of noise management actions. A series of recommendations and research priorities are proposed that could shape the future of noise management, including potential changes to European policy that more explicitly advocate for communication and engagement as a noise management tool in its own right.

Keywords: airport noise; ANIMA project; annoyance; balanced approach; communication and engagement; non-acoustic factors

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1. Introduction

1.1. Background

Air transport has shaped the world in which we live, ushering in a wide range of socio-economic benefits but at the cost of a wide range of negative environmental externalities associated with issues such as climate change, local air quality, and noise [1]. The first editorial complaint about aircraft noise was published just 8 years after the Wright brothers' maiden flight [2], and today, just 47 major European airports are responsible for exposing approximately 2.52 million people to noise of 55 dB L_{DEN} [3], a figure that can be put into perspective through a 2018 WHO recommendation that noise in areas around airports should be limited to 45 dB L_{DEN} to avoid adverse health impacts [4].

These health impacts can be significant, are increasingly well documented [4–6], and can include stress-related effects outside the hearing system that can play a key role in health outcomes, such as sleep disturbance, cardiovascular diseases, and cognitive impairment in children [7,8]. A key determinant in such factors is noise annoyance, defined as a feeling of displeasure, nuisance, disturbance, or irritation caused by a specific sound [9]. The role of annoyance is so strong that the World Health Organisation Environmental Noise

Guidelines [4] consider it as a noise-associated health outcome in its own right. This claim is supported in a major European research study into noise impact, ANIMA [8], with both reports highlighting the importance of addressing annoyance (and sleep disturbance) as the most critical outcomes of noise impact management. This is based on the understanding that "on the one hand they represent direct disturbance and irritation to residents living near airports, and on the other hand persistent annoyance and sleep disturbance have been linked to other adverse health effects through the stress mechanism" [8]).

Airports have responded via a range of noise management measures that are typically techno-centric in nature, as illustrated by the ICAO Balanced Approach [10]—a four-element approach based on "reduction of noise at source", "noise abatement procedures", "land-use planning", and "operational restrictions". However, despite decades of noise management, exemplified by the fact that aircraft have become 75% less noisy over the past 30 years [11], airports still face major opposition to activity from noise-exposed communities.

1.2. Non-Acoustic Factors and the Role of Communication and Engagement

ANIMA [7] performed a review of the academic literature surrounding the human response to noise, finding that acoustical factors explain only a part of the annoyance response to noise and that "non-noise-related characteristics of the person or environment play a crucial role in the formation and explanation of noise annoyance" [7]. Following the work of Vader [12], such non-acoustic factors were found to not only play a key role in annoyance but also to be open to influence by airports, with seven non-acoustic factors found to play a strong role in annoyance and being open to modification. The nature of these factors (e.g., attitude towards the noise source, choice in insulation, and trust) has seen the industry identify communication and engagement as key elements in the management of noise impact—see for example: Federal Aviation Authority [13,14]; Airport Cooperative Research Program [15]; Canadian Airports Council [16]; European Economic and Social Committee [17]; Eurocontrol [18]; Sustainable Aviation [19,20], 2014; and Civil Air Navigation Service Organisation (CANSO) [21,22]. Moreover, when re-visiting their four core principles of the Balanced Approach [23] in 2007, ICAO introduced the concept of a '5th Pillar'—'People issues'. This commitment was later developed further in Circular 351—Community Engagement for Aviation Environmental Management [24].

Asensio et al. [25] talked about communication and engagement as a complementary approach to traditional techno-centric approaches to noise management, due to its ability to leverage non-acoustic factors that can negatively influence community responses to noise, and by building trust amongst stakeholders, through long-term, honest, and transparent two-way communication. They concluded that the noise management can be enhanced through communication and engagement and proposed a range of recommendations that may enhance communication activity, including the provision of metrics that better reflect citizen experiences, something that has been called for previously by other authors [26]. Such claims are supported by the work of Taff et al. [27], who investigated noise from military aircraft over Sequoia National Park in the United States. Although this study was from the perspectives of visitors rather than residents in the region, the research showed that messaging about the presence of military aircraft and corresponding noise enhanced the acceptability of experienced noise by 15%. Conversely, Asensio et al. [28] have shown that resident perception of given noise management measures (in this case insulation) can also be influenced by a range of non-acoustic factors. The implication is that communication and engagement has the capacity to enhance noise management by the perceptions of noise and of noise management measures themselves.

The role of communication and engagement has also been extended to soundscape research, which is an "acoustic environment as perceived or experienced and/or under-stood by a person or people, in context" [29]. The ISO soundscape standard, ISO 12913-1:2014, has been going through a series of updates [29–31] which acknowledges the importance of the perception of users of spaces and puts this sort of thinking at the heart of community

noise management, by making community engagement a core element, through the application of new multidisciplinary approaches to noise control [32,33]. Indeed, Lavia et al. [34] described the role of engagement in informing soundscape planning practices within airport expansion projects in the United Kingdom, acknowledging the important role of non-acoustic factors, notably the 'perceived control' over noise that users are exposed to and any related abatement measures.

1.3. Aim of This Paper

This paper investigates a range of noise management initiatives conducted by European airports. It pays particular focus to the role of communication and engagement in contributing to overall community satisfaction with airport activity. Research has highlighted approaches that can, in theory, enhance the effectiveness of any public engagement activities carried out and the overall degree of community satisfaction achieved. However, in the context of aircraft noise management, there is little in the way of evidence to demonstrate the effectiveness of these approaches. In addition, there is considerable evidence that noise management practice has not resolved the issue of aircraft noise nuisance for all residents near airports. The result is continuing opposition to airport development and in many cases consuming considerable resources simply in keeping ongoing noise issues under control.

This paper makes a number of suggestions and recommendations regarding public engagement, and the subsequent evaluation of noise management initiatives which may lead to general improvements in airport–community relations. Ultimately, this may help to minimise any adverse health effects attributable to aircraft noise disturbance [4,6,35]. In line with the objectives of the H2020 ANIMA project [36], the information reported in this paper and associated deliverables [8,9,37] would be beneficial to 'emerging airports' [38] whose rapid growth may see them quickly encounter noise management challenges for the first time and who to date may have had other development priorities than noise management and associated public engagement.

1.4. Review of Communication and Engagement Best Practice Theory

The importance of communication in managing noise impact is illustrated in a range of industry guidance [14–17,20,22], and previous discussions to formally adopt 'People Issues' into the ICAO Balanced Approach legislation as a fifth pillar of noise management [7]. It refers to engagement on "any process that involves stakeholders in some form of collaborative effort directed towards a decision, which might involve future planning and/or behaviour change" [39] and the "building of relationships with people and putting those relationships to work to accomplish shared goals, i.e., involving those who are at the heart of the change we wish to see" [40]. As airport community residents can be impacted by airport noise and may influence airport activity, this suggests that effective communication may have an important role in the perceived acceptability of noise produced by airport operations activity [12].

Communication and engagement exists on a spectrum, from the simple provision of information to the more participatory levels that afford degrees of citizen power through partnerships, delegation, or control [41]. The conventional approach of many airports has been towards the information provision end of this spectrum, an approach criticised for providing information in ways that are incomprehensible to non-experts and that could even exacerbate annoyance as a result [7,27,42]. Such approaches, in the context of the role played by non-acoustic factors in noise annoyance [8,43,44], suggests that airports may benefit from more extensive and participatory engagement approaches that are able to positively influence non-acoustic factors directly.

Academic reviews of good practice in communication and engagement can be traced to the idea of public participation and the 'public sphere', first used by German philosopher Jürgen Habermas (1962). Today, a range of established definitions of the components of public participation are available [45–49], including Hanchey's [50] identification of three

principal objectives of public participation, and seven second-order objectives (Figure 1), which emphasise not only the importance of the distribution of information but also the potential for promoting community acceptance and diffusing conflict—these appear to be key requirements of airport communication.

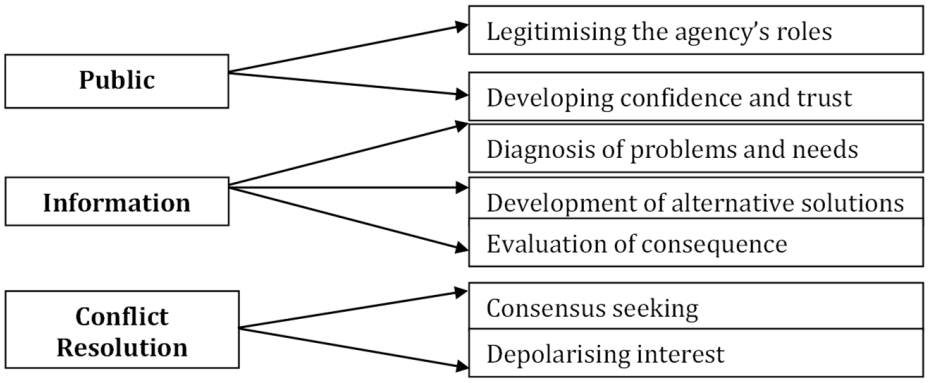

Figure 1. Objectives of public participation [50].

Effective public participation has the potential to facilitate greater organisational transparency and develop community trust in, and an understanding of, organisation activity. This offers the potential to reduce stakeholder–business conflict and can lead to "increasing the likelihood that environmental decisions are perceived to be holistic and fair, accounting for a diversity of values and needs, whilst recognising the complexity of human–environmental interactions" [48]. The concept lends itself to what Webler [51] termed 'social-learning', which takes place when the conditions of 'ideal speech', as illustrated in Table 1 below, allow the public to unite to solve a shared problem.

Table 1. Conditions for fair and competent ideal speech situation [51].

Fairness	Competence
Anyone may participate	Access the knowledge
Assert validity claims	Consensually approved translation scheme
Challenge validity claims	Most reliable methodological techniques available
Influence final determinations of validity	Minimal standards for cognitive and lingual competence

The relevance of airport community engagement is clear, particularly in cases where one community stands to suffer from increased noise for the benefit of another. This also has parallels with the modifiable non-acoustic factors of having a voice or influence over an issue. This is only possible if opportunities for genuine two-way communication are provided, and seen to be provided, to influence the behaviour of the noise source, leading to decisions that are perceived to be fairer [42].

Importantly, Webler suggests that social-learning can lead to cognitive enhancement ("the acquisition of knowledge") and moral development ("the reservation of personal and selfish requests in favour of actions which benefit society as a whole") [52], so that "equality and popular sovereignty can emerge, and personal competence can develop" [51]. It seems important that ideas of fairness and competence are considered in the totality of the airport noise problem to gain public understanding and reduce resistance. This could for example be done by increasing awareness of the socio-economic benefits provided to airport regions as a result of air traffic movement and the role of environmental interdependencies which may be impacted by, for example, flight paths designed to avoid overflying communities but at the cost of increased emissions. The implication is that if participation is to be secured and meaningful (and thus likely to influence attributes such as attitudes and perceptions of

fairness and trust) then communication and engagement should not only relate to noise but also to the wider aspects of airport operations.

This indicates a prominent role for communication, engagement, and public participation in an airport's ability to obtain a licence to operate from noise-affected communities, and that [7]:

- Where possible, communication should be underpinned by a 'common language' that is comprehensible to all.
- Access to unbiased and independent expertise should be available to all.
- Decision-making processes should be inclusive and transparent and should allow the validity of claims to be challenged through two-way dialogues, even if it is not possible to satisfy every stakeholder's wishes and aspirations.

The theory described above is consistent with emerging approaches in the science communication literature. Interestingly, this field of research shares many similarities with airports seeing as it represents a group of 'experts' (scientists/airports) looking to engage with public stakeholders through the dissemination of data on often complex issues. The trend in this academic community has been an evolution from a 'public understanding of science' (PUS) model, to a 'public engagement with science and technology (PEST)' model. In essence, this has seen a shift from "increasing publics' knowledge of scientific content and processes" through "the transmission of scientific knowledge from the scientific community to individuals in society" [53] to a model in which "focus should be on the valuable perspectives and knowledge publics bring from their lives that enhance the discussions of science and issues of science-related societal issues". This shift is illustrated in Table 2 below.

Table 2. The evolution of communication and engagement theory towards a system of public engagement.

	Public Understanding of Science Model	**Public Engagement with Science and Technology Model**
Aim	To increase public appreciation for science by telling people more about science.	To stimulate and inform discussion and to increase public awareness of scientific knowledge.
Ownership	Scientific output is owned by the scientific community.	Scientific output is owned by society.
Methods	One-way—tells people about science.	Two-way—encourages feedback and discussion to both test and contribute to enhanced understanding on all sides.
Scope	Narrow—considers issues only within the scientific paradigm. Traditionally quantitative.	Broad—considers science issues within various social contexts and allows values and feelings to be included, i.e., qualitative.
Starting position	Science is expert—people just need to understand and accept their wisdom.	Open minded—different parties come with different views towards reaching consensus.
Impact and subsequent evaluation	A secondary concern. Evaluation rarely considered.	A primary concern. Objectives of activities outlined from the start. Evaluation considered throughout.

In terms of public participation, guidance exists at a general level and with regard to specific contexts, notably with regard to environmental management and sustainability [48,54,55], as outlined below:

- Best practice is a process: Effective noise management is a process from understanding the need for an intervention, designing intervention options, selecting and implementing the change, and evaluating impact [41,56]. Each phase may require specific interactions with communities to understand their needs, preferences, fears, and so on.
- Each airport needs its own approach: The significant differences in the characteristics and specific challenges between airports and their different surrounding communities

means that the structure and associated methods of public participation should be tailored to the characteristics of each airport and their own definitions of success.

- Participation should be based on concepts of empowerment, trust, and learning: Participation and engagement without these factors is less likely to lead to socially optimal outcomes.
- All stakeholders should be identified, empathised with, and represented in dialogues: All stakeholders may have expert knowledge that can inform dialogues. They should be empowered to question the inputs of others, thus levelling hierarchies. Engaging with all stakeholders ensures that no voices are left out and disenfranchised from the process. Effective stakeholder mapping with empathy building ensures that the needs of all different users can be taken into account when decisions are made, whilst also supporting ongoing assessment and evaluation.
- Dialogues may be best led by an independent expert facilitator: High-level public participation is not an easy task. It can involve having difficult conversations with conflicting voices and requiring a long time for appropriate levels of trust to be established. Expert and fully independent facilitation can help to ensure the success of any interactions that take place.
- Early engagement fosters enhanced legitimacy: It is possible to help circumvent many of the difficulties of public participation by engaging with stakeholders at an early stage in the decision-making process and ideally by doing so before the need for a noise management intervention has been realised. This should ensure a co-created process that increases the opportunities for buy-in and outcomes agreeable to all parties.
- The impacts of any decisions made through participation should be evaluated post-hoc: The success or effectiveness of a participation or a proceeding decision cannot be determined without evaluation. In the context of airport noise, evaluation based solely on objective (acoustic) metrics cannot be relied upon as any kind of assessment of human impact, which often depends as much or as more on non-acoustic factors as on acoustic metrics. Evaluation should be against targeted outcomes, towards achieving an overarching vision, and where possible, agreed to by all stakeholders.

Such guidance can be helpful in understanding the broad requirements of effective public participation. In addition, appreciation that guidance from different sources has similar content suggests that the application of such frameworks to airport noise management may be possible. However, the air transport industry is complex: it comprises a number of stakeholders and involves a range of sensitive issues such as safety, security, operational feasibility, and environmental interdependencies that make the decision-making process complicated and necessitate a high level of comprehension in order to be effective. This complexity suggests that these recommendations, as well as the rest of the theory presented in this paper, need to be investigated in terms of their appropriateness for use in noise management so that an evidence base can be established, best practices can be identified, and appropriate guidance produced.

This paper aims to begin this discussion and facilitate new phases of research to address such issues through an assessment of existing communication and engagement activities undertaken by airports, in light of the theoretical best practices outlined above. In so doing, the paper highlights and comments on the extent to which the industry is using communication and engagement as a noise management tool and the manner in which it does so, and it discusses the nuances of transposing theory to practice. Section 2 describes the methodology followed in the work, with the results obtained found in Section 3. Section 4 presents a discussion of the findings, before Section 5 makes recommendations and summarises the most important conclusions.

2. Materials and Methods

2.1. Research Design

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 a review of the literature [57–60], within the ANIMA Project, a decision was made to pursue a case-study approach as the primary research methodology.

Case-study research is considered to be 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" [61]. Case-study research is an accepted and valid method within the field of organisational research [62], as it can facilitate the building of theories, the development of concepts, the drawing of specific implications, and contribute with rich insights to support, or counter, existing material within the literature [57]. Additionally, this approach empowers the researcher to use a combination of several different data collection methods, both quantitative and qualitative in nature [58].

The research focuses on a narrow set of 'exemplar' case studies, based on rich qualitative data, rather than a quantitative analysis across a broader number of cases. Such an approach is important because, as acknowledged in an ANIMA deliverable [42], all airports have different political, economic, environmental, and cultural contexts that can influence which noise management actions may have been considered most appropriate in a given setting. This means that approaches taken by different airports are likely to differ on a case-by-case basis, and that this may not reflect different levels of good practice against some absolute scale but may rather represent the most appropriate practice for each specific airport based on their current operating environment and internal capacity to develop effective noise management strategies, bearing always in mind that different approaches often meet with different degrees of success.

For each case, a review of publicly available documentation regarding each airport and its case intervention took place, followed by in-depth semi-structured interviews with airport representatives to understand in greater detail the different approaches taken in the implementation of each intervention. The interviews conducted were facilitated by local members of the research team to reflect local expertise and to avoid language difficulties. Doing so empowered the researchers to develop their own questions relevant to each specific case study and the airports to mention specific topics that seemed interesting to them; however, guidance on the key aspects of each case to be investigated were outlined in advance to aid consistency in the development of the specific interview protocols. Such protocols were focused on the 'processes' behind the implementation of a given intervention:

- Identification of the need or opportunity for the intervention.
- The design of different intervention options.
- The selection of the chosen intervention.
- Its implementation.
- The extent of any post-implementation evaluation.

2.2. Case Selection

The selection of airport case studies was a combination of ANIMA project partners, researcher contacts, and a desire to select airports of different sizes and from across Europe. The case-study airports, their size [37], and the specific interventions studied are listed below:

- *Barcelona El Prat (Spain; approx. 269,656 annual aircraft movements):* Focused on an operational procedure related to the switching role of each runway during the day and a new flight configuration during the night. The study provided insight into a new Commission for Environmental Monitoring of the Airport Expansion Works (CSAAB), which aims to monitor and control compliance with the preventive and corrective measures developed during the construction and operation phase of Barcelona Airport's expansion.
- *Catania (Italy; approx. 56,055 annual aircraft movements):* A land-use focused case study, based on legislation regarding a noise zoning system approach and a land-use

planning acoustic classification plan by Catania Council, based on noise maps and airport inputs, approved in 2013.

- *Cluj-Napoca Avram Iancu (Romania; approx. 24,450 annual aircraft movements):* Cluj-Napoca Airport is undergoing major development in anticipation of future growth, with a new runway being built in phases to handle larger aircraft. This case study looked at the use of preferential runways and night-time restrictions at the airport to avoid flying over Cluj city centre and acts as a useful case study to inform both on the implementation of operating restrictions and noise-abatement operational procedures.
- *Frankfurt (Germany; approx. 513,912 annual aircraft movements):* The Frankfurt case study discusses the interventions and measures taken by Frankfurt airport with respect to land-use planning. Following expansion between 1997–2011, Frankfurt airport now provides an example of how German airports operate for the construction or expansion of airports, implications for spatial planning, and how environmental concerns (especially noise) are taken into consideration.
- *London Heathrow (UK; approx. 476,000 annual aircraft movements):* 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 proposed 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; approx. 295,659 annual aircraft movements):* 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, this case also required changes to airspace—thus representing a useful case through which operational procedures can be investigated.
- *Iasi (Romania; approx. 12,749 annual aircraft movements):* This land-use planning case study looked at understanding 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.
- *Kiev (Ukraine; approx. 107,000 annual aircraft movements):* This case study provides an overview of the previous, current, and proposed aircraft noise management practices of Boryspil International Airport (Kiev), as a part of their development of noise protection zones, under the Aerodrome Certification requirements.
- *Ljubljana (Slovenia; approx. 34,444 annual aircraft movements):* This case study provides an overview of the previous, current, and proposed practices of Ljubljana Airport, in line with their strategy for managing aircraft noise, included within periodic sustainability reports.
- *Amsterdam Schiphol (The Netherlands; approx. 499,446 annual aircraft movements):* This case study looks at the implementation of a noise-abatement operational procedure to provide noise relief to communities around Schiphol Airport from both arriving and departing aircraft. This is an interesting case from an environmental interdependencies perspective, in that it was anticipated that this change would deliver fuel savings for airlines.
- *Stockholm-Arlanda (Sweden; approx. 240,000 annual aircraft movements):* This case study discusses the implications of a proposed curved approach to reduce noise impact in response to opening an additional runway at Stockholm Arlanda International Airport. The case study also discusses the impact of community engagement by airport authorities.
- *Vienna (Austria; approx. 240,000 annual aircraft movements):* 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.

Case-study management actions at each airport were selected through discussions with airport noise management representatives who were asked for examples of what they saw as best practice. As such, the cases studied provide an insight into management awareness of noise management issues and best practices—not least the potential role of communication and engagement in modifying certain non-acoustic factors. Full reports of the individual case studies and research data can be found in findings from the ANIMA project [41].

3. Results

On reviewing the case studies, a number of key findings and implications for airport noise management and associated community engagement became clear and are presented in this section. Due to the number of disparate case studies and the different kinds of data collected, detailed results of each are not listed here. Instead, we present the key findings and core messages from their analysis and most representative airports.

3.1. Nature of Stakeholder Engagement

The majority of cases included at least some form of engagement, typically through consultation events between the airport and its stakeholders. In all cases, the airport took the dominant role as the 'expert', being the lead actor in determining what data were pertinent, how they were collected (via monitoring or modelling), and their subsequent dissemination.

The only significant deviations from this approach were at Heathrow, Vienna, Frankfurt, and Arlanda. At Heathrow, the airport was responding to specific concerns from a community about the altitude of aircraft; thus, a wide range of information was provided specifically to address issues and concerns raised by residents. Information was presented at a consultation event; however, no official public report was made available. Although the data provided were in response to specific community needs, it was aviation stakeholders who determined which information was relevant, which should be collected, and how it should be presented. The case study focused on reducing noise outcomes as described through noise exposure, and therefore, it is perhaps no surprise that non-acoustic factors were not reported or seen to be contributing to decision making, other than the initial response to community suggestions. That said, there were no attempts to evaluate any impact on non-acoustic factors or indeed the extent to which airport efforts allayed the original community concerns, as a result of airport interventions.

At Vienna, the airport was also responding to a specific community claim and provided information and conducted trials based on these concerns, as well as considering necessary technical and safety specifications. The 'Vienna Dialogue Forum' acted (and continues to do so) as a means through which the airport could regularly communicate with its stakeholders and through which communities represented could input into decision-making processes, although it is unclear to what extent the deliberations of the dialogue forum achieves any wider penetration into the community as a whole.

At Frankfurt, the Airport and Region Forum, established in 2008, performs a similar function to the Vienna Dialogue Forum, acting as an independent forum where the airport at least attempts to engage not as the 'expert' but merely as another stakeholder. Notably, the Forum's Board of Directors comprises three members—an independent expert, an airport representative, and a representative of towns and cities, ensuring that both the airport and the regions have equal representation at this level. The Forum had significant success in 2011 with the launch of the NORAH Noise Impact Study ("Noise-Related Annoyance, Cognition, and Health") [63]. Similar schemes were found at other airports, for example the 'Noise Technical Working Group' at Barcelona.

At Arlanda, a 'Virtual Community Noise Simulator' was used to help community members experience the noise situation of future flight path changes virtually. By using a post-use questionnaire, perceived differences in the flight path changes were assessed; however, the aim of the assessment was primarily to understand if the public could perceive

changes in glide approach angle, rather than considering the value, acceptability, etc., of the proposed changes. Communities engaged were informed about different glide slope angles, and a joint decision was made about the location of the new flight procedure, demonstrating that community views were taken into consideration based on what was considered to be technically feasible.

Overall, airports mainly focussed on technical noise metrics to describe the 'what' of a noise situation. To describe the 'why', consultation events with airport stakeholders tended to be used to explain the situation to small numbers of interested people. The latter should, at least in theory, help to move participant interactions with the airport towards higher levels of engagement, thereby potentially helping to positively modify perspectives on the noise source and the interventions themselves. Nevertheless, there was also no attempt to systematically evaluate the impact of the studied interventions from this perspective, for instance by speaking to residents to determine the impact of the intervention on their day-to-day lives, if their attitude to the noise source had changed, or if they believed they had been treated fairly.

3.2. Access to Expertise

In terms of access to expertise, Vienna utilises an independent employee of the National Air Navigation Service Provider Austro Control. This representative attends 'Dialogue Forum' meetings to provide an independent overview on all technical data presented, no matter the origin, with the objective of raising both transparency and trust in the data, whilst also acting as a means through which the data can be challenged. A similar approach was taken at Heathrow, where external consultancy was used to collect and disseminate the data. Generally, the cases showed that the airport and its industry partners were the primary owners of data and took the role of the expert voice in communication activities. It should be noted that it is not clear to what extent participants in engagement meetings and consultations who are direct employees of stakeholder institutions and organisations can ever be perceived as being truly 'impartial and independent'. It is however unlikely that any completely independent and disinterested 'expert' would be interested to participate in any such engagement without being paid for their time. There is an obvious difference between participants to stakeholder engagement events who do so on a voluntary basis and participants who do so as part of their regular employment, and no obvious solutions to any difficulties that may ensue.

3.3. Transparency and Inclusivity in the Decision-Making Process

The processes embedded in the 'Vienna Dialogue Forum' enabled a level of transparency in the decision-making process, as reported by interviewed airport participants. All members in the forum are empowered to engage in discussions, even if they are not directly impacted by a particular intervention. At Heathrow, a level of inclusivity can be garnered from the fact that it was residents' concerns about lower-flying aircraft over their community that was the impetus for the intervention and subsequent communication of trial data. This implies some level of two-way dialogue, and the lengths gone to by the airport to disseminate data through varied means and via an external agency suggest that transparency and inclusivity in the data was significant. However, interviews with operational and noise managers highlighted that community members still did not trust the data provided and found it hard to understand more technical information relating to the feasibility of different departure procedures. To at least some extent, this may be because airport stakeholders may in some cases be keen to avoid discussion of economic constraints or technical feasibility, whereby, for example, departure climb profiles are considerably affected by aircraft take-off weight which is affected both by aircraft loading and the amount of fuel carried. As previously mentioned, Frankfurt provides a further example of transparency and inclusivity in decision making, seeing as the Airport Regional Forum is 'independently' led and that community groups are represented at the highest level of the Forum's Board of Directors. Within the Forum, the 'Environment and Neighbourhood

House' acts as an observer of developments in the region, and an impartial information service provider and a mediator between conflicting parties. A central task of the group is to carry out independent aircraft noise measurements and to make the results available to the public. To this end, it has its own network of nine fixed and two mobile monitoring stations which are managed independently of the airport's 29 stations.

3.4. Use of a Common and Comprehensible Language

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. In the case of Iasi Airport, stakeholders' meetings supported the change of National legislative provisions regarding aircraft noise, to ensure their clarification and completion, while encouraging land-use planning.

Comparing alternative what-if scenarios was a common purpose for noise data collection and dissemination. At Helsinki, for example, noise data were used to ascertain the impacts of different operating procedures (alternative departure procedures). At Arlanda, noise data were used to investigate the impacts of implementing steeper arrival glide slopes. At Vienna and Schiphol, a curved approach and amendments to a noise-abatement departure profile used were investigated respectively.

The Heathrow, Vienna, and Frankfurt cases represent cases where noise data were not only used to investigate potential noise exposure outcomes of different operating procedures but also to inform significant community engagement with local community action groups, with an untested assumption that this would lead to better citizen engagement.

In terms of the amount of information provided, Heathrow, Frankfurt, and Vienna produced a significant amount of noise data relevant to each specific case, with both basing their data acquisition on resident concerns—with Vienna and Frankfurt going as far as performing additional monitoring of trial data based on specific resident requests. Heathrow presented their noise data via a consultation event in the affected community that raised the idea for the work but nowhere else. The data presented were detailed and pertinent without being onerous; however, they were not made available online after the event. At Vienna, the data regarding the implementation of a curved approach to avoid overflying a community were disseminated at 'Forum events', and noise data are published more generally in quarterly and annual reporting. The airport acknowledged the importance of only providing pertinent information (for instance, not overloading reports with technical information) by recently reducing the size of annual reporting from 133 pages in 2016 [64] to just 32 in 2018 [65].

3.5. Two-Way Dialogues

Only Vienna Airport was using a system that could be described as being truly two-way, with assumed to be 'equal' levels of hierarchy and expertise between different stakeholders and where all participants had a voice. This was made possible through the establishment and ongoing commitment to a 'Dialogue Forum' and is being driven by a vision agreed by all stakeholders, which acknowledged noise as a challenge for the airport to address, but also the vital role of the airport to the regional economy. A similar approach was taken at Frankfurt through their own noise forum, suggesting that there was an opportunity for citizen representation at the highest level, facilitated by two-way

dialogues. Some level of two-way dialogue was found at Heathrow in that the operational change was raised by citizens and addressed by the airport, but dialogues that took place saw the airport retain its perspective as the data owner and expert in the dialogue. At best, the airport could be described as responding to citizen requests, rather than engaging in a thorough process of ongoing dialogue.

Although other cases illustrated some consideration of two-way dialogues, they focused more on a request-data provision level rather than genuine two-way discussions in which hierarchies were levelled and through which genuine two-way discussions could take place.

3.6. Evaluation of Non-Acoustic Factors

As previously stated, there were no attempts to directly influence non-acoustic factors in the studied interventions, other than any effects of the engagement activities that were carried out, nor any attempt to systematically evaluate the impact, processes, and outcomes from a non-acoustic perspective. Nor was there any evidence of pre- or post- evaluation regarding such factors. Noise management interventions appear to be well informed by quantitative data, the vast experience of noise managers, and the collective expertise of the wider industry (i.e., through guidance such as the Balanced Approach). However, there was no systematic implementation of noise management interventions following a prescribed process with targeted outcomes established from the onset that could later be evaluated in terms of their effectiveness. The only significant exception relates to some basic principles underpinning activity in the 'Vienna Dialogue Forum', and some cases of standardised processes of dialogue between the airport and industry stakeholders regarding issues such as safety. The assessment of the success or otherwise of each intervention success was based purely on acoustic factors, other than noise-related complaints from communities.

4. Discussion

This paper looked at some of the theory surrounding communication and engagement and through this lens assessed how case study airports in Europe use communicative tools to enhance noise management, either as management interventions in their own right or as aspects of other noise management interventions, such as those defined by the ICAO Balanced Approach. The literature implies that communication and engagement has the potential to enhance the acceptability or effectiveness of management interventions; however, the cases explored in this paper suggest that communication and engagement activities are not implemented consistently, and when they are used, they are not executed with the same rigour as attempts to address acoustic factors. In essence, they are seen as ancillary management activities, rather than as management interventions in their own right. Noise managers increasingly understand the human reaction to noise and the role of non-acoustic factors. Addressing non-acoustic factors is however complicated and with many unknowns. This, as well as external pressure for absolute reductions in noise, has meant that the majority of noise management actions focus on addressing acoustic factors. This is perhaps understandable; however, doing so has not always been successful. This is exemplified by the fact that noise (as measured through metrics such as noise level equivalents) has remained stable or fallen at many airports, yet reported levels of annoyance, whenever these have been measured in quantitative surveys, have shown an upwards trend.

There is no shortage of guidance which details the importance of communication and engagement as a noise management tool. As a result, airports are beginning to acknowledge the importance of stakeholder engagement, as demonstrated by an increasingly mature noise management portfolio, in which communication and engagement is taking an increasingly prominent place—as exemplified by dialogue forums, consultation processes, and published noise action plans. Such guidance does not provide any sort of detailed support to guide airports in how to actually develop and implement communication campaigns that are suitable for the particular characteristics of different noise management

challenges, and the different stages of their development and delivery. Early engagement can, for example, help to better define noise management problems, helping to inform on the design of the interventions, any desired outcomes, and how outcomes, be they intended or unintended, can be evaluated. Failure to do this can lead to noise problems being inaccurately defined and potentially result in sub-optimal outcomes.

To increase the likelihood of noise management interventions being successful, it seems important that airports engage with citizens more effectively, throughout the entire process of developing and delivering an intervention. Research conducted in the ANIMA project [41] suggested that such a process could take airports from the identification of the need for change, through the design of appropriate interventions, the selection of the most appropriate option, its implementation, and its continued and ongoing evaluation. Similar processes are advocated for in the wider field of design and have been advocated for in regard to noise management previously [66], including through national guidance [67,68]. By engaging with stakeholders throughout this process, airports can ensure noise challenges are effectively understood and articulated, and that interventions that aim to address them can be developed and implemented in ways that are more likely to be deemed acceptable by all stakeholders. In short, the effectiveness of noise management interventions (including defining what effectiveness looks like) can potentially be enhanced when the need for interventions, their development, and their targeted outcomes are discussed and agreed with by their recipient communities. Importantly, incorporating resident perspectives in this way can also help to residents to feel empowered and with some sense of control over the noise that they are exposed to, which can further help to address perceptions of both the noise source and the management measure itself [25,32]. As such, the present authors believe that communication and engagement sits across all Balanced Approach interventions, as well as being a potential intervention in its own right, and that it should be considered throughout the process of developing and delivering noise management interventions (see Figure 2).

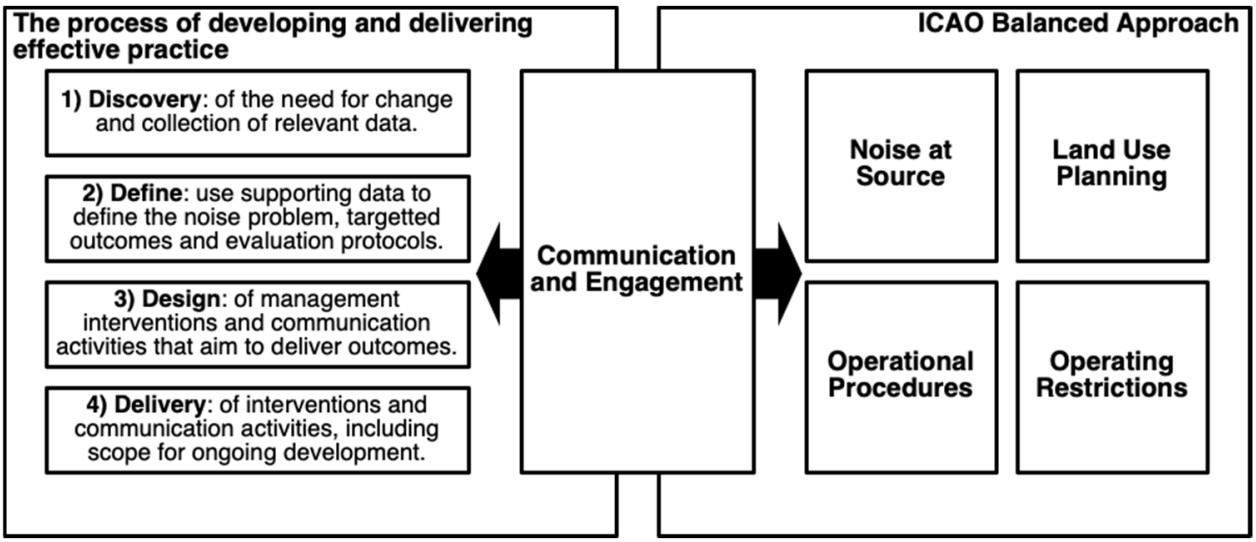

Figure 2. Illustrating the potential role of communication and engagement in airport noise management.

Embedding resident perspectives into management processes has synergies with the field of 'human-centred design', (the consideration of end-user needs, fears, and beliefs and in the development of services aimed to benefit them), and 'design innovation' which borrows elements from traditional design practices, including the use of iterative design and prototyping, holistic-systems thinking, and a multi-disciplinary approach to build empathy for end-users and to enhance the likelihood that products and services are more likely to be successfully adopted by them. This sort of human-centred thinking has

synergies in the material presented in Table 2 and adapted in Table 3, to demonstrate what effective noise management practice regarding communication and engagement might look like.

Table 3. Requirements for airport communication and engagement over time (authors own).

	Existing Practice	Suggested Practice
Aim	Present stakeholders 'what' is happening or has happened, or consult regarding a set of pre-determined interventions.	Consider explaining stakeholders 'why' things are happening and obtain their input to inform decisions that have not yet been taken. Aim to increase competence and produce fair outcomes.
Ownership	Important data and knowledge identified and owned by industry.	Residents are the experts on what it is like to live in noise-exposed areas and so have valuable information to contribute as to how the noise situation could evolve.
Methods	One-way (airport -> resident)	Two-way (airport <-> resident)
Scope	Narrow—communicated and managed through traditional and complicated technical noise metrics.	Wide—human-centric thinking that considers qualitative non-acoustic factors.
Starting position	Industry is the expert. Quantitative data used to make decisions and to communicate to stakeholders. Industry decides which information to release and which information to withhold.	Stakeholders have their own expertise and perspectives. This includes the 'vocal minority' which objects to airport noise, and the 'silent majority' which does not complain. A consensus is more likely to be reached through understanding input from all voices.
Impact and subsequent evaluation	Little evaluation beyond those measured by noise metrics that are often confusing and meaningless to community members. Communication and engagement activities take place with no stated objective.	Any intervention should have targeted outcomes and evaluation protocols established from the onset so as to evidence impact.

The complexities of noise management and the wide range of community voices who have different perspectives on noise mean that achieving the design of noise management interventions that are roundly accepted by all can be challenging. However, the very act of speaking and listening to such stakeholders—acknowledging and showing empathy to their concerns, and engaging them in open and two-way dialogues, can often help to foster a feeling of inclusion that is towards the higher levels of public participation. This approach may help airports to encourage feelings of control, trust, and understanding in airport activity—that is, directly addressing a number of non-acoustic factors by following the cognitive enhancement and moral development principles that define the concept of 'social learning'. This suggests that airports do not necessarily need to seek complete citizen control of their operations for effective stakeholder buy-in but can accomplish similar levels of acceptance by listening to residents, developing empathy for them, and building management strategies that are sensitive to their needs and wants.

Borrowing the terminology of human-centred design, we believe that noise management interventions need to be:

- Technically viable (i.e., in terms of complex factors such as aircraft performance, safety, security, environmental interdependencies, and legislative compliance),
- Economically feasible (in terms of airport resources and returns on investment), and
- Desirable (to stakeholders—including residents and including non-noise environmental interdependencies).

Communication and engagement plays a key role in each of these elements, and airports tend to do a good job when seeking to understand the technical and economic viability and feasibility of interventions. Effective communication and engagement with

residents provides the opportunity for the social and environmental desirability of interventions to also be enhanced and is an approach embedded in design thinking, an approach advocated for use with regard to noise management previously [38].

That said, we acknowledge that noise management is a complex area, and we do not yet have all the answers as to the practical implications of more considered communication approaches by airports. Hence, we call for more research in this field that looks to further extend theory into practice, for instance by:

- Developing a flexible, human-centred intervention development process in which the possible role of enhanced communication and engagement with stakeholders takes a higher priority than hitherto.
- Understanding the effectiveness of communication campaigns to address noise impact and the acceptability of noise.
- Identifying more effective methods for canvasing community perspectives on noise.
- Developing a better understanding of non-acoustic factors, notably, identifying the causal chains and pathways through which non-acoustic factors can be modified, which factors may represent 'first-order' or priority factors, and how such factors can be evaluated.
- Considering if and how airports should engage with vocal minority and silent majority groups differently, including how to capture the voices of those who may not wish to engage with the airport but may still desire for noise management action to be taken.
- Understanding how holistic dialogues surrounding the environmental interdependencies linked to noise management can also be addressed in communication campaigns.
- Identifying how changing perspectives of residents be measured over time, perhaps leveraging big data and digital technology solutions.

5. Conclusions

Noise is major strategic and operational challenge for many airports. Research suggests that non-acoustic factors play a key role in the human response to noise; that such factors can have a marked impact on the perception of noise and the acceptability of airport operations, including actions taken by the airport to reduce noise exposure; and that communication and engagement can play an important role in noise management by directly influencing such factors.

This paper reviewed some of the theory surrounding effective communication and engagement and through this lens assessed a number of case-study noise management interventions from across Europe, finding that, in general, airports do not yet see communicative tools and processes as specific noise management interventions in their own right or as important ancillary aspects of other management interventions.

Reported noise annoyance and complaints around airports have not fallen in a manner commensurate with reductions in noise exposure at many airports. Airports may be able to enhance the quality of noise management by considering communication and engagement opportunities at all stages in the development and delivery of noise management actions and strategies so that stakeholder needs, opinions, and fears can be understood and addressed—either through further communication and engagement or through changes to noise management actions.

We, the authors, call for airports to better engage with their communities and recommend that this requirement is integrated into Regulation (EU) 598/2014, with thorough guidance also provided by the industry to help airports understand how and when to effectively engage with their communities and what successfully evaluated communication activities look like.

It should, however, always be considered that effective noise management almost invariably requires compromise between competing priorities such that it may be impossible to satisfy every possible conflicting stakeholder point of view. This means that nothing less than the 'best' compromise solutions should be accepted simply because of a lack of knowledge or insufficient investment in proper procedures, and one of the main

objectives of this work has been to encourage effective evaluation as an integral component of discovery, definition, design, and delivery as best practice for the future.

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