Overall Perspectives

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Abstract This section sums up the main findings from ANIMA and from associated projects related to aviation noise in order to deliver some key messages for policy-makers. These messages intend both to orient future research and to propose some concrete way to implement measures that could alleviate the noise burden endured by airports' neighbouring communities. The final table gives an even more synthetic view of these messages, the institutions they target, their objectives and the best ways that are likely to support them.

Keywords Aircraft noise · Aviation noise · Noise regulations · Annoyance · Airport communities

The world that we used to know has been increasingly shaped by a worldwide phenomenon named globalisation. For more than fifty years, globalisation has pushed our societies in a direction seen by most of the people as a progress: Interweaving of nations, economies and the exchange of goods and services have been deemed the most efficient way to increase nations' wealth and to repel the prospect of confrontations by the advent of a kind of global culture.

Transport has been and is at the heart of such a conception, privileging flows over stocks. And aviation at large has largely accompanied this trend and benefited from it. Fifty years ago, aviation was for the upper class in the Western hemisphere and for elites only elsewhere. Nowadays, even if it implies only a few percents of the world population, it has become a mass transportation. Certainly, this way of life, which spread over the world, was criticised by some groups that were marginal at the beginning. But such criticisms taking ground on the increasing economic, sociological and environmental disequilibria became audible if not dominant, despite the secondary impact of aviation on both noise and pollution as constantly evidenced by the successive European

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Environmental Reports.¹ They ultimately led to some frontal opposition such as the “flight shame” movement pinpointing the very question of the social usefulness of air transport.

The recent COVID pandemic—which is more a systemic consequence of globalisation than a regrettable accident—gives the opportunity for an in-depth revision of the air transport system and for its possible reboot on a more sustainable basis. The aviation noise issue must be now considered in this prospect and lessons learnt from ANIMA and other past European research projects could be usefully taken into account. What are these lessons and what are recommendations stemming from them?

Lesson One—Aircraft Noise Is Not Aviation Noise

So far, most of the efforts have been put on the reduction of noise at source, i.e. on aircraft noise. Associated research is certainly much needed but not directly for relieving the quality of life of people impacted by aviation noise. **Actually, if the European Union must maintain its support of aircraft noise research, it is for the sake of competitiveness.** As recalled by the European Commission itself, aeronautics is one of the EU’s key high-tech sectors on the global market, providing more than 500,000 jobs and generating a turnover of close to €180 billion euros in 2019. If the EU is a world leader in the production of civil aircraft, including helicopters, aircraft engines, parts and components, other global players constantly challenge it and low aircraft noise is a key commercial argument, especially with respect to the more and more stringent associated regulations. **Therefore, research aiming at reducing the noise at source is always needed.**

Recommendation: Member States—especially those with an aircraft industry—as well as the European Commission should maintain a significant level of financial support on research intending to lower aircraft noise for the competitiveness and the leadership of the European industry.

Lesson two—As for Technology, Research On Aircraft Noise Must Favour Disruptive Concepts

Many past research projects addressed specific noise sources such as—for instance—“airframe noise”, “jet noise”, “turbofan noise”. A decade ago, outcomes of such projects led at low Technology Readiness Levels (TRL) were progressively embarked

¹ Non-road transports are responsible of only 1.7% of particle matters under 10µm, 2.9% of particle matters under 2.5µm, 7.3% of the nitrogen oxide; International aviation is responsible of 3.4% of all greenhouse gas in transport; number of people affected by aviation noise in Europe is below 3 millions, 19 millions for rail transport, 76 millions for road transport

in some demonstration platforms through some large projects such as Silencer, Openair or, more recently, CleanSky. A few years ago, the European Commission fortunately decided to support again low TRL research on aircraft noise to keep on favouring the competitiveness of the European industry. **It is recommended to orient as far as possible these low TRL research toward disruptive concepts.** This recommendation takes ground on the one hand on the fact that incremental progresses on noise sources are going to saturate. There is still margin for progress but roadmaps maintained in ANIMA and through the former X-Noise networks give reasonable assessment for such margins which are limited. Recently launched projects are for instance intending to gain no more than 0.5 to 2 dB at the utmost for new concepts of landing gears or high-lift devices studied at low TRL. If ever integrated on an actual aircraft with all its operational constraints, figures could be even lower. This recommendation for disruptive concepts also takes ground on the great deal of uncertainties about what will be the future of aviation. Energetic consideration, other environmental concerns such as noise but also societal evolutions such as the already mentioned “flight shame” may dismiss traditional long-haul/mid-haul airliners based on regional hubs saturated with an overloaded demand in resources. The recent stop in producing A380—a blatant success for the European technology that was once considered as a market game changer—is very significant in this regard. Various scenarios may arise in the future—such as for instance those put forward by the Association of European Research Establishments in Aeronautics (EREA) in its vision study 2050 (<https://erea.org/erea-vision-studies/>). In this prospect, breakthrough noise technologies may give genuine competitive advantages to unnoticed trends or disregarded options that would eventually come true. Recent efforts put on new aircraft design—such as in the **ARTEM project**—new propulsion types, whatever hybrid or fully distributed-electric, or on UAVs for carrying people and goods is a commendable trend and **research on evaluating and lowering the noise of such new aircraft or of newer concepts of noise reduction technologies must be pursued.**

Recommendation: Member States—especially those with an aircraft industry—as well as the European Commission should orient low TRL research for aircraft noise reduction on disruptive concepts rather than on incremental research.

Lesson Three—Noise Regulations Based on Metrics Do Not Protect Against Annoyance

Noise metrics are the historical instrument to assess noise impact, and especially aircraft noise impact. There are good reasons to justify this situation: Studies of aircraft noise are first and foremost performed by engineers and specialised acousticians for whom noise metrics are the most “scientific” and “natural” tools. “Scientific” here means related to hard science and, indeed, noise metrics are very suitable,

as related measures are comparable, reproducible and objective. **That is why noise metrics are and must remain privileged for aircraft certification purposes.** But they are more than questionable for assessing annoyance. Nobody ever heard a L_{den} level nor an EPNL one. And if one once “heard” a dB(A), this instantaneous figure alone is not representative of annoyance. There are certainly plenty of other indicators which are more suitable for this endeavour, going from “number above” up to awakening indices. However, even these indicators cannot figure out alone what annoyance endured by an individual means, and annoyance, encompassing most of the time one or several non-acoustical factors, can barely be represented by a number or a percentage.

In this regard, the usage of noise indicators in regulations dedicated to lower annoyance, for instance the Environmental Noise Directive (2002/49/EC) or the Regulation 598/2014 introducing noise-related operating restrictions at Union airports within a Balanced Approach, is only a bottom line and must be augmented on a local basis by other instruments. **Best practices exemplified in the ANIMA project could be the basis for such more elaborated instruments, especially because many local actors are in need for such guidelines.**

Recommendation: The European Commission, the EASA along with the ICAO may perform an insightful review of the ANIMA project’s outcomes in order to further refine, elaborate and endorse joint and/or official guidelines on how to cope with annoyance beyond complying to noise metric-based regulations.

The European Commission could also envisage maintaining and developing further the ANIMA top-level outcomes—and especially the Best Practice Portal—as a basis of such guidelines.

Lesson Four—We Do Not Know What Annoyance Is, But We Know How It Is Mediated

Annoyance is a kind of portmanteau word under which there is an incredible wealth of concepts and issues. The annoyance endured during business hours, which prevents concentration, and which is detrimental to children’s learning, is not the same as the annoyance endured on the weekend when one cannot enjoy a party outside with relatives or friends. It is also not the same as the one which is stemming from a series of nights during which one has been prevented from sleeping or has been awakened. Eventually, it is not the same one, which ends in long-term fatigue, possible anxiety or even nervous breakdown. Last, causal pathways between such noise-induced annoyance and physiological effects such as hypertension or strokes remain unclear even if these pathways are now clearly evidenced. In this regard, ANIMA confirmed the previous conclusions from the World Health Organisation (WHO) “strongly recommending” that noise levels around airports should be reduced to below 45dBA L_{den} and 40dBA L_{night} based on the percentage of highly annoyed

and highly sleep disturbed people, respectively. **ANIMA also found out that sleep disturbance is the chief impact to remedy, as it is likely to mediate long-term effects and especially physiological ones.** This conclusion says nothing about the non-acoustical factors, which are also heavily affecting annoyance felt by individuals. Though some of these non-acoustical factors are now clearly understood, additional research is needed on that specific point.

- **Recommendations: In terms of actual implementation, Civil Aviation Authorities and Airports must do their best to comply with the very challenging WHO recommendations. Priority must be put on preventing awakening.**
- **In terms of research, the European Commission should keep on supporting works dedicated to deepening our understanding of the influence of non-acoustical factors on annoyance.**

Lesson Five—Do Not Presume Communities’ Expectations. Be Fair With Them, Listen To Them And Empower Them

Even if all is not understood about non-acoustical factors, some points are now quite clear. In particular, a substantial part of the annoyance derives from the feeling of being deprived of any way to cope with aviation noise. Whether it is true or not, most airports’ neighbours consider that they are not associated with decisions, that such decisions are taken through top-down and technocratic processes and that eventual communications are just intending to mislead or manipulate them through screening, obscure and too sophisticated concepts.

It would be far more fruitful to engage such communities in a positive way, and there are ANIMA-evidenced recipes in this regard. They are not necessarily easy to implement, but they are worth trying.

First, airports should not presume to know what communities want; for instance, they should not presume that window insulation is a necessity or that annoyance should be evaluated through the L_{den} metrics. They should rather engage in a genuine dialogue with all the stakeholders, of course including vocal activists or environmental associations but also the silent majority among which some stakeholders are sensitive to the social and economic importance of airports’ infrastructure. To be effective, the engagement must be underpinned by a ‘common language’ that is comprehensible to all. Jargon and dominant attitudes must be banned in order to give fair access to expertise to all the audience. In particular, the various options must be fairly exposed with all their implications and with all the other considerations than noise (for instance, prohibitive safety ones or business impact). In this formatted dialogue, the rules of the game must be clear and known to all in advance. In particular, decision-making processes must be inclusive, transparent and they must allow the validity of claims to be challenged. Citizens understand that tough decisions, not always in their interest, must be made, but if the process is unclear, even good

decisions will be questioned. As a prerequisite, it also means that the instigators of such processes must be ready to accept and endorse their conclusions otherwise, it would be even more counterproductive than doing nothing.

Recommendations: Airports must locally engage their community to reach a consensus between all the stakeholders, including the silent majority, and then to endorse conclusions reached by the group.

Lesson Six—Evaluate Measures Taken On A Regular Basis

This lesson may sound obvious but it is not. Very often, some airports, even those at the leading-edge, implement some ambitious plans intending to lower the annoyance but there is little or no systematic evaluation of these efforts, nor indeed their wider consequences. Further, research into the efficacy of certain forms of communication and engagement is so limited as to be of little use to airports when designing noise management interventions or more general community outreach programmes. This additional factor may explain why in many cases airport community engagement efforts do not yield the intended benefits for airports and communities alike.

Recommendations: Airports must evaluate and survey on a regular basis measures they have taken and compare them with the updated expectations of the neighbouring communities.

Lesson Seven—Do Not Wait Until It Is Too Late For Implementing Regulation 598/2014

Regulation 598/2014 supersedes Directive EC 2002/30 and establishes “*rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach*”. However, applying this regulation is mandatory only for airports above 50,000 civil aircraft movements per calendar year. It appears to be too late for small but rapidly growing airports, especially when it comes to land-use planning issues. Around some airports “starting the journey” on noise management and mitigation—for instance, in Eastern Europe—there is an actual risk that prospects for jobs and economic growth tend to override on the short-term any societal or environmental considerations. Uncontrolled or commercially driven developments of inappropriate land uses may then occur, strongly encroaching lands around airports and preventing or threatening any further enforcement of the regulation.

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 a 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 proactive and developing long-term noise management strategies, these rapidly growing airports will be able to better control their ongoing 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 resist the encroachment of noise-sensitive buildings such as public residences, thus leading to fewer noise problems in the longer term.

Recommendation: The ICAO and the European Commission may develop an authoritative guidance targeting regional airports beyond the threshold of 50,000 movements per year in order to provide an incentive for starting to implement Balanced Approach interventions to pave the way for a possible smooth implementation of the directive in the future.

Lesson Eight—Providing Experience Of “Pathfinders” And “Experienced Travellers” To Airports “Starting The Journey”

Through the case studies examined, ANIMA clearly showed that not all airports have the same level of experience, understanding and achievements when it comes to noise management and mitigation. On the one hand, “pathfinders” are airports at the leading-edge of Balanced Approach implementation. They are usually large and experienced platforms 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.

In the middle, there are airports that are “experienced travellers” 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.

On the other hand, airports “starting the journey” have 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 of 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.

It could be a good idea to make the latter benefit from the experience of the former. In this regard, the European Commission, along with dedicated associations such as ACI or ARC, possibly as well as with training companies, may envisage exchange of personnel and dedicated experts to favour learning-by-doing of the less experienced.

This could look like the TEAMING or Erasmus work programme of the European Commission.

Recommendation: The European Commission along with private partners may favour exchange of personnel and experience between advanced and less advanced airports in a kind of “Airasmus” programme

Lesson 9—Build On And Widen The Anima Experience And Its Methods

Through its successive framework programmes for Research and Innovation, the European Commission progressively enlarged its scope, starting from the key but narrow concern of scientific Excellence to the market competitiveness of the European industry and to the return on investments for its citizens and taxpayers. In this evolution, ANIMA has been a landmark with—maybe for the first time—associations of scholars from universities, research centres, industries’ primes but also of experts in Human sciences and end-users that are airports. Led within Horizon 2020, ANIMA arose high expectations and the involved teams, at least, deem the project a success: on the one hand, the cross-fertilisation of up-to-then siloed disciplines not only led to effective solutions or methods, but it also partook to build up a common language, shared concerns and a comprehensive culture for the involved stakeholders. This methodology is worth extending far beyond the single aviation noise issue. It is noticeable that it is perfectly fitting new orientations put forward by Horizon Europe through its highly transversal calls for proposals, notably an increased and quick impact on citizens and taxpayers as well as the decarbonisation of European economies.

On the other hand, ANIMA not only maintained the European Strategic Roadmap on Aviation noise that was initiated by the successive X-Noise networks but it also substantially enlarged it to Airport Noise Management and Indicators and to Impacts Understanding. It also took this opportunity to enlarge the network of related national focal points (NFPs) and therefore to amplify the EU influence on regions up-to-then poorly connected to the European research ecosystem, such as for instance the Western Balkans. It is believed that such a roadmap and such a network are very valuable European assets which are not only allowing the Continent to weigh in International bodies such as the ICAO but also to act as a major pole of reference for its neighbourhood, whether Eastern or Southern.

Recommendation: The European Commission could take advantage of the ANIMA experience, on the one hand by elaborating tailored calls for proposals that would allow part of the consortium to embark with newcomers on enlarged topics with strong interdependencies, for instance related to the highly complex issue of decarbonising the air transport. It should also set conditions to maintain the unique European Strategic Roadmap on Aviation noise and the associated

network of experts as a major asset for leadership and for influence toward its Eastern and Southern neighbours.

Summary of Recommendations

#	To whom	What	How	Objective
1	Member States and the European Commission	Maintain a significant level of financial support on research intending to lower aircraft noise	Nat'l research projects & RIAs	Competitiveness of EU industry
2	Member States and the European Commission	Orient low TRL research for aircraft noise reduction on disruptive concepts rather than on incremental research	Nat'l research projects & RIAs	Competitiveness of EU industry
3	European Commission, EASA & ICAO	Elaborate and endorse guidelines on how to cope with annoyance beyond complying to noise metric-based regulations	Based on the WHO and ANIMA findings	Social acceptance of air transport
4	European Commission	Maintain and Develop further the ANIMA top-level outcomes —and especially the Best Practice Portal—as a basis of such guidelines	Internal achievement, call for tender	Dissemination of knowledge, Impact of Horizon Europe
5	Civil Aviation Authorities & Airports	Comply with the WHO recommendations, especially in order to prevent awakening	Based on the WHO and ANIMA findings	Citizens health and quality of life
6	European Commission	Keep supporting research on non-acoustical factors	RIAs & CSAs	Social acceptance of air transport and citizens health
7	Airports	Engage communities to reach a consensus between all the stakeholders, including the silent majority, and then to endorse conclusions reached by the group	ANIMA recipes in the best practice portal	Social acceptance of air transport

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#	To whom	What	How	Objective
8	Airports	Evaluate and survey on a regular basis, take measures and compare them with the updated expectations of the neighbouring communities	Polling	Social acceptance of air transport
9	ICAO European Commission	Develop a guidance targeting regional airports below the threshold of 50,000 movements per year for convincing them to start implementing balanced approach interventions	Communication policy	Social acceptance of air transport and quality of life
10	European Commission	Favour exchange of personnel and experience between advanced and less advanced airports in a kind of "Airasmus" programme	IA, Other financial instruments	Training and knowledge of experts Quality of life
11	European Commission	Elaborate calls for proposals that would take benefit from the ANIMA experience, for instance on decarbonising the air transport	RIA	Impact of Horizon Europe
12	European Commission	Maintain the European Strategic Roadmap on Aviation noise and the associated network of experts	CSA	Leadership of the EU, Influence on neighbourhood

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