U.S. Federal Aviation Administration Research on Aviation Noise:

Understanding Challenges, Developing Solution, and Informing Decision Making

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ABSTRACT

The U.S. Federal Aviation Administration is actively working to understand, manage, and reduce the environmental impacts of global aviation through research, technological innovation, policy, and outreach to benefit the public.

With the vision of removing the environmental constraints on aviation growth by achieving quiet, clean, and efficient air transportation; the FAA has assembled a comprehensive portfolio of research activities to guide investments in analytical tools, operational procedures, and aircraft technology; and informing decision making related to aviation noise, energy, and emissions.

This paper will provide an overview of FAA's aircraft noise research portfolio and the agency's broader goals to reduce the environmental impacts of aviation. Efforts in three key areas will be discussed:

1. **Effects of Aircraft Noise on Individuals and Communities**: Speech Interference and Children's Learning, Health and Human Impacts Research, Neighborhood Environmental Survey – including a summary of the recently released technical findings on aircraft noise annoyance

2. **Noise Modeling, Noise Metrics and Environmental Data Visualization**: Aviation Environmental Design Tool, Noise Screening, Environmental Data Visualization, Supplemental Noise Metrics

3. **Reduction, Abatement and Mitigation of Aviation Noise**: Aircraft Source Noise Reduction, Noise Abatement, Noise Mitigation Research

BACKGROUND:

Since the mid-1970s, the number of people living in areas exposed to significant levels of aircraft noise [1] in the United States has declined from roughly 7 million to just over 400,000 today. At the same time, the number of commercial enplanements has increased from approximately 200 million in 1975 to approximately 930 million in 2018. The single most influential factor in that decline was the phased transition to quieter aircraft, which effectively reduced the size of the areas around airports experiencing significant noise levels. That transition was the result of the development of new technology by aircraft and engine manufacturers; establishment of increasingly stringent noise standards for civil subsonic aircraft [2] investments by U.S. airlines in newer, quieter aircraft; and requirements by the FAA and the United States Congress to phase out operations by older, noisier aircraft.

A second factor has been cooperative efforts by airports, airlines and other aircraft operators, State and local governments, and communities to reduce the number of people living in areas near airports exposed to significant levels of aircraft noise. Under the FAA's Airport Noise Compatibility Planning Program [3], airports may voluntarily initiate a collaborative process to consider measures that reduce existing noncompatible land uses and prevent new noncompatible land uses in areas exposed to significant levels of aircraft noise. Since 1983, more than 250 airports have used this process to consider changes to local land use planning and zoning, sound insulation, acquisition of homes and other noise-sensitive property, aircraft noise abatement routes and procedures, and other measures. Over $6 billion in funding has been provided for airports to undertake noise compatibility programs and implement noise mitigation measures. The FAA encourages the process by providing financial and technical assistance to airport sponsors to develop Noise Exposure Maps and Noise Compatibility Programs, and implement eligible noise-related mitigation measures recommended in the program, depending upon the availability of funding.

In addition to noise compatibility planning, the FAA also issues grants to airport operators and units of local government to fund mitigation projects, most notably to sound-insulate homes, schools, and other noise-sensitive facilities. While sound insulation reduces indoor noise levels, it does not address concerns about noise interfering with the enjoyment of the outdoors. Moreover, there are limits to the effectiveness of sound insulation. In some areas with elevated noise levels, sound insulation may not sufficiently reduce interior noise levels to meet established interior noise standards [4]. Conversely, in areas where overall noise levels are lower, interior noise standards may already be met without additional sound insulation treatments [5].

Today's civilian aircraft are quieter than at any time in the history of jet-powered flight. The FAA, aircraft manufacturers, and airlines continue to work toward further reducing aircraft noise at the source [6]. As an example, the noise produced by one Boeing 707-200 flight, typical in the 1970s, is equivalent in noise to 30 Boeing 737-800 flights that are typical today [7]. As a result, for many years there was a steady decline in the number of people exposed to significant noise in communities located near airports. In recent years, however, as aviation industry growth has led to an increase in operations in many areas, the number of people and the size of the areas experiencing significant aircraft noise has started to show a gradual expansion. The introduction of Performance Based Navigation (PBN) procedures, as needed to safely and efficiently modernize the national air transportation system [8], has also provided noise benefits for many by allowing for new and more efficient flight paths, but has in some places resulted in community concerns, particularly related to increased concentration of flights.

In conjunction with increased efforts to engage airport communities on their concerns related to aircraft noise, the research programs detailed in this paper represent FAA’s efforts to better understand and address these concerns through data driven analysis designed to inform the agency’s policies.

OVERVIEW OF FAA RESEARCH ON AIRCRAFT NOISE:

Recognizing that aircraft noise remains a primary concern of many stakeholders, the FAA is actively working to understand, manage, and reduce the environmental impacts of global aviation through research, technological innovation, policy, and outreach to benefit the public.

With the vision of removing environmental constraints on aviation growth by achieving quieter, cleaner, and more efficient air transportation, the FAA has worked closely with a number of industry, academic, and governmental stakeholders to assemble a comprehensive portfolio of research activities (including leveraging research undertaken by others) aimed at guiding investments in scientific studies, analytical tools, and innovative technologies to better understand and manage aircraft noise. However, due to the complex nature of aircraft noise and the varied priorities and concerns of stakeholders, no single set of findings can completely guide decision making. A broad understanding of aircraft noise and any potential impacts, from many different perspectives, is therefore needed. Summaries of the FAA's key research, tools, and technology programs designed to potentially inform aircraft noise policy are provided below.

EFFECTS OF AIRCRAFT NOISE ON INDIVIDUALS AND COMMUNITIES:

Speech Interference and Children's Learning

Much of our current understanding on speech interference due to noise was established by the Environmental Protection Agency (EPA) in the 1970s [9]. The findings from these early research assessments are still relevant for today's considerations on the impacts from aircraft noise. However, the FAA is also investigating whether there are related considerations warranting more detailed studies. One area in particular is the potential effects of aviation noise on reading comprehension and learning motivation in children. Initial research in this area has shown there are challenges in designing effective studies, and this continues to be an area of interest to better inform noise mitigation and abatement strategies for schools and other noise-sensitive facilities. While additional research in this area is still being explored, the FAA has invested more than $440 million in sound insulation treatments at schools around the country [10] in order to mitigate any potential issues related to aircraft noise.

Health and Human Impacts Research

While community annoyance due to aircraft noise exposure provides a useful summary measure that captures public perceptions of noise, a full understanding of the impact of noise on communities requires a careful consideration of the potential physiological impacts as well. Knowledge of physiological impacts could also help the FAA develop targeted measures to address aircraft noise. Emerging research capabilities are providing new opportunities to examine specific impacts of noise on humans. When these are examined in a holistic manner with research on community annoyance, they could further inform aircraft noise policy considerations. The FAA is conducting research on the potential impacts of aircraft noise on cardiovascular health and sleep disturbance, as described below.

Impacts to Cardiovascular Health

In partnership with academic researchers that are being led by the Boston University School of Public Health, the FAA is working to understand the relationship between aircraft noise exposure and cardiovascular health [11. The researchers are doing this by leveraging existing national longitudinal health cohorts wherein statistically large numbers of people provide data about their health on a periodic basis over the course of many years. These studies are typically used to understand the relative risk of different factors like diet on different health outcomes like heart disease. The Boston University team is expanding the list of factors to include aircraft noise exposure such that it can be placed in context with other factors that could increase one's risk of cardiovascular disease. The team is leveraging existing collaborations with well-recognized and respected health cohorts including the Nurses' Health Studies and the Health Professionals Follow-Up Study, as well as a complementary study at Boston University that is examining the Women' Heath Initiative cohort through funding from the National Institutes of Health.

Sleep Disturbance

The FAA is working with a team led by the University of Pennsylvania School of Medicine to conduct a national sleep study that will quantify the impact of aircraft noise exposure on sleep [12. The study will collect nationally representative information on the probability of being awoken by aircraft noise exposure. The study will start with input being requested from approximately 25,000 respondents through a mail survey. These surveys will be used to determine the eligibility of respondents for a detailed field study that will involve roughly 400 volunteers. The volunteers in the detailed field study will use equipment provided by the research team to collect both noise and electrocardiography data in their homes while they sleep. The electrocardiography data combined with information on the level of aircraft noise exposure will advance our understanding of the physiological effects of aircraft noise on sleep.

Economic Impacts

In addition to the aforementioned community and physiological impacts, the FAA is also working with researchers at Massachusetts Institute of Technology (MIT) to conduct an empirical assessment of the economic impacts to businesses located underneath aircraft flight paths [13]. This assessment will take into account the economic benefits from aviation activities, as well as potential environmental and health impacts that might reduce economic productivity. The FAA is also conducting research to examine housing value data to reveal the willingness of people to pay to avoid aircraft noise exposure [14]. This research is intended to serve as a follow on to the Neighborhood Environmental Survey (described in the next section), to determine whether the findings of that survey on residents' sensitivity to aviation noise is also reflected in their “revealed preferences” when making housing location decisions.

Neighborhood Environmental Survey

To review and improve the agency's understanding of community response to aircraft noise, the FAA initiated the Neighborhood Environmental Survey (NES) [15] to help inform ongoing research and policy priorities on aviation noise.

Working with statisticians and noise experts [16], the FAA worked with other Federal agencies that have statutory, regulatory, or other policy interests in aviation noise, to conduct a nationwide survey to update the scientific evidence on the relationship between aircraft noise exposure and its annoyance effects on communities around airports, based on today's aircraft fleet and operations. The NES included a range of questions on a variety of environmental concerns, including aviation noise exposure.

The team of expert consultants, under direction from the FAA, surveyed residents living around representative U.S. airports, drawing upon well-established research methods in order to ensure scientific integrity and historical continuity with prior studies, while also employing advancements in techniques for noise modeling and social surveys. The NES consisted of over 10,000 mail responses from residents in communities around 20 statistically representative airports across the Nation, making it the single largest survey of this type undertaken at one time. In addition to the mail responses, the consultants also conducted a follow-up phone survey, which included over 2,000 responses to a series of more detailed questions. The FAA is now considering the full NES results, in conjunction with additional research findings as they become available, to determine how they may inform its noise policy considerations.

Overview of Community Response to Noise

Historically, two of the main types of information considered by the FAA and other Federal agencies in relating noise exposure to community response have been: (1) Case studies analyzing individual and group actions (e.g., complaints or legal action) taken by residents of communities in response to noise; and (2) social surveys (such as the NES) that elicit information from community residents regarding their level of noise-induced annoyance. Annoyance is defined as a “summary measure of the general adverse reaction of people to noise that causes interference with speech, sleep, the desire for a tranquil environment, and the ability to use the telephone, radio, or television satisfactorily” [17]. The results of social surveys of noise-induced annoyance are typically plotted as “dose-response curves” on a graph showing the relationship between the level of DNL [18] cumulative noise exposure and the percentage of the population that is “highly annoyed.”

Current FAA noise policy is informed by a dose-response curve initially created in the 1970s known as the Schultz Curve [19]. This dose-response curve is generally accepted as a representation of noise impacts and has been revalidated by subsequent analyses over the years [20]. The dose-response relationship it depicts has provided the best tool available to predict noise-induced annoyance for several decades. In 1992, the Federal Interagency Committee on Noise (FICON) reviewed the use of the Schultz Curve, and created an updated version of the curve using additional social survey data [21]. The updated dose response curve was found to agree within one to two percent of the original curve, leading FICON to conclude that “the updated Schultz Curve remains the best available source of empirical dosage-effect to predict community response to transportation noise.” [22] According to the 1992 FICON Report, the DNL-annoyance relationship depicted on the Schultz Curve “is an invaluable aid in assessing community response as it relates the response to increases in both sound intensity and frequency of occurrence.” Although the predicted annoyance, in terms of absolute levels, may vary among different communities, the Schultz Curve can reliably indicate changes in the level of annoyance for defined ranges of sound exposure for any given community [23]. While the validity of the dose-response methodology used to create the Schultz Curve remains well supported, its underlying social survey data, including the additional data used by FICON to update the curve, is now on average more than 40 years old and warrants an update. The NES was conducted to create a new nationally representative dose-response curve to understand how community response to aircraft noise may have changed.

The NES's collection of a nationally representative dataset on community annoyance in response to aircraft noise provides a contemporary update to the Schultz Curve, including technical refinements to improve its reliability. As with the Schultz Curve, the NES describes community annoyance in terms of the percentage of people who are "highly annoyed" and describes aircraft noise exposure in terms of the DNL noise metric. Based on the 1992 FICON Report, discussed previously, both the percentage of population highly annoyed and the DNL noise metric have continued to be recognized for this purpose including by FICON's successor, the Federal Interagency Committee on Aviation Noise in its 2018 report [24].

Survey Results

As summarized in Table 1 and shown in Figure 1, compared with the Schultz Curve representing transportation noise, the NES results show a substantially higher percentage of people highly annoyed over the entire range of aircraft noise levels (i.e., from DNL 50 to 75 dB) at which the NES was conducted. This includes an increase in annoyance at lower noise levels. The NES results also show proportionally less change in annoyance from the lower noise levels to the higher noise levels.

Table 1: Comparison of Dose-Response Results

DNL Noise Level	FICON 92 Curve % Highly Annoyed	National Curve % Highly Annoyed	National Curve % Highly Annoyed (95% Confidence Limits)
65dB	12.3%	65.7%	60.1%-70.9%
60dB	6.5%	48.8%	43.8%-53.7%
55dB	3.3%	32.1%	27.8%-36.8%
50dB	1.7%	19.1%	15.4%-23.4%

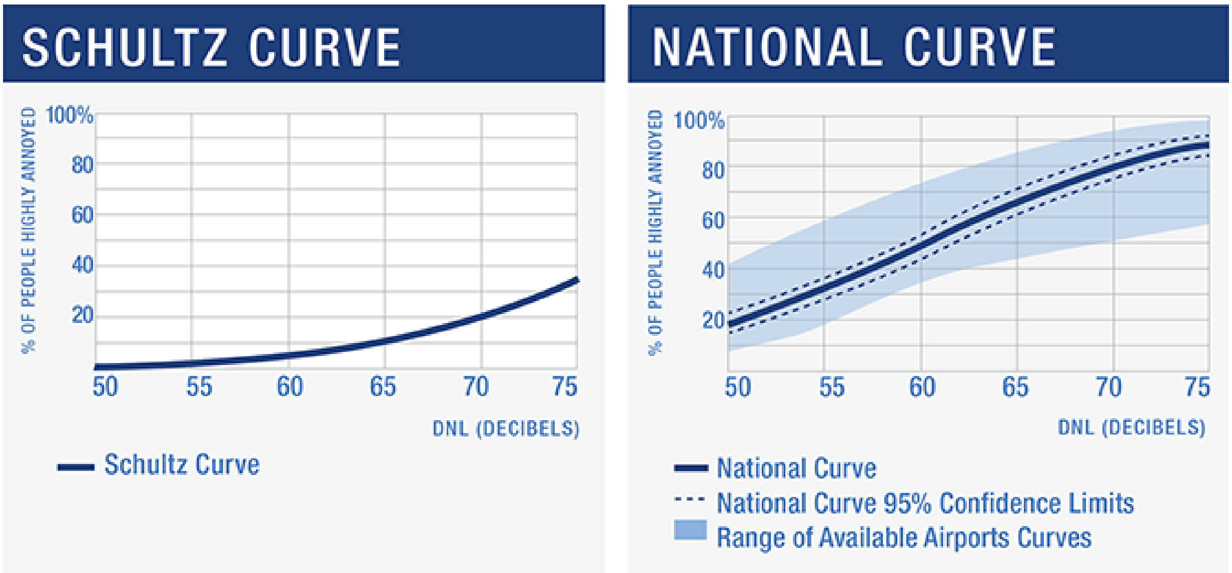

Figure 1: Comparison of Shultz Curve and the U.S. National Curve from the NES

Advancements in Survey Methodology

Earlier work to understand community response to noise, including Schultz's dose-response analysis, was based on the premise that the annoyance from any source of noise would be the same for a given DNL noise level. However, more recent work has shown that aircraft noise often results in higher levels of annoyance compared to the same level of noise from ground transportation sources [25]. There have been relatively few surveys of communities in the United States about aircraft noise undertaken over the last four decades. However, other countries around the world have conducted aircraft noise surveys during this time considering aircraft noise separately from noise from other modes of transportation. The results of these surveys, as reflected in a dose-response relationship published by the International Organization for Standardization [26], have consistently shown higher levels of annoyance than exhibited by the Schultz Curve. Informed by these results, the national dose-response curve in the NES report reflects only responses to the question about aircraft noise exposure.

Other Factors

In addition to enhancements in survey techniques and changes to the way aircraft operate, there are likely other factors contributing to a change in the way communities respond to aircraft noise. Future work is needed to fully understand the specific drivers behind these reasons, but several possibilities include:

Changes to where people are choosing to live, including societal migration to increasingly urban environments [27]. Additionally, growth and changes to the makeup of suburban communities and their proximity to urban hubs may also be influencing factors on community expectations for aircraft noise exposure.

How people work and live, including influencing factors such as increased in-home business and teleworking in today's economy [28]. Changes in expectations for spending time outdoors versus indoors and the associated aircraft noise exposure may also be a factor.

The rise of social media, the internet, and other national and global information sources, leading to an increased awareness and perception of local and national noise issues. Overall societal response to noise due to a combination of these or other factors.

In addition to the NES, which focuses on annoyance, the FAA is also engaged in a range of research initiatives aimed at providing information on other impacts of aircraft noise, including effects on children's learning, sleep disturbance, and potential health effects. Each of these research initiatives focuses on a distinct type of potential adverse effect associated with aviation noise exposure. The potential adverse effects explored by these initiatives may also be factors influencing the annoyance reported by the NES. However, research in these areas is still ongoing and therefore was not specifically addressed by the NES. Additional details on these research programs is provided below.

NOISE MODELING, NOISE METRICS, AND ENVIRONMENTAL DATA VISUALIZATION:

As a core component of FAA's work to address aircraft noise, as well as a requirement of its environmental regulatory commitments, the FAA must maintain the ability to accurately quantify aircraft noise exposure around airports and throughout the National Airspace System. High-fidelity modeling is the only practical method to accomplish this objective, as aircraft noise needs to be quantified over relatively large scales in an efficient and consistent manner. For more than four decades, the FAA has worked closely with industry, academic, and governmental stakeholders to advance research and development in aircraft noise modeling. This effort advances the analytical tools, metrics, data, and standards required to provide high quality results to inform the public and other stakeholders about noise exposure levels. The FAA has also been actively exploring ways to use emerging technologies to visualize environmental data including noise exposure.

Aviation Environmental Design Tool

The Aviation Environmental Design Tool (AEDT) [29] is the FAA's required noise and environmental modeling application for all U.S. domestic regulatory analyses requiring FAA review. The AEDT also provides analysis support for the International Civil Aviation Organization—Committee on Aviation Environmental Protection, and is used as a research and assessment tool by other Federal agencies, universities, and industry stakeholders.

Through collaborations with government, university, and industry partners, the FAA actively manages AEDT to ensure that features and capabilities are developed to meet expanding environmental analysis needs, and to ensure that as new data and technologies become available they are incorporated in order to enhance modeling accuracy and efficiency. The AEDT builds on a legacy of noise modeling development, and is based on detailed aircraft-specific noise measurements and internationally accepted aircraft performance models and standards. A dynamic development process is used to create new versions of AEDT. This process allows for new features and capabilities to be added as needed, for example, when required by policy updates or informed by emerging research findings.

Noise Screening

Building from the high-fidelity noise modeling capabilities available through AEDT, the FAA is also working to develop an updated noise screening tool. This updated noise screening tool will use a simplified noise modeling process to facilitate an expedited review of proposed Federal actions where significant noise impacts are not expected. Such an approach is beneficial where a proposed Federal Action is limited in scope and could qualify for a categorical exclusion under the FAA's procedures for implementing the National Environmental Policy Act (NEPA) [30]. The primary goal of updating the noise screening tool is to decrease the amount of time that an analyst will need to conduct an assessment while also ensuring a fully validated result that is readily understandable by the public. While the output from a noise screening tool cannot provide the same level of detail as a comprehensive modeling tool, the simplified process provides for an expedited initial view of any potential changes in aircraft noise exposure.

Environmental Data Visualization

The FAA has been developing ways to utilize geospatial data to improve the agency's ability to communicate environmental data to the public. For example, the FAA has designed an Environmental Visualization Tool to take advantage of the availability of high quality geospatial data to deliver an agency-wide resource using a consistent, common visual language. Once fully implemented, this common visualization platform will serve the needs of multiple environmental programs within the FAA, including those presenting aircraft noise data to the public.

Supplemental Noise Metrics

The FAA's primary noise metric, DNL, was developed and validated to identify significant aviation noise exposure for land use and mitigation planning as well as for determining significant change in noise exposure under NEPA review. In some cases, however, it can be useful to supplement DNL with the use of other noise metrics. While other noise metrics may not provide as complete an understanding of the cumulative noise exposure from activity around an airport and its associated airspace, they often can provide opportunities to communicate the specific characteristics of noise changes due to the unique aspects of a proposed action. The FAA's NEPA procedures address the use of supplemental noise metrics [31]. To assist the public in understanding noise impacts, and to better facilitate communication among communities interested in systematic departure flight track dispersion, the FAA is working to assess the use of potential supplemental metrics. For a supplemental metric to be effective in evaluating potential means of achieving flight track dispersion, and to ensure that communities understand the impacts of dispersion (i.e., that dispersion does not eliminate noise but rather it may move noise to other neighborhoods), the supplemental metric will need to effectively communicate the changes in noise exposure that will occur in all of the communities affected by the change, both those that would be exposed to less noise and those that would be exposed to more noise [32].

REDUCTION, ABATEMENT, AND MITIGATION OF AVIATION NOISE:

To directly address noise concerns, the FAA sponsors multiple research programs to explore different concepts for aircraft noise reduction. As aircraft noise is a complex issue, no single concept is capable of providing a universal solution. However, by conducting research across different areas, the FAA is developing solutions to reduce noise at its source, abate noise through operations, and mitigate the effects of noise on communities. The intent of this approach is to have a variety of options to reduce the noise being experienced by those living near airports around the country and to have options that could be tailored to specific airports.

Aircraft Source Noise Reduction

As noted previously, the single most influential factor in the historical decline in noise exposure was the phased transition to quieter aircraft. Through the public-private partnership of the Continuous Lower Energy, Emissions, and Noise (CLEEN) Program, the FAA and industry are working together to develop technologies that will enable manufacturers to create aircraft and engines with lower noise and emissions as well as improved fuel efficiency [33]. The technologies being accelerated by the CLEEN Program have relatively large technological risk. Government resources help mitigate this risk and incentivize aviation manufacturers to invest and develop these technologies. By cost-sharing the development with the FAA, industry is willing to accept the greater risk and can better support the business case for this technological development. Once entered into service, the CLEEN technologies will provide societal benefits in terms of reduced noise, fuel burn, and emissions throughout the fleet for years to come. In addition to the benefits provided by technologies developed under the CLEEN, the program leads to advances in the analysis and design tools that are used on every aircraft or engine product being made by these companies; this extends the benefits of the CLEEN Program well beyond the individual technologies being matured.

As new aircraft and engine technologies lead to quieter aircraft over time, the FAA works to establish aircraft certification standards based on noise stringency requirements. These standards are a requirement of the airworthiness process and are described in 14 CFR part 36. These requirements do not force manufactures to develop new technology. However, as new noise reduction technologies emerge they do ensure that new aircraft continue to meet increasingly quieter standards within the bounds of what is technologically feasible and economically reasonable.

Noise Abatement

The FAA is also supporting multiple efforts to identify means to abate noise through changes in how aircraft are operated in the airspace over communities. In the immediate vicinity of an airport, use of voluntary noise abatement departure procedures (NADP) has been a longstanding technique available to reduce noise. Recent research is examining the effectiveness of these procedures and identifying means of improving their use.

As the FAA works to modernize the National Airspace System, new aircraft flight procedures have been designed to take advantage of PBN technologies. To better understand both the environmental benefits and challenges posed by PBN, the FAA is working to re-examine ways to routinely consider noise during flight procedure design. This effort includes an exploration of how PBN can better control flight paths and move them away from noise-sensitive areas, how changes in aircraft performance could be safely managed to reduce noise, and how systematic departure flight track dispersion can be implemented to abate noise concerns.

In a recent partnership with the Massachusetts Port Authority (Massport) and MIT, the FAA jointly contributed to research considering how Area Navigation (RNAV) PBN procedures could be designed and implemented to reduce noise. Multiple concepts were explored that highlighted how collaborations between the FAA, airport operators, and community members can produce innovative noise abatement strategies.

A recently completed analysis of operational procedures that resulted from the Massport-MIT-FAA partnership shows that for modern aircraft on departure, changes in aircraft climb speed have minimal impact on the overall aircraft departure noise. The current best practice for NADP, using International Civil Aviation Organization distant community or “NADP-2” departure procedure, has been shown to minimize modeled noise impacts. This analysis also shows that for modern aircraft on arrival, changes in approach airspeed could have a noticeable impact (reductions of 4-8 dBA) on the overall aircraft noise at relatively large distances from touching down (between 10 and 25 nautical miles from the runway). While NADP procedures have the potential to reduce community noise, they may also have implementation challenges that will need to be overcome. Research is ongoing at MIT to address these challenges [34].

In addition to airplane operations, the FAA is also examining the potential for helicopter noise abatement through changes in operational procedures. The FAA has partnered with the Volpe Center, the National Aeronautics and Space Administration, the Pennsylvania State University, and operator organizations to explore new ways to safely fly rotorcraft while also reducing noise through the Fly Neighborly Program [35].

Noise Mitigation Research

Noise mitigation is the effort to take actions to reduce the impact of aircraft noise exposure that occurs. The primary mitigation strategies involve encouraging responsible land use planning in airport communities and, where appropriate, the application of sound insulation treatments to eligible homes or other noise-sensitive public buildings (e.g., schools or hospitals). In extreme cases where sound insulation technologies cannot provide adequate mitigation, the acquisition of residential homes and conversion to non-residential land use is also an option.

As sound insulation treatment costs have continued to rise and new research on the human impacts from noise becomes available, the FAA is exploring the cost-benefit calculus of existing noise mitigation strategies and technologies in order to better direct where and how limited mitigation resources should be applied. Recent academic research [36] and internal assessments have raised questions about the benefits of sound insulation relative to the costs. While the relative benefits of sound insulation for noise exposures above DNL 65dB will depend on the individual home treatment costs, minimal benefit can be expected for sound insulation treatments applied for noise exposures below DNL 65dB.

CONSIDERATIONS FOR AIRCRAFT NOISE POLICY

Community response to noise has historically been a primary factor underlying the FAA's noise-related policies, including the establishment of DNL 65 dB as the threshold of “significant” aircraft noise exposure. The FAA has been using a DNL of 65 dB as the basis for: (1) Setting the agency's policy goal of reducing the number of people exposed to significant aircraft noise [37]; (2) the level of aircraft noise exposure below which residential land use is “normally compatible,” as defined in regulations implementing the Aviation Safety and Noise Abatement Act of 1979 [38], and (3) the level of aircraft noise exposure below which noise impacts of FAA actions in residential areas are not considered “significant” under section 102(2)(C) of the National Environmental Policy Act of 1969 [39].

While the FAA will not make any determinations on implications from these emerging research results for noise policies until it has carefully considered public and other stakeholder input, and assesses the factors behind any increases in community impacts from aircraft noise exposure; the research results, as reflected in the programs and studies described in this article, will provide new information on how aircraft noise in communities near airports may be effectively managed and will inform future decision making on the FAA's future aviation noise research priorities and noise policies.

REFERENCES

[1] Under longstanding FAA policy, the threshold of significant aircraft noise exposure in residential areas is a Day-Night Average Sound Level of 65 decibels (dB). See the “Aviation Noise Abatement Policy,” issued by the Secretary of Transportation and the FAA Administrator in 1976. This document is available on the FAA website at https://www.faa.gov/regulations_policies/policy_guidance/envir_policy/.

[2] Consistent with International Civil Aviation Organization standards, FAA has set increasingly more stringent aircraft certification noise standards, such as the Stage 5 noise certification standard. 82 FR 46123 (October 4, 2017).

[3] This process is outlined under 49 U.S.C. 47501 et seq., as implemented by 14 CFR part 150.

[4] FAA Order 5100.38D, Appendix R.

[5] P.J. Wolfe et al., 2016 Costs and benefits of US aviation noise land-use policies Transportation Research Part D 44 (2016) 147-156, http://dx.doi.org/10.1016/j.trd.2016.02.010.

[6] See, for example, information on the FAA's "Continuous Lower Energy, Emissions, and Noise" (CLEEN) Program at: https://www.faa.gov/about/office_org/headquarters_offices/apl/research/aircraft_technology/cleen/.

[7] Based on an average of approach and takeoff certificated noise levels as defined in 14 CFR part 36.

[8] See Section 213, "Acceleration of NextGen Technologies," of the FAA Modernization and Reform Act of 2012, Public Law 112-95, 213, 126 Stat. 11, 46-50 (2012), 49 U.S.C. 40101 note (PBN implementation required at key airports by statutory deadline).

[9] EPA, 1973, Public Health and Welfare Criteria For Noise, https://nepis.epa.gov/.

[10] Provided through Airport Improvement Program funding since 1994.

[11] https://ascent.aero/project/noise-impact-health-research/

[12] https://ascent.aero/project/noise-exposure-response-sleep-disturbance/

[13] ASCENT Project 003: https://ascent.aero/project/noise-impact-health-research/

[14] https://ascent.aero/project/aircraft-noise-exposure-and-market-outcomes-in-the-us/

[15] Analysis of the Neighborhood Environmental Survey, 2021 https://www.airporttech.tc.faa.gov/Products/Airport-Safety-Papers-Publications/Airport-Safety-Detail/ArtMID/3682/ArticleID/2845/Analysis-of-NES

[16] The FAA contracted with Westat, a leading statistics firm, and HMMH, a leading noise consultancy, to conduct the survey.

[17] Federal Agency Review of Selected Airport Noise Analysis Issues (FICON), 1992.

[18] The Day-Night Average Sound Level (DNL or Ldn) is the 24-hour average sound level, in decibels, for the period from midnight to midnight, obtained after the addition of ten decibels to sound levels for the periods between midnight and 7 a.m., and between 10 p.m., and midnight, local time. See 14 CFR 150.7.

[19] See Schultz, T.J. 1978, "Synthesis of Social Surveys on Noise Annoyance," Journal of the Acoustical Society of America 64(2): 377-405.

[20] See Fidell, S., D. Barber, "Updating a Dosage-Effect Relationship for the Prevalence of Annoyance Due to General Transportation Noise," Journal of the Acoustical Society of America, 89, January 1991, pp. 221-233; also see Finegold, L.S., C.S. Harris, and H.E. von Gierke, 1992, Applied Acoustical Report: Criteria for Assessment of Noise Impacts on People, Journal of the Acoustical Society of America, June 1992; also see Finegold, L.S., C.S. Harris, and H.E. von Gierke, 1994, Community Annoyance and Sleep Disturbance: Updated Criteria for Assessing the Impacts of General Transportation Noise on People, Noise Control Engineering Journal, Volume 42, Number 1, January-February 1994, pp. 25-30.

[21] The FICON 1992 analysis added to the Schultz Curve's original database of 161 survey data points and calculated an updated dose-response curve using the same methodology but with a total of 400 survey data points.

[22] FICON, 1992.

[23] Ibid., vol. 1, p. 2-6.

[24] Federal Interagency Committee on Aviation Noise Research Review of Selected Aviation Noise Issues (FICAN), 2018.

[25] See, for example: Janssen, S., &, Vos, H. (2011). Dose-Response Relationship between DNL and Aircraft Noise Annoyance: Contribution of TNO. Retrieved from TNO Report TNO-060-UT-2011-00207.

[26] International Organization for Standardization. (2016, March 1, 2016). International Standard 1996-1, Acoustics—Description Measurement and Assessment of Environmental Noise—Part 1: Basic Quantities and Assessment Procedures, 3rd edition.

[27] The U.S. Census Bureau indicates that the percentage of the population living in urban areas has increased from 73.6 percent in 1970 to 80.7 percent in 2010, an increase of 7.1 percent.

[28] Work to explore changes to how population distribution throughout the day are related to aircraft noise exposure is planned under Airport Cooperative Research Project (ACRP) 02-84 [Anticipated] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4421.

[29] https://aedt.faa.gov/

[30] See FAA Order 1050.1F, Environmental Impacts: Policies and Procedures, Chapter 5 ("Categorical Exclusions").

[31] See FAA Order 1050.1F, Environmental Impacts: Policies and Procedures, Appendix B, paragraph B-1.6; 1050.1F Desk Reference, Section 11.4.

[32] FAA, 2020, Report to Congress: FAA Reauthorization Act of 2018 (Pub. L. 115-254) Section 188 and Sec 173, https://www.faa.gov/about/plans_reports/congress/media/Day-Night_Average_Sound_Levels_COMPLETED_report_w_letters.pdf.

[33] See, for example, information on the FAA's "Continuous Lower Energy, Emissions, and Noise" (CLEEN) Program at: https://www.faa.gov/about/office_org/headquarters_offices/apl/research/aircraft_technology/cleen/.

[34] https://ascent.aero/project/analytical-approach-for-quantifying-noise-from-advanced-operational-procedures/, https://ascent.aero/project/aircraft-noise-abatement-procedure-modeling-and-validation/.

[35] https://www.rotor.org/initiatives/fly-neighborly.

[36] Wolfe, Malina, Barrett & Waitz 2016, Cost and benefits of US Aviation noise land-use policies, Transportation Research Part D.

[37] See "Aviation Environmental and Energy Policy Statement," 77 FR 43137, 43138 (July 23, 2012), available on the FAA website at [URL]. The "noise goal" identified in this document includes "[r]educ[ing] the number of people exposed to significant noise around U.S. airports."

[38] 49 U.S.C. 47502. The regulations implementing this section are codified at 14 CFR part 150.

[39] 49 U.S.C. 4332(2)(C). See FAA Order 1050.1F, "Environmental Impacts: Policies and Procedures" (2015), Exhibit 4-1. The significance threshold for noise used for NEPA purposes in FAA Order 1050.1F is also used by the FAA for determining significant adverse noise effects under 49 U.S.C. 47106(c)(1)(B) for airport development projects involving the location of an airport or runway or a major runway extension. See 80 FR 44209, 44223 (July 24, 2015) (preamble to FAA Order 1050.1F).