A Primer and Framework for Considering an Airport Noise and Operations Monitoring System (NOMS)

Appendices A Through K

Appendix A: Literature Review

A.1 Best Practice International Guidance Documents and Building Code Standards

A.1.1 Guidance Documents

Two international documents provide guidance on the installation and operation of airport permanent noise monitoring systems: the Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4721[1] document [and the International Standards Organization (ISO) 20906 (ISO 2009). The following sections outline the contents of ARP 4721 and ISO 20906 and include comments particularly relevant to *ACRP Research Report 237*. These documents are both technical in nature but provide very useful information.

A.1.1.1 SAE ARP 4721 Part 1:

This SAE ARP provides guidance for monitoring aircraft noise and operations in the vicinity of airports using either attended portable or unattended monitoring systems[2]. Part 1 provides guidance on the components, installation, and administration of permanent systems and guidance on analysis of data collected from temporary monitoring of aircraft noise.

The topics addressed in Part 1 are identified in seven subsections. Sections 2 and 3 give References and Definitions. Sections 4 through 6 provide guidance and information intended for those who have had little experience with the design, installation, and use of permanent aircraft noise and operations monitoring system. Section 4, System Description, describes the basic components of a complete airport noise and operations monitoring system and gives minimum requirements. Section 5, Site Selection and Installation, describes what steps should be taken in locating noise monitors and provides minimum requirements for monitor and microphone installation. Section 6, System Administration, describes basic administrative and maintenance activities that are necessary in order to ensure an installed system performs as intended. Lastly, Section 7 provides detailed guidance for making and reporting on aircraft noise measurements made using unattended portable noise monitors. Note that ARP 4721 is currently being revised with expected publication in early 2022.

A.1.1.2 SAE ARP 4721 Part 2:

As automated noise and operations monitoring systems have become widely installed at airports, the airports, vendors, and surrounding communities, reliable methods for validating the data reported by the systems are needed. Were systems providing reliable data? What uncertainties might be associated with the data? This ARP provides two levels of tests for validating system data. The first level, Post-installation Screening Tests, describes simple methods that use only data readily available from most systems. The second, System Validation for Special Studies, uses alternative data collection methods,

[1] Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4721. https://www.sae.org/standards/content/arp4721/1/

[2] International Organization for Standardization (ISO), Acoustics — Unattended monitoring of aircraft sound in the vicinity of airports, ISO 20906, 2009. https://www.iso.org/obp/ui/#iso:std:iso:20906:ed-1:v1:en

and provides detailed statistical methods for assessing the uncertainties associated with system measured data.

The topics addressed in Part 2 are identified in six subsections. Sections 2 and 3 give References and Definitions. Section 4, Post-Installation Screening Tests, identifies tests that may be conducted immediately after a system has been installed and is operational.

These tests use only data directly from the system and should efficiently identify any major short comings, such as missing significant numbers of operations or missing or erroneous aircraft noise event data. These tests may also be run at any time that some major portion or type of system reported data is in question, airport operations have changed, or community noise levels have changed. Section 5, System Validation for Special Studies, provides more rigorous and time-consuming methods for quantifying a permanent system's capabilities when special needs require detailed, quantitative analysis of system data.

A.1.1.3 ISO 20906:

The guidance provided in ISO 20906 is solely for permanent airport noise monitoring systems. Its guidance is generally similar to ARP 4721. One area of difference is the guidance provided relative to microphone location. ISO 20906 recommends microphone locations that are well removed from any buildings or obstructions, so much so that its location guidance is not very practical for built communities near airports.

ISO 20906 provides guidance in the following areas:

- Typical application for a permanently installed sound-monitoring system around an airport;
- Performance specifications for instruments and requirements for the installation and operation to enable the airport to determine continuously monitored sound pressure levels of aircraft sound at selected locations;
- Requirements for monitoring the sound of aircraft operations from an airport;
- Requirements for the quantities to be determined to describe the sound of aircraft operations;
- Requirements for data to be reported and frequency of publication of reports;
- Procedure for determining the expanded uncertainty of the reported data.

A.1.1.4 Guidance on Calibration for Airport Permanent Noise Monitoring Systems

It is impractical to go through the ARP and ISO document in detail for the purpose of *ACRP Report 237*, but there is one area worth highlighting for readers regarding the guidance provided for calibrating an airports permanent noise monitoring system.

The SAE standard provides the following guidance for calibration:

"It is recommended that every 1 to 3 years each instrument is tested to verify that it is operating within the original specifications of the instrument. The interval for performing these tests is dependent on the

use of the system. If a system is used to enforce single event noise limits, noise budgets, or other regulatory limits the system should be tested every year."

The ISO standard provides the following guidance for calibration:

"Means shall be provided to apply an acoustical calibration signal by a sound calibrator to each microphone to check the acoustical sensitivity of the measurement system.

The calibration signal shall be a sinusoidal tone in the range 250 Hz to 1 000 Hz. The sound pressure level of the tone shall be in the range 90 dB to 125 dB. A coupler or other means may be provided to exclude ambient sound during calibration. Also, means shall be provided at the microphone site to read out the data corresponding to the calibration level and to adjust the latter as necessary to the sound pressure level in the cavity of the coupler at the time of checking the sensitivity. The calibrator used shall conform to the requirements of International Electrotechnical Commission (IEC) 60942 for a class 1 instrument and shall be calibrated by an accredited or otherwise nationally recognized laboratory at least once every 12 months. Such an acoustical calibration shall be performed for each sound monitor at least once per year. More frequent calibrations (e.g. quarterly) are recommended."

While the particulars of the calibrations may vary between the two documents, both detail annual calibration, which is common practice at most airports with permanent noise monitoring systems.

A.1.2 The Building Codes

The International Building Code[3] (IBC) is the current building code used throughout the U.S. Local jurisdictions may adopt parts of the IBC rather than the content in its entirety in addition to adding their own local codes. The IBC is published every three years (2018 is current version, the next version will be published in 2021) and replaces the Uniform Building Code (UBC). Note that in some states, school districts and hospitals may have separate and unique building code requirements for schools and hospitals. The building code is of interest to airport noise monitoring system development because it guides the health and safety provisions of system installation. Of most concern are structural and soils requirements and electrical code provisions, including lightening protection. The structural requirements primarily related to foundations and soils conditions for the microphone pole installation vary considerably from state to state, depending on seismic requirements and local soils conditions. Care should be taken when siting microphones for adverse conditions that could greatly affect installation costs. Poles mounted near the top of slopes may require substantial footings beyond normal standards. Similarly, installation in soils subject to settling or liquefaction may be impractical. The electrical code requirements are for the safety of service personnel or any member of the public that has potential to contact the field installation. This may include lightening protection in some parts of the U.S. While system vendors have standard designs for their field monitors, local conditions and building code requirements may require substantial upgrades.

[3] International Code Council (ICC), International Building Code, 2018

A.2 FAA Guidance

A.2.1 FAA Guidance - Needs and Uses

In 1980, the FAA Office of Energy and Environment published "The Need for Airport Noise Monitoring Systems, Their Uses and Value in Promoting Civil Aviation"[4] Despite its age, the document provides useful guidance on the needs and uses of systems. Given the age of the document, the information on system costs and graphics, particularly flight track maps, are woefully out of date.

From the Abstract:

"The need for airport noise monitoring systems is addressed from a variety of perspectives focusing on potential benefits to airport proprietors, the airlines, noise impacted airport communities and civil aviation in general. The operation and cost of typical noise monitoring systems is discussed. Various techniques for noise data presentation are also reviewed. The uses of radar tracking data in providing aircraft identification, position and ground track information is explored. Legal requirements for monitoring are specified and airport use restrictions are discussed. A list of U.S. and foreign airports with noise monitoring systems is presented. FAA research efforts pertaining to airport noise monitoring systems are also outlined"

From the Introduction:

"Airport noise monitoring systems provide an important tool for assessing noise levels around airports and provide concrete evidence that airport proprietors, state governments and the Federal Government are serious about controlling aviation noise impact on communities surrounding airports."

A.2.2 FAA Guidance - Funding

A.2.2.1 Federal Aviation Administration (FAA) – Order 5100.38D (change 1), "Airport Improvement Program Handbook", February 26, 2019

FAA Order 5100.38D (change 1) "Airport Improvement Program Handbook" describes the Airport Improvement Program (AIP) grant program. This order explains the AIP process and grant program and is of high importance for airports looking to receive funding for noise programs including a Noise and Operations Monitoring System (NOMS). The most important information is contained in the following chapters:

- Chapter 2: "Who can get a Grant?"
- Chapter 3: "What projects can be funded?"
- Chapter 4: "What AIP funding is available?"

[4] Federal Aviation Administration, J.S Newman, "The Need for Airport Noise Monitoring Systems, Their Uses and Value in Promoting Civil Aviation," FAA Office of Energy and Environment, 1980.

- Chapter 5: "How does the grant process work?"

Chapter 4 is important in that it specifies that large hub/medium hub airports can receive AIP grants that total a normal Federal share of 75% to 80%, while small hub/non-hub/general aviation/reliever airports can receive AIP grants that total a normal Federal share of 90%.

Appendix R. Noise Compatibility Planning/Projects outlines everything related to noise projects. *Table R-1. General Eligibility Requirements for Noise Compatibility Projects* outlines the four (4) types of justification for a noise compatibility project to be AIP eligible include the following:

- Included in an FAA approved 14 CFR part 150 Program;
- A Facility Used Primarily for Medical or Educational Purposes;
- In a Land Use Compatibility Plan;
- In a Record of Decision.

Table R-6. Noise Compatibility Planning/Project Requirements (k) & (l) for installing a Noise and Operations Monitoring System (NOMS) outlines the factors to consider justification and eligibility for NOMS funding.

Appendix C. Prohibited Projects and Unallowable Costs outlines costs and projects that are prohibited. *Table C-5. Examples of Prohibited Projects/Costs for Noise Mitigation* shows certain aspects of NOMS installations that are not considered eligible costs and includes (16), (17), (18), & (21).

A.2.2.2 Federal Aviation Administration (FAA) – Order 5500.1, "Passenger Facility Charges", August 9, 2001

FAA Order 5500.1 "Passenger Facility Charge"[5] (PFC) describes the PFC process. As explained under the AIP grant program above, airports often use the PFC revenue as one option for the matching local share contribution for an AIP project. If a project is AIP eligible, it is also eligible for PFC funding. As long as the PFC funded project will "reduce noise or mitigate noise impacts resulting from an airport……," it is eligible to use PFCs. Noise project eligibility under the PFC program is the same as described above in FAA Order 5100.38D, except that the project does not have to be included in an approved Part 150 Noise Compatibility Plan (NCP). If a project would qualify for inclusion in a Part 150 NCP, but the agency/airport did not undertake or complete the Part 150, the project may be PFC eligible but not AIP eligible, however, noise contours would be required to support the project.

[5]Federal Aviation Administration, Order 5500.1 – Passenger Facility Charge Document Information. 2001 https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.information/documentID/12947

A.2.2.3 Title 14 Code of Federal Regulations (CFR) Part 158 - (158.13 – Use of PFC Revenue, 158.15 - Project Eligibility at PFC levels of $1, $2, or $3, & 158.17 – Project Eligibility at PFC levels of $4 or $4.50), current as of May 13, 2020

The Federal Aviation Regulations (FARs) are rules prescribed by the FAA governing all aviation activities in the U.S. The FARs are part of Title 14 of the Code of Federal Regulations (CFR)[6]. Title 14 CFR Part 158 describes Passenger Facility Charges or PFC'S.
Section 158.13 describes the use of the revenue from PFCs. Section 158.15 discusses eligibility for projects funded under PFCs levels of $1, $2, or $3. This does include projects that "Reduce noise or mitigate noise impacts resulting from an airport." Section 158.17 discusses eligibility for projects funded under PFCs levels of $4 or $4.50. This does include projects at large or medium airports for "reducing the impact of aviation noise on people living near the airport."

A.2.2.4 ACRP WebResource 1: Aligning Community Expectations with Airport Roles, 2017

ACRP WebResource 1 contains an Aviation Toolkit for airports that includes information on funding sources for airports. The section "Federal, State and Local Funding Sources for Airports,"[7] provides excellent background information on airport funding options including AIP funding, PFC funding, State government funding, local funding sources, and tax-exempt bond funding. The AIP and PFC options were explained in detail previously. State funding particulars may vary between states, but funding can be provided by fees and taxes on aircraft owners and users. This funding is usually through a State Department of Transportation or Aviation. Local funding can be provided through various tax revenues and usage fees. Tax-exempt or general obligation bonds are backed by credit from the public-at-large residing within the local general tax authorities.

A.2.2.5 Airport Cooperative Research Program (ACRP) – ACRP Synthesis 1: "Innovative Finance and Alternative Sources of Revenue for Airports," 2007[8]

This report is intended to inform airport operators about alternative financing options and revenue sources that are currently available to airport operators in the U.S. It provides an overview of common capital funding sources, a review of capital financing mechanisms, and a description of the various revenue sources developed by airport operators. The principal sources of funds for airport capital projects, listed from largest to smallest, include the following:

- Proceeds of bonds;
- PFC revenues;
- AIP grants (from the Airport and Airways Trust Fund);

[6] Electronic Code of Federal Regulations, Part 158 – Passenger Facility Charges. https://ecfr.io/Title-14/cfr158_main

[7] https://crp.trb.org/acrp0331/federal-state-and-local-funding-sources-for-airports/

[8] Nichol, Cindy, *ACRP Synthesis 1: Innovative Finance and Alternative Sources for Revenue for Airports*, 2007. http://www.trb.org/Publications/Blurbs/158669.aspx

- Internally generated capital (from retained airport revenues);
- Security grants (administered by the Transportation Security Administration (TSA) but not applicable to non-security projects);
- State grants and local financial support (Some states provide funding for airport and aviation-related projects in the form of outright grants or matching share for federal.

Airport operators regularly participate in the municipal bond markets to finance capital projects, utilizing:

- Numerous types of bonds - includes general obligation bonds, general airport revenue bonds, bonds backed by PFCs, bonds backed by customer facility charges (CFCs; fees paid by rental car customers), bonds to be paid with future AIP or state grants, and special facility bonds to finance capital projects;
- Other financial instruments – includes commercial paper, bond anticipation notes, grant anticipation notes, pooled credit programs, and capital leases;
- Minimized interest expenses – includes reduced interest rates on outstanding bonds and manages interest rate risk by entering into interest rate swaps with investment banks.

New projects can also be funded with other airline revenues, such as:

- Airport parking revenues – Parking has long been a major revenue source for airports and can be enhanced by offering premium services and enhancements;
- Rental car revenues – Airports change fees and rentals, and sometimes a CFC is collected from rental car customers and used to pay the operating and capital costs of a consolidated rental car facility or transportation to the terminals;
- Terminal concessions – Airport concession sales are a major revenue source and airports have been able to maximize revenues by enhancing terminal concession programs;
- Advertising programs – Airport advertising programs can generate income through sales of advertising at airports;
- Commercial development and land use – Revenue-producing leases can be generated from non-airline operations including manufacturing, warehousing, freight forwarding, and others.

A.2.2.6 U.S. General Accounting Office (GAO) – RCED-98-71, "Airport Financing: Funding Sources for Airport Development", March 12, 1998[9]

This report by the U.S. General Accounting Office (GAO) provides background information on funding options for airports. These include tax-exempt bonds, AIP grants, PFC fees, state and local contributions, and other airport revenues. Although this report tracks the split of funding sources from the early 1980's

[9] https://www.gao.gov/products/RCED-98-71

up until 1996, it demonstrates how funding sources vary widely between large/medium hub airports and all other airports.

A.2.2.7 U.S. General Accounting Office (GAO) – GAO-20-298, "Airport Infrastructure: Information on Funding and Financing for Planned Projects", February 13, 2020[10]

This report by the GAO provides updated background information on the funding options for airports. These options include AIP grants, PFC fees, municipal bonds, state and local contributions, and other airport-generated revenue. For larger airports, PFC fees and airport-generated revenue are the largest sources of funding. The airport-generated revenue includes both "airside" aeronautical and "landside" non-aeronautical sources. Aeronautical revenue can be collected through fixed-base operator fees, airline and cargo landing fees, fuel sales, cargo and hangar rentals, airline arrival fees, and rents. Non-aeronautical sources include hotel charges, terminal services including food and beverage, facility leases, terminal retail, rental cars, parking fees, and ground transport.

A.2.2.8 Airports Council International – North America (ACI-NA) Website – Advocacy for "Airport Infrastructure Funding", 2020[11]

The Airports Council International-North America (ACI-NA) represents over 300 commercial airports in the U.S. and Canada. Part of its mission is to advocate for policies in Washington D.C. that help airports operate efficiently and safely. This advocacy extends to "Airport Infrastructure Funding." The website provides excellent background information on airport funding options, including federal grants through the FAA's AIP, PFC user fees, tenant rents and fees, and also tax-exempt municipal bonds. AIP grants and PFC fees typically provide the majority of funding for AIP projects. Currently, ACI-NA is urging the U.S. Congress to eliminate the current cap on PFC user fees.

A.2.2.9 Federal Aviation Administration (FAA) – Airport and Airway Trust Fund (AATF) Fact Sheet, Updated: April 2020[12]

The FAA provides a fact sheet on the Airport and Airway Trust Fund (AATF) that was recently updated in April 2020. This fact sheet explains how revenues are derived from aviation-related excise taxes on passengers, cargo, and fuel and provides a breakdown of the tax revenue sources and corresponding rates as of January 1, 2020. These taxes provide funding for capital improvement projects through grants at U.S. airports.

A.2.3 FAA Guidance – Planning and Environmental Studies

This section addresses the guidance in the FAA noise/land use planning process (Federal Aviation Regulation Part 150) and the FAA environmental order regarding environmental documents (FAA Order

[10] https://www.gao.gov/products/GAO-20-298

[11] https://airportscouncil.org/advocacy/airport-infrastructure-funding/

[12] https://www.faa.gov/about/budget/aatf/media/AATF_Fact_Sheet.pdf

1050.1F[13]). Neither Part 150 nor FAA Order 1050 requires the use of, or installation of, a permanent noise monitoring system. The following addresses the use of noise measurements in both documents:

A.2.3.1 Part 150, Airport Noise Compatibility Planning

The appendix of FAR Part 150 includes Section A150.5 "Noise measurement procedures and equipment." This appendix outlines the measurement standards and references methods for short-term portable noise monitoring and provides no guidance relative to permanent noise monitoring systems. This appendix states: "Whenever noise monitoring is used, under this part, it should be accomplished in accordance with Sec. A150.5 of this appendix," thus indicating that noise measurements are not a requirement for a Part 150 study. It is important to note that FAA funding of a permanent noise monitoring system may depend on permanent noise monitoring being a part of an accepted Part 150 Noise Control Plan.

Part 150 Guidelines (FAA, 1983): In 1983, the FAA published guidelines for implementing FAR Part 150 programs. It includes the following section describing potential uses and reasons for including a permanent noise monitoring system as part of a Noise Control Program. This is the entirety of the discussion.

"226. CONTINUOUS AIRPORT NOISE MONITORING SYSTEMS. There are several optional measures which may be undertaken as part of an airport noise compatibility program and which can enhance its effectiveness. Continuous airport noise monitoring systems fall into this category. Such systems can provide important input to the process of refining airport noise contours. (Contact AEE-120 for specific details). In brief, any FAA approved noise monitoring system would have the following minimum capabilities:

- *Provides continuous measurement of dBA at each site;*
- *Provides hourly Leq data;*
- *Provides daily DNL data;*
- *Provides single event maximum A-weighted sound level data.*

Desirable but nonessential capabilities include:

- *Aircraft event discrimination ability;*
- *Single event LAE data for each aircraft event;*
- *Differentiation between ambient and aircraft contributions to hourly Leq and Ldn;*
- *Monitoring data can be used to develop a statistical database of noise levels for each aircraft type category."*

[13] Federal Aviation Administration, Order 1050.1F- Environmental Impacts: Policies and Procedures, 2015

The above text from the Part 150 guidelines on 'desirable but nonessential capabilities" is woefully out of date. Aircraft event discrimination and differentiation between ambient and aircraft contributions to hourly Leq and daily Ldn should be mandatory for any modern system. At the time these guidelines were written, 1983, radar data was not available to airports and these tasks were quite difficult, expensive, and not very reliable.

A.2.3.2 FAA Order 1050.1F- Environmental Impacts: Policies and Procedures

The FAA order, specifying in detail the requirements for compliance with the National Environmental Policy Act (NEPA), does not provide any requirements or guidance on the use of permanent noise monitoring systems:

"Noise monitoring data is not required for FAA noise analyses but may optionally be included in a National Environmental Policy Act (NEPA) document."

In practice, when noise measurement data is provided in an Environmental Assessment or Environmental Impact Statement, the guidance provided in the FAR Part 150 guidelines[14] is used.

A.3 Technical Papers

There is a relatively small amount of recently published literature on the general topic of airport noise monitoring systems. Technical bulletins and sales literature from system vendors are readily available online and are thus not presented here. The technical papers that are reviewed herein all relate to the difficult task of recognizing aircraft noise in the built environment where other background noise makes source identification very difficult.

Close to the airport where aircraft noise levels are much higher than the community noise sources like cars, trucks, buses, motorcycles, lawnmowers, leaf blowers, etc., aircraft noise is easy to identify and early noise monitoring systems installed around airports generally were close to the airport and source classification was relatively easy. In more recent years, the aircraft noise levels in communities farther from the airport have become more of an interest and aircrafts are much quieter than in the early years, making source identification more difficult. In this case, the problem of distinguishing aircraft noise from other community noise sources is much more difficult. The problem is generally and technically called a signal to noise ratio (SNR or s/n) problem. The holy grail of this industry is finding an acoustical method to determine the aircraft portion of the total community noise.

A.3.1 Papers

The papers discussed below are published efforts to solve this problem, but none have led to a practical solution that can be incorporated into today's noise monitoring systems.

[14] Federal Aviation Administration, Advisory Circular AC 150/5020-1, "Noise Control and Compatibility Planning for Airports" (aka, FAR Part 150 Guidelines), 1983

A.3.1.1 "Environmental noise monitoring using source classification in sensors," Maijala, P. et al, Applied Acoustics, 2017.

This technical paper attempts to use pattern classification algorithms and artificial neural networks to separate the desired source noise from community and wind noise. The authors test the system using rock quarry noise but identify these techniques as applicable to aircraft noise. Note that approaches like this have been attempted since the first digital audio processors were developed in the late 1970s. Because jet aircraft noise has few, if any, unique identifying frequency characteristics, this paper is yet another example of the search for the key to audio aircraft identification.

A.3.1.2 "Noise Pattern Recognition of Airplanes Taking Off: Task for a Monitoring System," Fernández L., et al, Progress in Pattern Recognition, Image Analysis and Applications. CIARP 2007. Lecture Notes in Computer Science, vol 4756. Springer, Berlin, Heidelberg.

This paper, based on conference proceedings, is another example of using complex spectral analysis to identify aircraft noise from background noise. The paper provides significant insight into the difficult mathematics needed to characterize the spectral content of aircraft noise and concludes with some good examples of aircraft spectral data. The paper recommends additional work needed to complete the task of finding this spectral signature within background noise.

A.3.1.3 Aircraft Noise Monitoring: Noise Level Shape and Spectrum Pattern Recognition Applied to Aircraft Noise Detection," C. Rosin, et al, Internoise 2010.

This paper provides a very good example of a practical method to identify aircraft noise from background noise using traditional and spectral methods. The work was done using the permanent noise monitoring system at Aéroports de Paris by their staff. The paper goes through the process in some detail and includes the following steps:

- Cut off the noise level signal in items by slope analysis;
- Filter out the improbable aircraft noise items on duration and noise level threshold;
- Validate the probable aircraft items by a pattern recognition from the noise spectrum;
- Correlate with the flight path from radar information.

This process of aircraft noise identification is similar to what is currently done in most airport noise monitoring systems, but includes the added step of pattern recognition from the noise spectrum. This is somewhat useful, but their method still requires the noise event exceed a noise event threshold which does not solve the problem of aircraft noise mixed in with high background noise levels.

A.3.1.4 "Convolutional Neural Networks for Aircraft Noise Monitoring," N. Heller, et al, arXiv:1806.04779, 2018

The paper is a preprint article not yet subjected to peer review but is notable because it was done in conjunction with the noise staff at the Metropolitan Airports Commission (Minneapolis) using data from their airport noise monitoring system. They summarize the problem as follows:

"Noise monitoring and analysis is complicated by the fact that aircraft are not the only source of noise. In this work, we show that a Convolutional Neural Network is well-suited for the task of identifying noise events which are not caused by aircraft."

Their approach of using complex spectral analysis of neural networks is beyond the scope of this review. They report good success for aircraft events that exceed the noise event threshold. That is, when there are noise events that exceed the noise threshold, but not caused by an aircraft, the system was mostly successful in classifying the event as non-aircraft. The authors go on to state the key step needed for distinguishing aircraft noise from high background noise as follows:

"In the future, we plan to extend this work to examining the entire time-stream from each monitoring station in order to attempt classification of noises that fall short of the event threshold, but still may have been caused by aircraft."

This next step would improve noise monitoring at sites removed from the airport where community noise competes with aircraft noise.

Appendix B: List of NOMS, Non-NOMS, & Other Airports

NOMS Airports (89)*	
ABQ – Albuquerque International Airport	ACK – Nantucket Memorial Airport
APA – Centennial Airport	APF – Naples Airport
ATL – Hartsfield-Jackson Atlanta International Airport	AUS – Austin-Bergstrom International Airport
BCT – Boca Raton Airport	BDL – Bradley International Airport
BED – Laurence G. Hanscom Field	BFI – Boeing Field/King County International Airport
BNA – Nashville International Airport	BOS – General E.L. Logan International Airport
BUR – Hollywood Burbank Airport	BWI – Baltimore-Washington International Airport
CLE – Cleveland Hopkins International Airport	CLT – Charlotte-Douglas International Airport
CMH – John Glenn Columbus International Airport	CRG – Jacksonville Executive Airport
CRQ – McClellan-Palomar Airport	CVG – Cincinnati/Northern Kentucky International Airport
DAL – Dallas Love Field	DCA – Ronald Reagan Washington National Airport
DEN – Denver International Airport	DFW – Dallas/Ft. Worth International Airport
EFD – Ellington Field	EWR – Newark Liberty International Airport
FLL – Fort Lauderdale-Hollywood International	FXE – Fort Lauderdale Executive Airport
GSO – Piedmont-Triad International Airport	HNL – Daniel K. Inouye International Airport
HOU – William P. Hobby Airport	HPN – Westchester County Airport
HTO – East Hampton Airport	HWD – Haywood Executive Airport
HYA – Barnstable Municipal Airport	IAD – Washington Dulles International Airport
IAH – George Bush Intercontinental Airport	IND – Indianapolis International Airport
ITO – Hilo International Airport	IWA – Phoenix-Mesa Gateway Airport
JAX – Jacksonville International Airport	JFK – John F. Kennedy International Airport
LAS – McCarran International Airport	LAX – Los Angeles International Airport
LGA – LaGuardia Airport	LGB – Long Beach Airport
LUK – Lunken Airport	MCO – Orlando International Airport
MDW – Chicago Midway International Airport	MIA – Miami International Airport
MKE – Milwaukee Mitchell International Airport	MSP – Minneapolis-Saint Paul International Airport
MYF – Montgomery Field	OAK – Oakland International Airport
ONT – Ontario International Airport	ORD – Chicago O'Hare International Airport

List of NOMS, Non-NOMS, & Other Airports (continued)

NOMS Airports – (cont.)	
PAE – Paine Field/Snohomish County Airport	PBI – Palm Beach International Airport
PDK – DeKalb-Peachtree Airport	PDX – Portland International Airport
PGD – Punta Gorda Airport	PHL – Philadelphia International Airport
PHX – Phoenix Sky Harbor International Airport	PVD – Theodore Francis Green State Airport
PWM – Portland International Jetport	RDU – Raleigh-Durham International Airport
RNO – Reno/Tahoe International Airport	SAN – San Diego International Airport
SAT – San Antonio International Airport	SBA – Santa Barbara Municipal Airport
SDF – Louisville International Airport	SEA – Seattle-Tacoma International Airport
SFB – Orlando Sanford International Airport	SFO – San Francisco International Airport
SJC – Norman J. Mineta San Jose International	SMF – Sacramento International Airport
SMO – Santa Monica Airport	SNA – John Wayne Airport
SQL – San Carlos Airport	SRQ – Sarasota-Bradenton International Airport
STL – St. Louis Lambert International Airport	STS – Charles M. Schulz-Sonoma County Airport
SUA – Witham Field Martin County Airport	SWF – Stewart International Airport
TOA – Torrance Municipal Airport	TEB – Teterboro Airport
TRK – Truckee Tahoe Airport	TPA – Tampa International Airport
VQQ – Cecil Airport	VNY – Van Nuys Airport

* Received the Type A Airport Questionnaire.
Source: Landrum & Brown, 2021.

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – Commercial Services Airports (306)*	
(Including 50 States, American Samoa, Guam, Northern Marianas, Puerto Rico, & U.S. Virgin Islands)	
Alabama (5)	
MOB – Mobile Regional Airport	MGM – Montgomery Regional Airport
HSV – Huntsville International Airport	DHN - Dothan Regional Airport
BHM - Birmingham Shuttlesworth International Airport	
Alaska (25)	
MRI – Merrill Field	ANI – Aniak Airport
BRW – Wiley Post-Will Rogers Memorial Airport	BET – Bethel Airport
CDV – Merle K. (Mudhole) Smith Airport	SCC – Deadhorse Airport
DLG – Dillingham Airport	FAI – Fairbanks International Airport
GAL – Edward G. Pitka St. Airport	HOM – Homer Airport
JNU - Juneau International Airport	ENA – Kenai Municipal Airport
KTN – Ketchikan International Airport	AKN – King Salmon Airport
ADQ – Kodiak Airport	OTZ – Ralph Wien Memorial Airport
OME – Nome Airport	PSG – Petersburg James A. Johnson Airport
SIT – Sitka Rocky Gutierrez Airport	KSM – St. Mary's Airport
UNK – Unalakleet Airport	VDZ – Valdez Airport
DUT – Unalaska Airport	WRG – Wrangell Airport
YAK – Yakutat Airport	
Arizona (7)	
TUS - Tucson International Airport	IFP – Laughlin/Bullhead International Airport
FLG – Flagstaff Pulliam Airport	GCN – Grand Canyon National Park Airport
PGA – Page Municipal Airport	YUM – Yuma International Airport
GCW – Grand Canyon West Airport	
Arkansas (4)	
XNA – Northwest Arkansas Regional Airport	FSM – Fort Smith Regional Airport
LIT – Bill and Hillary Clinton National Airport	TXK – Texarkana Regional Airport
California (10)	
ACV – Arcata Airport	BFL – Meadows Field
FAT – Fresno Yosemite International Airport	MMH – Mammoth Yosemite Airport
MRY – Monterey Regional Airport	PSP – Palm Springs International Airport

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – Commercial Services Airports (cont.)	
(Including 50 States, American Samoa, Guam, Northern Marianas, Puerto Rico, & U.S. Virgin Islands)	
California (10) (cont.)	
RDD – Redding Municipal Airport	SBP – San Luis Obispo County Regional Airport
SMX – Santa Maria Public Airport	SCK – Stockton Metropolitan Airport
Colorado (8)	
ASE – Aspen-Pitkin County Airport	COS – Colorado Springs Municipal Airport
DRO – Durango-La Plata County Airport	EGE – Eagle County Regional Airport
GJT – Grand Junction Regional Airport	GUC – Gunnison-Crested Butte Regional Airport
HDN – Yampa Valley Airport	MTJ – Montrose Regional Airport
Connecticut (1)	
HVN – Tweed New Haven Regional Airport	
Delaware (1)	
ILG – Wilmington Airport	
Florida (11)	
DAB – Daytona Beach International Airport	RSW – Southwest Florida International Airport
VPS – Destin-Fort Walton Beach Airport	GNV – Gainesville Regional Airport
EYW – Key West International Airport	MLB – Orlando Melbourne International Airport
ECP – Northwest Florida Beaches International Airport	TLH – Tallahassee International Airport
PNS – Pensacola International Airport	UST – Northeast Florida Regional Airport
PIE – St. Pete-Clearwater International Airport	
Georgia (6)	
ABY – Southwest Georgia Regional Airport	AGS – Augusta Regional Airport
BQK – Brunswick Golden Isles Airport	CSG – Columbus Metropolitan Airport
SAV – Savannah/Hilton Head International Airport	VLD – Valdosta Regional Airport
Hawaii (5)	
OGG – Kahului Airport	KOA – E. Onizuka Kona International Airport
MKK – Molokai Airport	LNY – Lanai Airport
LIH – Lihue Airport	

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – Commercial Services Airports (cont.)	
(Including 50 States, American Samoa, Guam, Northern Marianas, Puerto Rico, & U.S. Virgin Islands)	
Idaho (5)	
IDA – Idaho Falls Regional Airport	LWS – Lewiston-Nez Perce County Airport
PIH – Pocatello Regional Airport	SUN – Friedman Memorial Airport
TWF – Magic Valley Regional Airport	
Illinois (9)	
BLV – MidAmerica St. Louis Airport	BMI – Central Illinois Regional Airport
CMI – University of Illinois-Willard Airport	MWA – Williamson County Regional Airport
MLI – Quad City International Airport	RFD – Chicago Rockford International Airport
UIN – Quincy Regional Airport	SPI – Abraham Lincoln Capital Airport
PIA – General Wayne A. Downing Peoria International Airport	
Indiana (3)	
EVV – Evansville Regional Airport	FWA – Fort Wayne International Airport
SBN – South Bend International Airport	
Iowa (5)	
CID – Eastern Iowa Airport	DSM – Des Moines International Airport
DBQ – Dubuque Regional Airport	SUX – Sioux Gateway Airport
ALO – Waterloo Regional Airport	
Kansas (4)	
GCK – Garden City Regional Airport	MHK – Manhattan Regional Airport
FOE – Topeka Regional Airport	ICT – Wichita Dwight D. Eisenhower National Airport
Kentucky (3)	
LEX – Blue Grass Airport	OWB – Owensboro-Daviess County Regional Airport
PAH – Barkley Regional Airport	
Louisiana (7)	
AEX – Alexandria International Airport	LFT – Lafayette Regional Airport
LCH – Lake Charles Regional Airport	MLU – Monroe Regional Airport
SHV – Shreveport Regional Airport	MSY – Louis Armstrong New Orleans Int. Airport
BTR – Baton Rouge Metropolitan Airport	

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – Commercial Services Airports (cont.)	
(Including 50 States, American Samoa, Guam, Northern Marianas, Puerto Rico, & U.S. Virgin Islands)	
Maine (3)	
BGR – Bangor International Airport	PQI – Northern Maine Regional Airport
RKD – Knox County Regional Airport	
Maryland (2)	
HGR – Hagerstown Regional Airport	SBY – Salisbury-Ocean City Regional Airport
Massachusetts (3)	
PVC – Provincetown Municipal Airport	MVY – Martha's Vineyard Airport
ORH – Worcester Regional Airport	
Michigan (14)	
APN – Alpena County Regional Airport	ESC – Delta County Airport
FNT – Bishop International Airport	GRR – Gerald R. Ford International Airport
CMX – Houghton County Memorial Airport	IMT – Ford Airport
AZO – Kalamazoo/Battle Creek International Airport	TVC – Cherry Capital Airport
LAN – Capital Region International Airport	MQT – Sawyer International Airport
MKG – Muskegon County Airport	PLN – Pellston Regional Airport
MBS – Saginaw International Airport	CIU – Chippewa County International Airport
Minnesota (7)	
BJI – Bemidji Regional Airport	BRD – Brainerd Lakes Regional Airport
DLH – Duluth International Airport	HIB – Range Regional Airport
INL – Falls International Airport	RST - Rochester International Airport
STC – St. Cloud Regional Airport	
Mississippi (3)	
GTR – Golden Triangle Regional Airport	GPT – Gulfport-Biloxi International Airport
JAN – Jackson-Evers International Airport	
Missouri (4)	
COU – Columbia Regional Airport	JLN – Joplin Regional Airport
SGF – Springfield-Branson National Airport	MCI – Kansas City International Airport
Montana (8)	
BIL – Billings L International Airport	BZN – Bozeman Yellowstone International Airport
BTM – Bert Mooney Airport	GTF – Great Falls International Airport

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – Commercial Services Airports (cont.)	
(Including 50 States, American Samoa, Guam, Northern Marianas, Puerto Rico, & U.S. Virgin Islands)	
Montana (8) (cont.)	
HLN – Helena Regional Airport	FCA – Glacier Park International Airport
MSO – Missoula International Airport	SDY – Sidney-Richland Municipal Airport
Nebraska (3)	
GRI – Central Nebraska Regional Airport	LNK – Lincoln Airport
OMA – Eppley Field	
Nevada (3)	
BLD – Boulder City Municipal Airport	EKO – Elko Regional Airport
VGT – North Las Vegas Airport	
New Hampshire (3)	
LEB – Lebanon Municipal Airport	MHT – Manchester-Boston Regional Airport
PSM – Portsmouth International Airport	
New Jersey (2)	
ACY – Atlantic City International Airport	TTN – Trenton Mercer Airport
New Mexico (3)	
HOB – Lea County Regional Airport	ROW – Roswell International Air Center
ROW – Roswell International Air Center	
New York (13)	
ALB – Albany International Airport	BGM – Greater Binghamton Airport
BUF – Buffalo Niagara International Airport	ELM – Elmira/Corning Regional Airport
FRG – Republic Airport	ISP – Long Island MacArthur Airport
ITH – Ithaca Tompkins International Airport	IAG – Niagara Falls International Airport
ROC – Greater Rochester International Airport	PBG - Plattsburgh International Airport
ART – Watertown International Airport	SYR – Syracuse Hancock International Airport
North Carolina (7)	
AVL – Asheville Regional Airport	USA - Concord Regional Airport
FAY - Fayetteville Regional Airport	PGV – Pitt-Greenville Airport
OAJ – Albert J. Ellis Airport	EWN – Coastal Carolina Regional Airport
ILM – Wilmington International Airport	

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – Commercial Services Airports (cont.)	
(Including 50 States, American Samoa, Guam, Northern Marianas, Puerto Rico, & U.S. Virgin Islands)	
North Dakota (6)	
BIS – Bismarck Municipal Airport	DIK – Dickinson Theodore Roosevelt Int. Airport
FAR – Hector International Airport	GFK – Grand Forks International Airport
MOT – Minot International Airport	XWA – Williston Basin International Airport
Ohio (5)	
CAK – Akron-Canton Regional Airport	LCK – Rickenbacker International Airport
DAY – James M. Cox Dayton International Airport	TOL – Toledo Express Airport
YNG – Youngstown-Warren Regional Airport	
Oklahoma (3)	
LAW – Lawton-Fort Sill Regional Airport	OKC – Will Rogers World Airport
TUL – Tulsa International Airport	
Oregon (4)	
EUG – Eugene Airport	MFR – Rogue Valley-Medford International Airport
OTH – Southwest Oregon Regional Airport	RDM – Redmond Municipal Airport
Pennsylvania (8)	
ABE – Lehigh Valley International Airport	ERI - Erie International Airport
MDT – Harrisburg International Airport	LBE – Arnold Palmer Regional Airport
PIT - Pittsburgh International Airport	SCE – University Park Airport
AVP – Wilkes-Barre/Scranton International Airport	IPT – Williamsport Regional Airport
Rhode Island (2)	
BID – Block Island State Airport	WST – Westerly State Airport
South Carolina (6)	
CHS - Charleston International Airport	CAE – Columbia Metropolitan Airport
FLO – Florence Regional Airport	GSP – Greenville-Spartanburg International Airport
HHH – Hilton Head Airport	MYR – Myrtle Beach International Airport
South Dakota (3)	
ABR – Aberdeen Regional Airport	RAP – Rapid City Regional Airport
FSD – Sioux Falls Regional Airport	

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – Commercial Services Airports (cont.)	
(Including 50 States, American Samoa, Guam, Northern Marianas, Puerto Rico, & U.S. Virgin Islands)	
Tennessee (4)	
CHA – Chattanooga Metropolitan Airport	TYS – McGhee Tyson Airport
MEM – Memphis International Airport	TRI – Tri-Cities Regional Airport
Texas (16)	
ABI – Abilene Regional Airport	AMA – Rick Husband Amarillo International Airport
BPT – Jack Brooks Regional Airport	BRO – Brownsville/South Padre Island Int. Airport
CLL – Easterwood Airport	CRP – Corpus Christi International Airport
ELP – El Paso International Airport	HRL – Valley International Airport
GRK – Killleen-Fort Hood Regional Airport	LRD – Laredo International Airport
MFE – McAllen Miller International Airport	MAF – Midland International Airport
SJT – San Angelo Regional Airport	TYR – Tyler Pounds Regional Airport
ACT – Waco Regional Airport	SPS – Wichita Falls Municipal Airport
Utah (5)	
SLC – Salt Lake City International Airport	OGD – Ogden-Hinckley Airport
PVU – Provo Municipal Airport	SGU – St. George Regional Airport
CDC – Cedar City Regional Airport	
Vermont (1)	
BTV – Burlington International Airport	
Virginia (6)	
CHO – Charlottesville-Albermale Airport	LYH – Lynchburg Regional Airport
PHF – Newport News/Williamsburg International Airport	ORF – Norfolk International Airport
RIC – Richmond International Airport	ROA – Roanoke-Blacksburg Regional Airport
Washington (8)	
BLI – Bellington International Airport	FRD – Friday Harbor Airport
PSC – Tri-Cities Airport	PUW – Pullman/Moscow Regional Airport
GEG – Spokane International Airport	ALW – Walla Walla Regional Airport
EAT – Pangborn Memorial Airport	YKM – Yakima Air Terminal
West Virginia (4)	
CRW – Yeager Airport	CKB – North Central West Virginia Airport
HTS – Tri-State Airport	MGW – Morgantown Municipal Airport

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – Commercial Services Airports (cont.)	
(Including 50 States, American Samoa, Guam, Northern Marianas, Puerto Rico, & U.S. Virgin Islands)	
Wisconsin (7)	
ATW - Appleton International Airport	EAU – Chippewa Valley Regional Airport
LSE – La Crosse Regional Airport	CWA – Central Wisconsin Airport
RHI – Rhinelander-Oneida County Airport	MSN – Dane County Regional Airport
GRB – Green Bay Austin Straubel International Airport	
Wyoming (6)	
CPR – Casper/Natrona County International Airport	COD – Yellowstone Regional Airport
GCC – Gillette-Campbell County Airport	JAC – Jackson Hole Airport
LAR – Laramie Regional Airport	RKS – Southwest Wyoming Regional Airport
American Samoa (1)	
PPG – Pago Pago International Airport	
Guam (1)	
GUM – Antonio B. Won Pat International Airport	
Northern Marianas (3)	
SPN – Saipan International Airport	ROP – Rota International Airport
TIQ – Tinian International Airport	
Puerto Rico (7)	
SJU – Luis Munoz Marin International Airport	BQN – Rafael Hernandez International Airport
NRR – Jose Aponte de la Torre Airport	CPX – Benjamin Rivera Noriega Airport
PSE – Mercedita International Airport	SIG – Fernando Luis Ribas Dominicci Airport
VQS – Antonio Rivera Rodriguez Airport	
U.S. Virgin Islands (2)	
STX – Henry E. Rohlsen Airport	STT – Cyril E. King Airport

* Received the Type B Airport Questionnaire.
Source: Landrum & Brown, 2021.

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – General Aviation Airports (110)*	
(Busiest 200 GA Airports from 2019 FAA ATADS & not included on other lists, w/ or w/o NOMS)	
Arizona (8)	
DVT – Deer Valley Airport	SDL – Scottsdale Airport
CHD – Chandler Municipal Airport	FFZ – Falcon Field Airport
PRC – Prescott Regional Airport	GYR – Phoenix Goodyear Airport
RYN – Ryan Airfield	GEU – Glendale Municipal Airport
California (20)	
SAC – Sacramento Executive Airport	CMA – Camarillo Airport
SEE – Gillespie Field	APC – Napa County Airport
SDM – Brown Municipal Field	SQL – San Carlos Airport
MHR – Sacramento Mather Airport	EMT – San Gabriel Valley Airport
HHR – Hawthorne Municipal Airport	WHP – Whiteman Airport
POC – Brackett Field	LVK – Livermore Municipal Airport
CNO – Chino Airport	FUL – Fullerton Municipal Airport
RNM – Ramona Airport	RAL – Riverside Municipal Airport
SNS – Salina Municipal Airport	CCR – Buchanan Field
PAO – Palo Alto Airport	BFL – Meadows Field
Colorado (2)	
FTG – Front Range Airport	BJC – Rocky Mountain Metropolitan Airport
Connecticut (1)	
GON – Groton-New London Airport	
Florida (20)	
TMB – Miami Executive Airport	OPF – Miami Opa Locka Executive Airport
VRB – Vero Beach Municipal Airport	BKV – Brooksville-Tampa Bay Regional Airport
TIX – Space Coast Regional Airport	LEE – Leesburg International Airport
SPG – Albert Whitted Airport	OMN – Ormond Beach Municipal Airport
DTS – Destin Executive Airport	OCF – Ocala International Airport
FIN – Flagler Executive Airport	SGJ – Northeast Florida Regional Airport
EVB – New Smyrna Beach Municipal Airport	ORL – Orlando Executive Airport
FMY – Paige Field	LAL – Lakeland Linder Regional Airport
PMP – Pompano Beach Airpark	FPR – St. Lucie County International Airport

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – General Aviation Airports (cont.)	
(Busiest 200 GA Airports from 2019 FAA ATADS & not included on other lists, w/ or w/o NOMS)	
Florida (20) (cont.)	
ISM – Kissimmee Gateway Airport	HWO – North Perry Airport
Georgia (3)	
FTY – Fulton County Airport	RYY – Cobb County International Airport
LZU – Gwinnett County Airport	
Illinois (3)	
ARR – Aurora Municipal Airport	PWK – Chicago Executive Airport
DPA – Dupage Airport	
Indiana (2)	
BAK – Columbus Municipal Airport	LAF – Purdue University Airport
Kentucky (1)	
LOU – Bowman Field	
Louisiana (1)	
NEW – Lakefront Airport	
Maryland (2)	
MTN – Martin State Airport	FDK – Frederick Municipal Airport
Massachusetts (2)	
OWD – Norwood Memorial Airport	BVY – Beverly Regional Airport
Michigan (3)	
ARB – Ann Arbor Municipal Airport	BTL – W.K. Kellogg Airport
PTK – Oakland County International Airport	
Minnesota (2)	
ANE – Anoka County Airport	FCM – Flying Cloud Airport
Missouri (2)	
MKC – Charles B. Wheeler Downtown Airport	SUS – Spirit of St. Louis Airport
Nevada (1)	
HND – Henderson Executive Airport	
New Hampshire (1)	
ASH – Boire Field	

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – General Aviation Airports (cont.)	
(Busiest 200 GA Airports from 2019 FAA ATADS & not included on other lists, w/ or w/o NOMS)	
New Jersey (2)	
CDW – Essex County Airport	MMU – Morristown Municipal Airport
New York (1)	
FOK – Francis S. Gabreski Airport	
North Carolina (1)	
JQF – Concord Regional Airport	
Ohio (1)	
OSU – Ohio State University Airport	
Oklahoma (3)	
PWA – Wiley Post Airport	SWO – Stillwater Regional Airport
RVS – Richard Lloyd Jones Jr Airport	
Oregon (2)	
UAO – Aurora State Airport	HIO – Portland-Hillsboro Airport
Pennsylvania (2)	
LNS – Lancaster Airport	PNE – Northeast Philadelphia Airport
South Carolina (1)	
GMU – Greenville Downtown Airport	
Tennessee (1)	
MQY – Smyrna/Rutherford County Airport	
Texas (17)	
DWH – David Wayne Hooks Memorial Airport	
FTW – Fort Worth Meacham International Airport	ADS – Addison Airport
CXO – Conroe-North Houston Regional Airport	DTO – Denton Enterprise Airport
AFW – Fort Worth Alliance Airport	GTU – Georgetown Municipal Airport
RBD – Dallas Executive Airport	GYI – North Texas Regional Airport
FWS – Fort Worth Spinks Airport	LBB – Lubbock Preston Smith International
GKY – Arlington Municipal Airport	SGR – Sugar Land Regional Airport
HYI – San Marcos Regional Airport	SSF – Stinson Municipal Airport
GPM – Grand Prairie Municipal Airport	TKI – McKinney National Airport

List of NOMS, Non-NOMS, & Other Airports (continued)

Non-NOMS Airports – General Aviation Airports (cont.)	
(Busiest 200 GA Airports from 2019 FAA ATADS & not included on other lists, w/ or w/o NOMS)	
Virginia (1)	
HEF – Manassas Regional Airport	
Washington (3)	
OLM – Olympia Regional Airport	TIW – Tacoma Narrows Airport
RNT – Renton Municipal Airport	
Wisconsin (1)	
ENW – Kenosha Airport	
Other Airports (3)**	
(Initiated & did not complete installation process)	
BOI – Boise Airport	DTW – Detroit Metropolitan Airport
RHV – Reid-Hillview Airport	
Other Airports (2)***	
(Procured & currently not operable)	
ANC – Ted Stevens Anchorage International Airport	SUA – Whitham Field (eventually acquired Vector)

* Received the Type B-1 and B-2 Airport Questionnaire.
** Received the Type B-3 Airport Questionnaire.
*** Received the Type B-4 Airport Questionnaire.
Source: Landrum & Brown, 2021.

Appendix C: Airport NOMS Questionnaire Type A

(Questionnaire Type A included questions for 89 airports that currently operate a Noise and Operations Monitoring System (NOMS). The pages were exported from the Survey Monkey questionnaire web page.)

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

Background

The objective of ACRP Research Project 02-89 is to develop a primer and a decision-making framework to help airports and other stakeholders assess the benefits and costs of acquiring, maintaining, and updating an airport Noise and Operations Monitoring System (NOMS).

The following questionnaire developed by Landrum & Brown and Barry Technologies (The Research Team) will be part of the research that will assist airports decide if a NOMS is appropriate for their situation, evaluating the benefits and costs of acquiring and updating such systems, and determining the general resources needed to acquire, operate, and maintain these systems.

The questions are grouped into the following sections:

- **Background**
- **NOMS Use**
- **Data Collection**
- **Data Distribution**
- **Requirements**
- **Benefits**
- **Reasoning, and**
- **Funding**

The survey format allows you to skip most questions, but we ask that you answer every question if possible. The questionnaire is compatible with computers, phones, and tablets.

Thank you in advance for your participation,

The Research Team

* 1. Please provide the following information for your airport:

Name(s) of airport(s):

3-letter identifier:

Owner/Operator of the airport:

2. Does the Owner/Operator manage multiple airports?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

Background

3. If the Owner/Operator manages multiple airports, do all airports operate a NOMS?

- ◯ Yes
- ◯ No

4. When was your NOMS procured?

Month/Year _____

5. If you've procured multiple NOMS, please provide all procurement dates:

Month/Year _____

Month/Year _____

6. When did your NOMS become fully operational?

Month/Year _____

7. If you've operated multiple NOMS, please provide multiple operational dates:

Month/Year _____

Month/Year _____

8. Has the NOMS gone through major upgrades?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

Background

9. If the NOMS has gone through major upgrades, please describe the upgrade(s):

10. What years were major NOMS upgrades done?

11. Were permanent noise monitors installed?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

Background

12. How many permanent noise monitors were installed?

13. Of the permanent monitors installed, how many were requested by a municipality/community?

14. Please select the following items that apply relative to the permanent noise monitor installation:

- [ ] Mount - Utility Pole
- [ ] Mount - Custom pole or mount
- [ ] Mount - Combination
- [ ] Power Source - Solar or A/C Power
- [ ] Power Source: D/C Power
- [ ] Power Source - Combination
- [ ] Data Connectivity - Wireless
- [ ] Data Connectivity - Phone Line
- [ ] Data Connectivity - Manual Download
- [ ] Data Connectivity - Combination

15. Were portable noise monitors provided with the NOMS?

- ( ) Yes
- ( ) No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

Background

16. How many portable monitors were provided?

17. Please describe how the portable noise monitors are used:

18. Were additional portable noise monitors purchased separately?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

Background

19. How many portable noise monitors were purchased separately?

20. Please describe the reasons the portable noise monitors were purchased separately:

21. Was a site selection analysis/study performed?

- Yes, in-house
- Yes, outsourced by consultant
- Yes, by NOMS vendor
- No

22. Was the public involved in site selection?

- Yes
- No

23. Are sites on public or private property?

- Public
- Private
- Both

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

Background

24. For sites on private property, do you pay a short/long-term lease or an annual stipend for access and use?

- ◯ Yes
- ◯ No

25. Does your airport use Virtual Noise Monitors (computed noise events instead of measured events)?

- ◯ Yes, at all monitoring locations
- ◯ Yes, to supplement permanent/portable noise monitors
- ◯ No

26. Does your airport use different vendors for NOMS components (e.g. one vendor for flight tracking, another vendor for complaint data, and another vendor for noise monitors)?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

Background

27. How many vendors supply your NOMS components?

28. Has your airport always used one NOMS vendor/software, or has your airport used multiple NOMS vendor/software services over time?

- ◯ One NOMS software
- ◯ Multiple NOMS software

29. How many years did you use each vendor/software?

Vendor/Software #1 Years:

Vendor/Software #2 Years:

Vendor/Software #3 Years:

30. If you switched from one NOMS software to a different NOMS software, please describe the reasons for switching:

31. Has your airport always used one model/brand of noise monitors, or has your airport used multiple models/brands over time?

- ◯ One NOMS Monitor
- ◯ Multiple NOMS Monitors

32. How many years did you use each model?

Model/Brand #1 Years

Model/Brand #2 Years

Model/Brand #3 Years

33. If you switched to a different model/brand of noise monitors, please describe the reasons for switching:

34. Does your airport currently plan to relocate or increase the number of noise monitoring terminals at your airport?

- Yes
- No

35. Besides the hardware and software components of the NOMS, please describe the types of tools (including hardware and software) your airport is using to handle flight data requests from the public, airport noise complaints, and noise-to-flight matching (if applicable):

36. Relative to maintaining and operating a NOMS; does your airport use an asset management system (i.e. Excel spreadsheets, Access Database, Other Program Software, etc.) to track NOMS monitoring sites and your inventory of equipment?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

Background

37. Please describe your asset management system:

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

NOMS Use

38. How is your NOMS used? (Check all that apply):

- ☐ To monitor flights in general
- ☐ To monitor specific noise abatement flight procedures
- ☐ To monitor noise abatement runway use
- ☐ To monitor noise levels/limits at monitors
- ☐ To monitor run-ups
- ☐ To monitor taxiing
- ☐ To monitor airspace use
- ☐ To monitor nighttime curfews
- ☐ To monitor aircraft departure and approach profiles
- ☐ To monitor community noise levels
- ☐ To monitor compliance with agreements/mandates i.e. community commitments
- ☐ Other (please specify)

39. Which methods/platforms does your community use to submit complaints? (Check all that apply).

- ☐ Postal mail
- ☐ Phone
- ☐ E-mail
- ☐ Other (please specify)
- ☐ Airport website noise complaint form
- ☐ Third-party platforms (e.g. Airnoise.io)

40. Do you use the NOMS for noise complaint data management or do you use a separate database or complaint software?

- ○ NOMS
- ○ Separate software

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

NOMS Use

41. Please describe the reasons for choosing a separate noise complaint management software:

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

Data Collection

42. Does your airport log/document noise complaints?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

Data Collection

43. How many noise complaints did your airport receive in 2019?

44. Does your airport publish/report the number of complainants or complaints per time period (i.e. month, year, etc.)?

- Complainant only
- Complaints only
- Both
- No

45. Does your airport publish noise complaint statistics on the airport's website?

- Yes
- No

46. Please describe the NOMS operational data type and source your system collects (e.g., SWIM, ADS-B, ASDE-X)?

47. Does your airport collect/integrate other types of data to supplement the NOMS data (e.g., video, radio transmission, weather)?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

Data Collection

48. Please describe what kind of supplemental data your airport uses:

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

Data Distribution

49. Describe how NOMS data is shared with or distributed to the public (Check all that apply):

- [ ] Community meetings or roundtables
- [ ] Airport website
- [ ] Airport Newsletters
- [ ] Social Media
- [ ] Other (please specify)

50. Does the airport provide reports to the public based on NOMS data?

- ◯ Yes
- ◯ No

51. Can the public access NOMS data via an online platform (e.g., online version of the NOMS flight tracking, dashboards, web portals)?

- ◯ Yes
- ◯ Yes, on a limited data access platform
- ◯ No
- ◯ Other (please specify)

52. Was NOMS data used to produce noise exposure contours?

- ◯ Yes
- ◯ No

53. Does your airport provide the noise exposure contours to the public (e.g., online, hard copies, during public meetings)?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

Requirements

54. How many Full-time (including manager/supervisor) and Part-time personnel staff your Airport Noise Abatement Office?

Full-time:

Part-time:

55. How many Full-time (including manager/supervisor) and Part-time personnel operate the NOMS to regularly respond to noise complaints and prepare reports?

Full-time:

Part-time:

56. How many contractors work for the Airport Noise Abatement Office?

57. How many contractors operate the NOMS?

58. Is noise monitor maintenance and troubleshooting performed by in-house personnel, NOMS vendor, or third-party outsourced?

- ◯ In-house
- ◯ NOMS vendor
- ◯ Third-party outsourced

59. If known, what was the start-up (e.g., first year) cost to procure your NOMS, the annual cost to maintain/support/update your NOMS, and the cost of the major upgrades to your NOMS?

Start-up($):

Annual Maintenance/Support/ Update ($/year):

Major Upgrade(s) ($):

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

Benefits

60. Beyond the core NOMS features/functions (e.g., noise-to-track matching, complaint logging, flight track display, basic queries, etc.), what are your secondary functions of having a NOMS (e.g., noise exposure contour validation, special analysis, noise abatement procedure development)? (Check all that apply):

- [ ] Noise exposure contour validation
- [ ] Special stand-alone analysis (non-periodic analysis)
- [ ] Noise abatement procedure development
- [ ] Other (please specify)

61. Please explain how the relationship between your airport and the community changed after the NOMS became operational:

62. Please describe the NOMS data/feature that has been the most effective at informing the public about airport noise:

63. Please describe what benefits your airport has experienced from operating a NOMS:

64. Please describe the disbenefit or downside to your airport having/operating a NOMS:

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

Reasoning

65. What type of study prompted your airport to acquire a NOMS? (Check all that apply):

- [ ] Part 150 NCP
- [ ] EIS/EA ROD
- [ ] Land Use Compatibility Plan
- [ ] Other (please specify)

66. For what reasons did your airport decide to procure and install a NOMS? (Check all that apply):

- [ ] NEPA mitigation requirement
- [ ] Legal requirement/agreement
- [ ] Public request/pressure
- [ ] Proactive strategy
- [ ] Other (please specify)

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

Funding

67. Was the NOMS a Noise Mitigation Measure of a Part 150 Study?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

Funding

68. Assuming you use NOMS data to update your Part 150 on a regular basis, when was the last time a Part 150 was updated and when are you planning on undertaking the next one?

69. Which funding sources contributed to the NOMS procurement? Please check all that apply:

- [ ] AIP Grants
- [ ] State Sources
- [ ] PFCs
- [ ] Local (e.g. City, County) Sources
- [ ] Airport Proprietor Sources
- [ ] Other (please specify)

70. May we contact you to highlight your airport as a Case Study that would be included in this ACRP report?

- ( ) Yes
- [ ] No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire A)

Funding

71. Please provide your preferred contact information:

Name:	
Title:	
Email Address:	
Phone Number:	

72. Would your airport prefer to remain anonymous in this ACRP project?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire A)

Thank you!

73. Thank you for taking the time to complete this survey. Please let us know if there is anything else you would like to share regarding your NOMS system.

Appendix D: Airport NOMS Questionnaires Type B1 & B2

(Questionnaires Type B1 & B2 included questions for 416 airports that currently do not operate a Noise and Operations Monitoring Systems (NOMS) and may haveevaluated the procurement of a NOMS. Pages were exported from Survey Monkey questionnaire web page.)

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B1/B2)

Background

The objective of ACRP Research Project 02-89 is to develop a primer and a decision-making framework to help airports and other stakeholders assess the benefits and costs of acquiring, maintaining, and updating an airport Noise and Operations Monitoring System (NOMS).

The following questionnaire developed by Landrum & Brown and Barry Technologies (The Research Team) will be part of the research that will assist airports decide if a NOMS is appropriate for their situation, evaluating the benefits and costs of acquiring and updating such systems, and determining the general resources needed to acquire, operate, and maintain these systems.

The questions are grouped into the following sections:

- **Background**
- **Data Collection**
- **Data Distribution, and**
- **Reasoning**

The survey format allows you to skip most questions, but we ask that you answer every question if possible. The questionnaire is compatible with computers, phones, and tablets.

Thank you in advance for your participation,

The Research Team

* 1. Please provide the following information about your airport:

Name(s) of airport(s):

3-letter identifier:

Owner/Operator of the airport:

2. Does your airport have staff or contractors who handle airport noise?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B1/B2)

Background

3. How many full-time (including manager/supervisor) and part-time personnel handle airport noise?

Full-time:

Part-Time:

4. How many contractors work for the Airport Noise Abatement Office?

5. Does your airport log/document noise complaints?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B1/B2)

Data Collection/Data Distribution

6. How many noise complaints did your airport receive in 2019?

7. Which methods/platforms does your community use to submit complaints? (Check all that apply):

- [ ] Postal mail
- [ ] Airport website noise complaint form
- [ ] Phone
- [ ] Third-party platforms (e.g., Airnoise.io)
- [ ] E-mail
- [ ] Other (please specify)

8. Does your airport publish/report the number of complainants or complaints per time period (i.e. month, year, etc.)?

- ( ) Complainant only
- ( ) Complaints only
- ( ) Both
- ( ) No

9. Does your airport publish noise complaint statistics on the airport's website?

- ( ) Yes
- ( ) No

10. Besides the hardware and software components of the NOMS, please describe the types of tools (including hardware and software) your airport is using to handle flight data requests from the public, airport noise complaints, and noise-to-flight matching (if applicable):

11. Has your airport evaluated the procurement of a NOMS?

- ( ) Yes
- ( ) No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B1/B2)

Reasoning

12. For what reasons did your airport evaluate the procurement of a NOMS?

- [ ] Increase in noise complaints
- [ ] Political/public pressure to monitor aircraft operations
- [ ] Political/public pressure to view aircraft noise and flight path data
- [ ] Other (please specify)

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B1/B2)

Reasoning

13. For what reasons did your airport decide not to procure a NOMS?

- [ ] Decrease in noise complaints
- [ ] Noise issues are being handled successfully without a NOMS
- [ ] Could not obtain funding
- [ ] Could not obtain staff to operate the NOMS
- [ ] Other (please specify)

14. Under what conditions would your airport decide to procure a NOMS?

- [ ] Increase in noise complaints
- [ ] Political/public pressure to monitor aircraft operations
- [ ] Political/public pressure to view aircraft noise and flight path data
- [ ] Obtained funding
- [ ] Obtained staff to operate the NOMS
- [ ] Other (please specify)

15. For what reasons has your airport not evaluated the procurement of a NOMS?

- [ ] There are no noise issues to address (If selected, please also select "Other" to describe what has led the airport to this conclusion)
- [ ] Noise issues are being handled successfully without a NOMS
- [ ] Did not know a NOMS exisited
- [ ] Other (please specify)

16. Under what conditions would you consider the evaluation of procuring a NOMS?

- ( ) Increase in noise complaints
- ( ) Political/public pressure to monitor aircraft operations
- ( ) Political/public pressure to view aircraft noise and flight path data?
- ( ) Other (please specify)

17. Is your airport currently planning on evaluating the procurement of a NOMS?

- ◯ Yes
- ◯ No

18. Has your airport produced an airport noise exposure contour?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B1/B2)

19. Please describe the airport operational data and sources used to produce the noise exposure contour:

20. Does your airport provide the noise exposure contours to the public (e.g., online, hardcopies, during public meetings)?

- Yes
- No

21. Does your airport plan on performing a Part 150 Study and including a NOMS as a Noise Mitigation Measure?

- Yes
- No

22. When was the last time your Part 150 was updated and when are you planning on undertaking the next one?

23. May we contact you to highlight your airport as a Case Study that would be included in this ACRP report?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B1/B2)

24. Please provide your preferred contact information:

Name:

Title:

Email Address:

Phone Number:

25. Would your airport prefer to remain anonymous in this ACRP project?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B1/B2)

Thank you!

26. Thank you for taking the time to complete this survey. Please let us know if there is anything else you would like to share regarding your airport.

Appendix E: Airport NOMS Questionnaire Type B3

(Questionnaire Type B3 included questions for three (3) airports that procured a Noise and Operations Monitoring Systems (NOMS), but did not complete the NOMS installation process. Pages were exported from the Survey Monkey questionnaire web page.)

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B3)

Background

The objective of ACRP Research Project 02-89 is to develop a primer and a decision-making framework to help airports and other stakeholders assess the benefits and costs of acquiring, maintaining, and updating an airport Noise and Operations Monitoring System (NOMS).

The following questionnaire developed by Landrum & Brown and Barry Technologies (The Research Team) will be part of the research that will assist airports decide if a NOMS is appropriate for their situation, evaluating the benefits and costs of acquiring and updating such systems, and determining the general resources needed to acquire, operate, and maintain these systems. The questionnaire is compatible with computers, phones, and tablets.

The questions are grouped into the following sections:

- **Background**
- **NOMS Use**
- **Data Collection**
- **Requirements**
- **Reasoning, and**
- **Funding**

The survey format allows you to skip most questions, but we ask that you answer every question if possible.

Thank you in advance for your participation,

The Research Team

* 1. Please provide the following information for your airport:

Name(s) of airport(s):	
3-letter identifier:	
Owner/Operator of the airport:	

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B3)

Background

2. When was your NOMS procured?

Month/Year

3. If you've procured multiple NOMS, please provide multiple procurement dates:

Month/Year

Month/Year

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Background

4. Were permanent noise monitors installed?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B3)

Background

5. How many permanent noise monitors were installed?

6. Of the permanent monitors installed, how many were requested by a municipality/community?

7. Were portable noise monitors provided with the NOMS?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Background

8. How many portable monitors were provided?

9. Please describe how the portable noise monitors are used:

10. Were additional portable noise monitors purchased separately?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Background

11. How many portable noise monitors were purchased separately?

12. Please describe the reasons the portable noise monitors were purchased separately:

13. Was a site selection analysis/study performed?

- Yes, in-house
- Yes, outsourced by consultant
- Yes, by NOMS vendor
- No

14. Was the public involved in site selection?

- Yes
- No

15. Were the sites on public or private property?

- Public
- Private
- Both

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B3)

Background

16. For sites on private property, did/do you pay a short/long-term lease or an annual stipend for access and use?

- ◯ Yes
- ◯ No

17. Does your airport plan on using Virtual Noise Monitors (computed noise events instead of measured events)?

- ◯ Yes, at all monitoring locations
- ◯ Yes, to supplement permanent/portable noise monitors
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Background

18. Please describe the types of tools (including hardware and software) your airport is using to handle flight data requests from the public, airport noise complaints, and noise-to-flight matching (if applicable):

19. Has your airport produced airport noise exposure contours?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B3)

Background

20. What airport operational data and sources were used to produce the noise exposure contours?

21. Does your airport provide the noise exposure contours to the public (e.g., online, hard copies, during public meetings)?

- Yes
- No

22. Relative to maintaining and operating a NOMS; does your airport use an asset management system (i.e. Excel spreadsheets, Access Database, Other Program Software, etc.) to track NOMS monitoring sites and your inventory of equipment?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Background

23. Please describe your asset management system:

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B3)

NOMS Use

24. If installed, how would the airport use the NOMS? (Check all that apply):

- ☐ To monitor flights in general
- ☐ To monitor specific noise abatement flight procedures
- ☐ To monitor noise abatement runway use
- ☐ To monitor noise levels/limits at monitors
- ☐ To monitor run-ups
- ☐ To monitor taxiing
- ☐ To monitor airspace use
- ☐ To monitor nighttime curfews
- ☐ To monitor aircraft departure and approach profiles
- ☐ To monitor community noise levels
- ☐ To monitor compliance with agreements/mandates i.e. community commitments
- ☐ Other (please specify)

25. Which methods/platforms does your community use to submit complaints? (Check all that apply).

- ☐ Postal mail
- ☐ Phone
- ☐ E-mail
- ☐ Other (please specify)
- ☐ Airport website noise complaint form
- ☐ Third-party platforms (e.g. Airnoise.io)

26. If NOMS is installed, would you use the NOMS for noise complaint data management or a separate database or complaint software?

- ◯ NOMS
- ◯ Separate software

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

NOMS Use

27. Please describe the reasons for choosing a separate noise complaint management software:

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Data Collection

28. Does your airport log/document noise complaints?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Data Collection

29. How many noise complaints did your airport receive in 2019?

30. Does your airport publish/report the number of complainants or complaints per time period (i.e. month, year, etc.)?

- Complainant only
- Complaints only
- Both
- No

31. Does your airport publish noise complaint statistics on the airport's website?

- Yes
- No

32. Please describe the NOMS operational data type and source your system collects (e.g., SWIM, ADS-B, ASDE-X)?

33. If NOMS is installed, would your airport collect/integrate other types of data to supplement the NOMS data (e.g., video, radio transmission, weather)?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Data Collection

34. Please describe what kind of supplemental data your airport would use:

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Requirements

35. Does your airport have staff or contractors who handle airport noise?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B3)

Requirements

36. How many Full-time (including manager/supervisor) and Part-time personnel handle airport noise?

Full-time:

Part-time:

37. How many Full-time (including manager/supervisor) and Part-time personnel would have operated the NOMS to regularly respond to noise complaints and prepare reports?

Full-time:

Part-time:

38. How many contractors work on airport noise?

39. How many contractors would have operated the NOMS?

40. If NOMS is installed, would noise monitor maintenance and troubleshooting be performed by in-house personnel, NOMS vendor, or third-party outsourced?

- ◯ In-house
- ◯ NOMS vendor
- ◯ Third-party outsourced

41. If known, what was the start-up (e.g., first year) cost to procure your NOMS, the annual cost to maintain/support/update your NOMS, and the cost of the major upgrades to your NOMS?

Start-up($):

Annual Maintenance/Support/ Update ($/year):

Major Upgrade(s) ($):

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B3)

Reasoning

42. What type of study prompted your airport to acquire a NOMS? (Check all that apply):

- [ ] Part 150 NCP
- [ ] EIS/EA ROD
- [ ] Land Use Compatibility Plan
- [ ] Other (please specify)

43. For what reasons did your airport decide to procure and install a NOMS? (Check all that apply):

- [ ] NEPA mitigation requirement
- [ ] Legal requirement/agreement
- [ ] Public request/pressure
- [ ] Proactive strategy
- [ ] Other (please specify)

44. For what reasons did the NOMS installation process stop? (Check all that apply)

- [ ] Decrease in noise complaints
- [ ] Noise issues are being handled successfully without a NOMS
- [ ] Other (please specify)

45. Please describe under what conditions would the NOMS installation process continue.

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Funding

46. Was the NOMS a Noise Mitigation Measure of a Part 150 Study?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Funding

47. Assuming you update your Part 150 on a regular basis, when was the last time a Part 150 was updated and when are you planning on undertaking the next one?

48. Which funding sources contributed to the NOMS procurement? (Check all that apply):

- [ ] AIP Grants
- [ ] PFCs
- [ ] Airport Proprietor Sources
- [ ] State Sources
- [ ] Local (e.g. City, County) Sources
- [ ] Other (please specify)

49. May we contact you to highlight your airport as a Case Study that would be included in this ACRP report?

- ( ) Yes
- [ ] No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B3)

Funding

50. Please provide your preferred contact information:

Name:	
Title:	
Email Address:	
Phone Number:	

51. Would your airport prefer to remain anonymous in this ACRP project?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems
(Questionnaire B3)

Thank you!

52. Thank you for taking the time to complete this survey. Please let us know if there is anything else you would like to share regarding your NOMS system.

Appendix F: Airports NOMS Questionnaire Type B4

(Questionnaire Type B4 included questions for two (2) airports that procured and installed a Noise and Operations Monitoring Systems (NOMS), but the NOMS is currently not operable. Pages were exported from Survey Monkey questionnaire web page.)

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Background

The objective of ACRP Research Project 02-89 is to develop a primer and a decision-making framework to help airports and other stakeholders assess the benefits and costs of acquiring, maintaining, and updating an airport Noise and Operations Monitoring System (NOMS).

The following questionnaire developed by Landrum & Brown and Barry Technologies (The Research Team) will be part of the research that will assist airports decide if a NOMS is appropriate for their situation, evaluating the benefits and costs of acquiring and updating such systems, and determining the general resources needed to acquire, operate, and maintain these systems.

The questions are grouped into the following sections:

- **Background**
- **NOMS Use**
- **Data Collection**
- **Data Distribution**
- **Requirements**
- **Benefits**
- **Reasoning, and**
- **Funding**

The survey format allows you to skip most questions, but we ask that you answer every question if possible. The questionnaire is compatible with computers, phones, and tablets.

Thank you in advance for your participation,

The Research Team

* 1. Please provide the following information for your airport:

Name(s) of airport(s):	
3-letter identifier:	
Owner/Operator of the airport:	

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Background

2. When was your NOMS procured?

Month/Year

3. If you've procured multiple NOMS, please provide all procurement dates:

Month/Year

Month/Year

4. When did your NOMS become fully operational?

Month/Year

5. If you've operated multiple NOMS, please provide multiple operational dates:

Month/Year

Month/Year

6. Has the NOMS gone through major upgrades?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Background

7. If the NOMS has gone through major upgrades, please describe the upgrade(s):

8. What years were major NOMS upgrades done?

9. Were permanent noise monitors installed?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Background

10. How many permanent noise monitors were installed?

11. Of the permanent monitors installed, how many were requested by a municipality/community?

12. Please select the following items that apply relative to the permanent noise monitor installation:

- [ ] Mount - Utility Pole
- [ ] Mount - Custom pole or mount
- [ ] Mount - Combination
- [ ] Power Source - Solar or A/C Power
- [ ] Power Source: D/C Power
- [ ] Power Source - Combination
- [ ] Data Connectivity - Wireless
- [ ] Data Connectivity - Phone Line
- [ ] Data Connectivity - Manual Download
- [ ] Data Connectivity - Combination

13. Were portable noise monitors provided with the NOMS?

- ( ) Yes
- ( ) No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Background

14. How many portable monitors were provided?

15. Please describe how the portable noise monitors are used:

16. Were additional portable noise monitors purchased separately?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Background

17. How many portable noise monitors were purchased separately?

18. Please describe the reasons the portable noise monitors were purchased separately:

19. Was a site selection analysis/study performed?

- Yes, in-house
- Yes, outsourced by consultant
- Yes, by NOMS vendor
- No

20. Was the public involved in site selection?

- Yes
- No

21. Are sites on public or private property?

- Public
- Private
- Both

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Background

22. For sites on private property, do you pay a short/long-term lease or an annual stipend for access and use?

- ◯ Yes
- ◯ No

23. Does your airport use Virtual Noise Monitors (computed noise events instead of measured events)?

- ◯ Yes, at all monitoring locations
- ◯ Yes, to supplement permanent/portable noise monitors
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Background

24. How many vendors supply your NOMS components?

25. Has your airport always used one NOMS vendor/software, or has your airport used multiple NOMS vendor/software services over time?

- ◯ One NOMS software
- ◯ Multiple NOMS software

26. How many years did you use each vendor/software?

Vendor/Software #1 Years:

Vendor/Software #2 Years:

Vendor/Software #3 Years:

27. If you switched from one NOMS software to a different NOMS software, please describe the reasons for switching:

28. Has your airport always used one model/brand of noise monitors, or has your airport used multiple models/brands over time?

- ◯ One NOMS Monitor
- ◯ Multiple NOMS Monitors

29. How many years did you use each model?

Model/Brand #1 Years

Model/Brand #2 Years

Model/Brand #3 Years

30. If you switched to a different model/brand of noise monitors, please describe the reasons for switching:

31. Besides the hardware and software components of the NOMS, please describe the types of tools (including hardware and software) your airport is using to handle flight data requests from the public, airport noise complaints, and noise-to-flight matching (if applicable):

32. Has your airport produced noise exposure contours?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Background

33. Please describe the airport operational data and sources used to produce the noise exposure contours:

34. Does your airport provide the noise exposure contours to the public (e.g., online, hard copies, during public meetings)?

- Yes
- No

35. Relative to maintaining and operating a NOMS; does your airport use an asset management system (i.e. Excel spreadsheets, Access Database, Other Program Software, etc.) to track NOMS components?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Background

36. Please describe your asset management system:

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

NOMS Use

37. While the NOMS was operable, how was the NOMS used? (Check all that apply):

- ☐ To monitor flights in general
- ☐ To monitor specific noise abatement flight procedures
- ☐ To monitor noise abatement runway use
- ☐ To monitor noise levels/limits at monitors
- ☐ To monitor run-ups
- ☐ To monitor taxiing
- ☐ To monitor airspace use
- ☐ To monitor nighttime curfews
- ☐ To monitor aircraft departure and approach profiles
- ☐ To monitor community noise levels
- ☐ To monitor compliance with agreements/mandates i.e. community commitments
- ☐ Other (please specify)

38. Which methods/platforms does your community use to submit complaints? (Check all that apply):

- ☐ Postal mail
- ☐ Phone
- ☐ E-mail
- ☐ Other (please specify)
- ☐ Airport website noise complaint form
- ☐ Third-party platforms (e.g. Airnoise.io)

39. Did you use the NOMS for noise complaint data management or did you use a separate database or complaint software?

- ○ NOMS
- ○ Separate software

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

NOMS Use

40. Please describe the reasons for choosing a separate noise complaint management software:

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Data Collection

41. Does your airport log/document noise complaints?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Data Collection

42. How many noise complaints did your airport receive in 2019?

43. Does your airport publish/report the number of complainants or complaints per time period (i.e. month, year, etc.)?

- ◯ Complainant only
- ◯ Complaints only
- ◯ Both
- ◯ No

44. Does your airport publish noise complaint statistics on the airport's website?

- ◯ Yes
- ◯ No

45. Please describe the NOMS operational data type and source your system collected (e.g., SWIM, ADS-B, ASDE-X)?

46. While the NOMS was operable, did your airport collect/integrate other types of data to supplement the NOMS data (e.g., video, radio transmission, weather)?

- ◯ Yes
- ◯ No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Data Collection

47. Please describe what kind of supplemental data your airport used:

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Data Distribution

48. Describe how NOMS data was shared with or distributed to the public (Check all that apply):

- [ ] Community meetings or roundtables
- [ ] Airport website
- [ ] Airport Newsletters
- [ ] Social Media
- [ ] Other (please specify)

49. While the NOMS was operable, did your airport provide reports to the public based on NOMS data?

- ◯ Yes
- ◯ No

50. Was the public able to access NOMS data via an online platform (e.g., online version of the NOMS flight tracking, dashboards, web portals)?

- ◯ Yes
- ◯ Yes, on a limited data access platform
- ◯ No
- ◯ Other (please specify)

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Requirements

51. How many Full-time (including manager/supervisor) and Part-time personnel staff your Airport Noise Abatement Office?

Full-time:

Part-time:

52. How many Full-time (including manager/supervisor) and Part-time personnel operated the NOMS to regularly respond to noise complaints and prepare reports?

Full-time:

Part-time:

53. How many contractors work for the Airport Noise Abatement Office?

54. How many contractors operate the NOMS?

55. Is/was noise monitor maintenance and troubleshooting performed by in-house personnel, NOMS vendor, or third-party outsourced?

- ◯ In-house
- ◯ NOMS vendor
- ◯ Third-party outsourced

56. If known, what was the start-up (e.g., first year) cost to procure your NOMS, the annual cost to maintain/support/update your NOMS, and the cost of the major upgrades to your NOMS?

Start-up($):

Annual Maintenance/Support/ Update ($/year):

Major Upgrade(s) ($):

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Benefits

57. Beyond the core NOMS features/functions (e.g., noise-to-track matching, complaint logging, flight track display, basic queries, etc.), what were your secondary functions of having a NOMS (e.g., noise exposure contour validation, special analysis, noise abatement procedure development)? (Check all that apply):

- ☐ Noise exposure contour validation
- ☐ Special stand-alone analysis (non-periodic analysis)
- ☐ Noise abatement procedure development
- ☐ Other (please specify)

58. Please explain how the relationship between your airport and the community changed after the NOMS became operational:

59. Please describe the NOMS data/feature that was the most effective at informing the public about airport noise:

60. Please describe what benefits your airport experienced from operating a NOMS:

61. Please describe the disbenefit or downside to your airport having/operating a NOMS:

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Reasoning

62. What type of study prompted your airport to acquire a NOMS? (Check all that apply):

- [ ] Part 150 NCP
- [ ] EIS/EA ROD
- [ ] Land Use Compatibility Plan
- [ ] Other (please specify)

63. For what reasons did your airport decide to procure and install a NOMS? (Check all that apply):

- [ ] NEPA mitigation requirement
- [ ] Legal requirement/agreement
- [ ] Public request/pressure
- [ ] Proactive strategy
- [ ] Other (please specify)

64. Please describe the reasons your NOMS is no longer in operation.

65. Please describe under what conditions, if met, would the NOMS become operable again.

66. What have you done with the system equipment (noise monitors/system software) following deactivation? (Check all that apply):

- [ ] Returned to vendor
- [ ] Left in place
- [ ] Disassembled and put into storage
- [ ] Disassembled and sold
- [ ] Other (please specify)

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Funding

67. Was the NOMS a Noise Mitigation Measure of a Part 150 Study?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Funding

68. Assuming you update your Part 150 on a regular basis, when was the last time a Part 150 was updated and when are you planning on undertaking the next one?

69. Which funding sources contributed to the NOMS procurement? Please check all that apply:

- [ ] AIP Grants
- [ ] State Sources
- [ ] PFCs
- [ ] Local (e.g. City, County) Sources
- [ ] Airport Proprietor Sources
- [ ] Other (please specify)

70. May we contact you to highlight your airport as a Case Study that would be included in this ACRP report?

- ( ) Yes
- ( ) No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Funding

71. Please provide your preferred contact information:

Name:	
Title:	
Email Address:	
Phone Number:	

72. Would your airport prefer to remain anonymous in this ACRP project?

- Yes
- No

Survey on Airport Noise and Operations Monitoring Systems (Questionnaire B4)

Thank you!

73. Thank you for taking the time to complete this survey. Please let us know if there is anything else you would like to share regarding your NOMS system.

Appendix G: Airport NOMS Questionnaire & Summary of Findings

G.1 Background

The airport questionnaires included 73 questions for airports operating a Noise and Operations Monitoring Systems (NOMS) (Type A Airports), 26 questions for airports that had not procured a NOMS (Type B-1 and Type B-2 Airports), 52 questions for airports that had not completed the NOMS installation process (Type B-3 Airports), and 73 questions for airports with non-operational NOMS (Type B-4 Airports). The results of the airport questionnaires are summarized relative to the types of information required by this research. The questionnaire format allowed airports to skip questions, provide multiple applicable responses, and provide other responses and descriptions.

G.2 Airport Questionnaires

G.2.1 Type A Airport Questionnaire

The **Type A** Airport questionnaire was sent to large hub and medium hub commercial service airports and to GA airports that currently operate NOMS. This airport recipient list was compiled through industry knowledge of airports by the Research Team and information provided by the NOMS vendors. At the time of the questionnaire's deployment, there were 89 airports in the U.S. that met the **Type A** definition.

A list of all 89 airports is provided in the **Appendix A: List of NOMS, Non-NOMS, & Other Survey Airports**. **Appendix C: Airport NOMS Questionnaire – Type A**, provides the list of questions provided to the **Type A** airports grouped relative to the required information, as well as background questions to add context to their responses.

G.2.2 Type B Airport Questionnaire

The **Type B** Airport questionnaire was sent to commercial service large hub and medium hub airports and to larger general aviation airports known to not currently operate a NOMS. This airport recipient list was compiled through industry knowledge of airports that are known not to operate NOMS and airports not in NOMS vendors installation lists. At the time of the questionnaire's deployment, there were 422 airports in the study area that did not operate NOMS. Of these airports, 306 were commercial service airports and 110 were general aviation airports (from the 200 busiest GA airports) and were considered **Type B-1** or **Type B-2** airports that have either never evaluated a NOMS or evaluated but never procured a NOMS. Five (5) airports are **Type B-3** or **Type B-4** airports that either procured, but did not complete installation of a NOMS, or procured and installed a NOMS, but the NOMS was not operable.

The following questionnaires were customized according the **Type B** Airport subgroups B-1 through B-4. A list of all 422 airports is provided in the **Appendix A: List of NOMS, Non-NOMS, & Other Survey Airports.**

Appendix D: Airport NOMS Questionnaire – Type B1 & B2, Appendix E: Airport NOMS Questionnaire – Type B3. **Appendix F: Airport NOMS Questionnaire – Type B4,** provides the list of questions to the **Type B** airports grouped relative to the required information, as well as background questions to add context to their responses.

G.2.3 Questionnaire Response Summary

During the initial round of questionnaire outreach, airports within each group were contacted by email, which included the Airport Cooperative Research Program (ACRP) research project information and a SurveyMonkey[15] link to the relevant group of questions. To ensure the questionnaire response rate provided sufficient research information, the Research Team followed up by contacting non-responsive airports by phone.

Table G-1, *Airport NOMS Questionnaire Response Summary,* presents the target and actual responses for all airport type surveys. For the **Type A** Airports, the response rate was 51% (45 out of 89 airports), just slightly above the goal of 50%. Of those responses, 30 airports volunteered to be candidates for the case studies. Some of these airports are part of multi-airport systems (ex: Chicago O'Hare International and Chicago Midway International airports), so the 45 responses represent 69 airports.

Given the large number of non-NOMS airports, with many of whom having little or no noise problems, the response rate was expected to be smaller. For the **Type B-1** and **Type B-2** Airports, the response rate was 28% (115 out of 416 airports), again just slightly above the goal of 25%. Of those responses, 52 airports volunteered to be candidates for the case studies. **Type B-3** and **Type B-4** airports (3 each) had one (1) response each, or a 33% response rate.

Table G-1 Airport NOMS Questionnaire Response Summary

Airport Type	Airports (No.)	Target Responses (No.)	Target Responses (%)	Actual Responses (No.)	Actual Responses (%)	Case Study Candidates (No.)
A	89	44	50%	45	51%	30
B-1/B-2	416	106	25%	115	28%	52
B-3	3	---	---	1	33%	---
B-4	3	---	---	1	33%	---

Source: Landrum & Brown, 2021

[15] SurveyMonkey is an online platform used to conduct surveys and questionnaires.

G.3 NOMS (Type A) Airports

G.3.1 Types of Data Being Collected

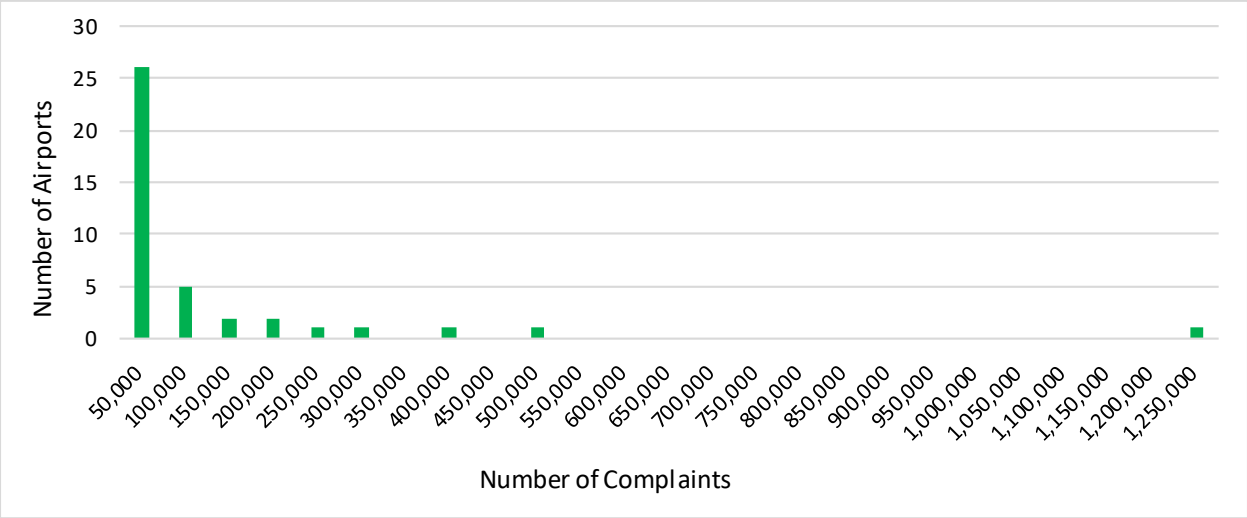
As described in Section 3.2, the first NOMS were installed in the 1967. NOMS installations continued in the 1980's and peaked at nine (9) installations between 1996 and 2000. Approximately 70% of airports installed permanent Noise Monitoring Terminals (NMTs), and a few airports used virtual NMTs for all noise monitoring or to supplement permanent noise monitoring.

The basic features of a NOMS collect and display noise and flight data, correlate aircraft operations to noise events, query system databases, output reports, and provide and interface to log noise complaints. Most airports collected flight operations data via the FAA's Automated Radar Terminal System (ARTS) or the System Wide Information Management (SWIM) feed. Several airports used multiple aircraft tracking data such as Automatic Dependent Surveillance-Broadcast (ADS-B), Airport Surface Detection Equipment – Model X (ASDE-X), Standard Terminal Automation Replacement System (STARS), and multi-lateration sources. The majority of airports supplemented NOMS flight and noise data with additional information such as run-up data, weather data, aircraft performance data, Air Traffic Control (ATC) transmissions, and passenger data.

Airports generally received noise complaints via phone, email, an airport website noise complaint form, and to a lesser extent, postal mail. In recent years, third-party platforms (apps) were developed to provide the public with easier and faster ways to submit aircraft noise complaints directly to airports, which contributed to significant increases in the number of noise complaints. In 2019, the number of aircraft noise complaints ranged from 22 to 1,228,420[16]. These are illustrated in **Figure G-1*, Aircraft Noise Complaints in 2019.*** Seventy percent of airports use the complaint logging feature of the NOMS. However, 30% of airports used a separate database or complaint software. Reasons for using separate software included the use of better features and continuing the use of legacy systems.

[16] At this particular airport, the large number of aircraft noise complaints were primarily related to a shift in departure paths and the location of a new proposed departure procedure. Approximately 98% of these complaints were submitted though the "button," which is an automated way for the public to submit aircraft noise complaints. The "button" is described in **Section 3.5.2.3 Noise Complaints**.

Figure G-1 Aircraft Noise Complaints in 2019



Source: Landrum & Brown, 2021.

G.3.2 How NOMS are Being Used

Airports and NOMS vendors have worked together to expand basic features to address an airport's specific NOMS-related needs. Modern NOMS have become informational tools to support additional airport needs beyond just noise, such as Remain Over Night management and airport planning. **Table G-2, *How Airports Use NOMS,*** presents 11 ways to use a NOMS as provided on the questionnaire and the percentage of responses received. The table is followed by other ways to use NOMS provided by responders.

Table G-2 How Airports Use NOMS

How is your NOMS used?	Response (%)
To monitor flights in general	97%
To monitor specific noise abatement flight procedures	84%
To monitor noise abatement runway use	74%
To monitor noise levels/limits at monitors	61%
To monitor airspace use	61%
To monitor aircraft departure and approach profiles	61%
To monitor community noise levels	61%
To monitor compliance with agreements/mandates; i.e. community commitments	53%
To monitor nighttime curfews	42%
To monitor run-ups	24%
To monitor taxiing	3%

Source: Landrum & Brown, 2021.

In addition to the above options, airports provided other ways to use their NOMS, which include the following:

- NOMS use by other airport proprietor departments and government agencies;
- Capacity utilization of departures;
- Remain Over Night management;
- NOMS data for annual noise contour production and validation;
- Use NOMS as an education and communication tool for the community;
- Investigate noise violations;
- NOMS data for airport planning;
- NOMS data for fleet mix assessments;
- Investigate incursions;
- Metroplex route impacts and compliance;
- Monitor nighttime noise thresholds;
- Cross-check airline self-reporting records;
- Measure off-airport temporary helistops using portable monitors;
- Special studies by consultants.

G.3.3 Degree of Public Access

Airports were asked whether the public could access NOMS data via an online platform. One third of airports responded that they did provide online access to the NOMS. One third of airports responded that they provided online access to the NOMS, but on a limited basis, and the remaining one third responded that they did not provide public access to the NOMS. Common features of online platforms include flight data replay, flight identification, noise event visualization, noise and operations-related reports, complaint logging, and complaint self-investigation.

For airports surveyed, 75% of airports shared NOMS data with the public via public meetings/roundtables and airport websites. To a lesser extent, airports shared NOMS data via airport newsletters and social media. Airports also shared NOMS data through the complaint response process and upon requests, and approximately 75% of airports provided reports based on NOMS data to the public.

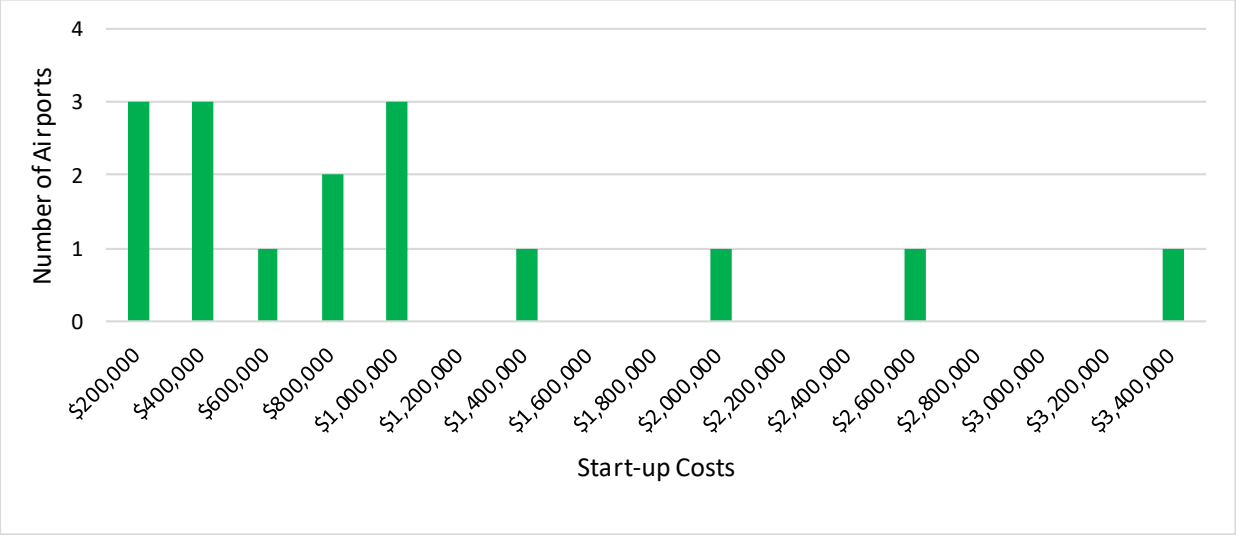
G.3.4 Resource Requirements

Airports were asked to provide information on their Airport Noise Abatement Office staffing levels, noise monitor maintenance requirements, and costs. Airports responded that staffing levels ranged between one (1) to seven (7) full-time staff with an average of 2.3 full-time staff and ranged between zero (0) to three (3) part-time staff with an average of less than one (1) part-time staff. In addition to staff, an average of two (2) contractors/consultants had access to the airport's NOMS.

To perform NOMS maintenance, most airports used the NOMS vendors. Approximately 10% of airports used in-house staff to perform NOMS maintenance and 10% of airports outsourced NOMS maintenance.

The NOMS start-up cost may vary greatly depending on the contractual specifications, such as the number of monitors, contract term, added maintenance, and added support services. The responses relative to start-up cost ranged between $100,000 to $3,264,700 (two-airport system and two-year maintenance). **Figure G-2*, NOMS Start-up Costs,*** are illustrated per airport:

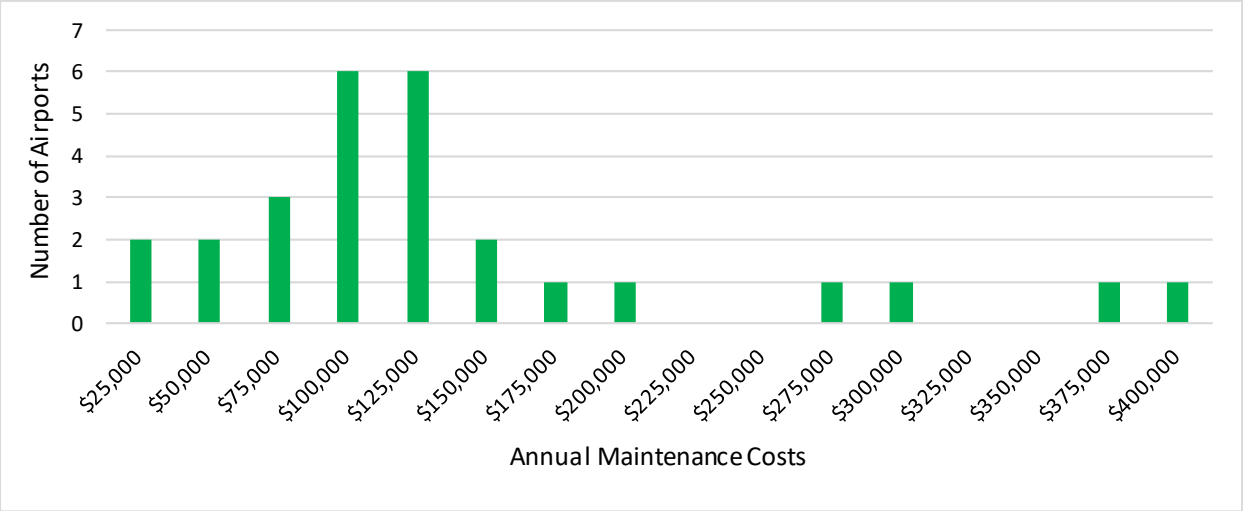
Figure G-2 NOMS Start-up Costs



Source: Landrum & Brown, 2021.

Annual NOMS maintenance costs may also vary by airport due to contract specifications. **Figure G-3, *NOMS Annual Maintenance Costs,*** illustrates the cost per airport:

Figure G-3 NOMS Annual Maintenance Costs



Source: Landrum & Brown, 2021.

G.3.5 Funding Sources

Funding for a NOMS can be obtained from various sources. **Table G-3, *NOMS Funding Sources,*** lists the percentages of responses received.

Table G-3 NOMS Funding Sources

NOMS Funding Sources	Response (%)
AIP Grants	29%
PFCs	12%
Airport Proprietor Sources	34%
State Sources	10%
Local (e.g. City, County) Sources	15%

Source: Landrum & Brown, 2021.

In addition to the above options, airports provided other funding sources. These sources include:

- Airport Revenue;
- Bonds;

- City's emergency funding[17].

G.3.6 Reasons for Acquiring a NOMS

Various reasons can support the acquisition of a NOMS including internal factors such a proactive strategy and external factors such as noise ordinance and public pressure for the airport to provide information about aircraft operations. **Table G-4, *Reasons for Acquiring a NOMS,*** lists the percentages of responses received.

Table G-4 Reasons for Acquiring a NOMS

Reasons for Acquiring a NOMS	Response (%)
Proactive strategy	34%
Part 150 NCP	23%
Public request/pressure	15%
Land Use Compatibility Plan	11%
Legal requirement/agreement	11%
EIS/EA ROD	3%
NEPA mitigation requirement	3%

Source: Landrum & Brown, 2021.

In addition to the above options, airports provided other reasons for acquiring a NOMS, which include the following:

- State reporting compliance;
- NOMS replacement;
- Litigation;
- Sponsor interest;
- Secondary enforcement of noise curfew;
- Community interest;
- To address community concerns.

G.3.7 Quantitative and Qualitative Benefits

A NOMS is not only a technological tool that provides benefits to airports, but also an investment that requires airport resources. The types of benefits gained by an airport and the magnitude of resources utilized by airports to operate a NOMS are largely dependent on the airport's goals and objectives relative to airport noise. Airports were asked to describe some of the benefits and disbenefits of

[17] The airport received funds set aside for matters related to the health and wellness of the community to fix their NOMS which had crashed.

operating a NOMS, and how the relationship between the airport and the community changes once the NOMS became operational.

Table G-5*, Benefits from Operating a NOMS,* lists the percentages of responses received.

Table G-5 Benefits from Operating a NOMS

Benefits	Response (%)
Improved complaint investigation and reporting	25%
Improved community engagement	15%
Improved transparency	11%
Document compliance with legal obligations	7%
Efficient use of staff time	7%
Increased credibility	5%
Increased trust	5%
Noise abatement procedure monitoring and continuous improvement	2%
Improved community education	2%
Consistent message	2%
Contour and noise event validation	2%
Accounting/Landing fee disputes	2%
Noise modeling data	2%
New procedure (Metroplex) development to protect noise sensitive areas	2%
Noise reduction program tracking	2%
Noise mitigation tool	2%
Established accountability to the community	2%
Safety/Incursions tool	2%
Elected Official Engagement	2%
Identify noise impact and trends	2%

Source: Landrum & Brown, 2021.

Table G-6*, Disbenefits from Operating a NOMS,* lists the percentage of responses received.

Table G-6 Disbenefits from Operating a NOMS

Disbenefits	Response (%)
Cost/Expensive	23%
None	21%
Public expectation that the airport can fix air traffic issues	5%
Public always wants more data	5%
Public expectation to address continuous complaints	5%
System data verification/validation	5%
Responding to noise complaints	5%
Improvements in technology have resulted in higher complaint counts	3%
Public distrust of data	3%
Expense to maintain system	3%
Required technical support	3%
Flight data integration	3%
Expect 100% accuracy	3%
Increased demand for permanent noise monitors	3%
Delays to upgrade	3%
Inaccurate data	3%
System hackers	3%
24-hour delay on data	3%
Plan/coordinate upgrades	3%

Source: Landrum & Brown, 2021.

Table G-7*, Changes to the Airport-Community Relationship,* are listed after the NOMS became operational and the percentage of responses received.

Table G-7 Changes to the Airport-Community Relationship

Changes in Relationship	Response (%)
Improved due to data/information sharing	23%
Improved in terms of transparency	21%
Gained trust	5%
Community empowerment due to self-investigation tools	5%
Relationship improved through monthly roundtable meetings	5%
Reestablished trust	5%
Fostered engagement	5%
Educated the public	3%
Relationship improved	3%
Replaced perceptions with facts	3%
From contentious to trusting	3%
Community feels like airport is more responsive	3%
Implemented a proactive and engaged approach with community	3%
Built relationships with community leaders	3%

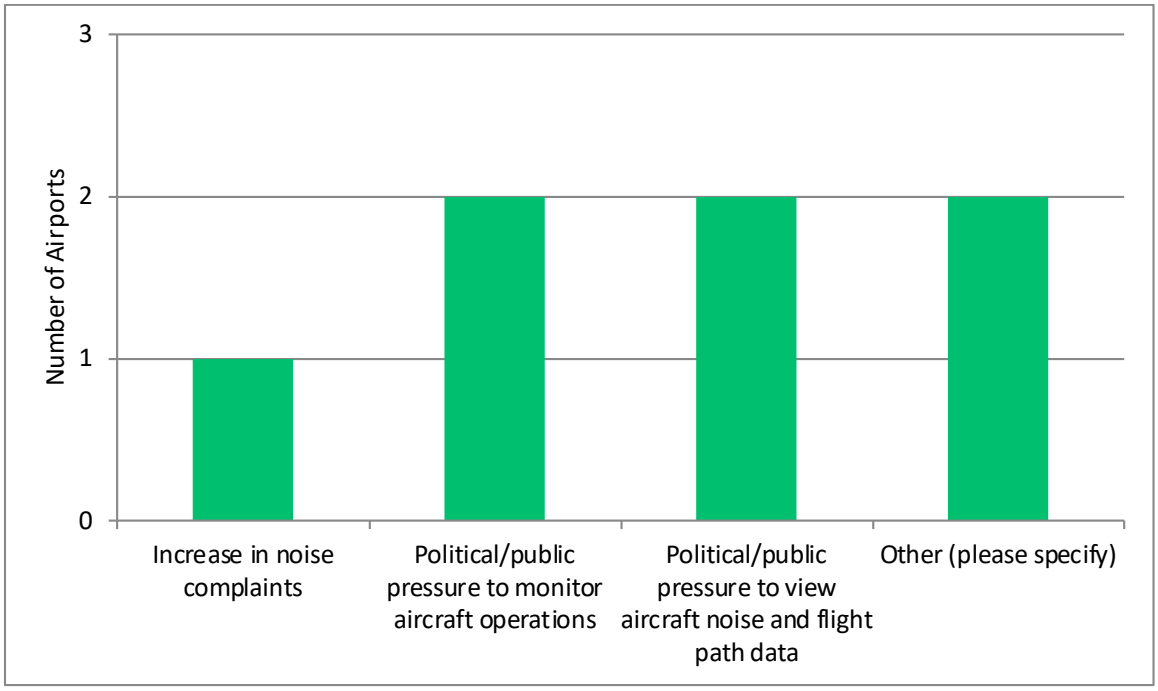
Source: Landrum & Brown, 2021.

G.4 Non-NOMS (Type B-1 & B-2) Airports

Among the 115 Type B-1 and B-2 airports that did not operate a NOMS, 45% had staff or contractors who handled airport noise issues and 64% logged airport noise complaints. Seven (7) airports evaluated the procurement of a NOMS for the reasons shown on **Figure G-4, *Reasons Airport Evaluated the Procurement of a NOMS.*** The two (2) other reasons for NOMS evaluation were:

- Proactive measure for individuals to monitor/report aircraft noise;
- Local fighter wing switching from F-16's to F-35's.

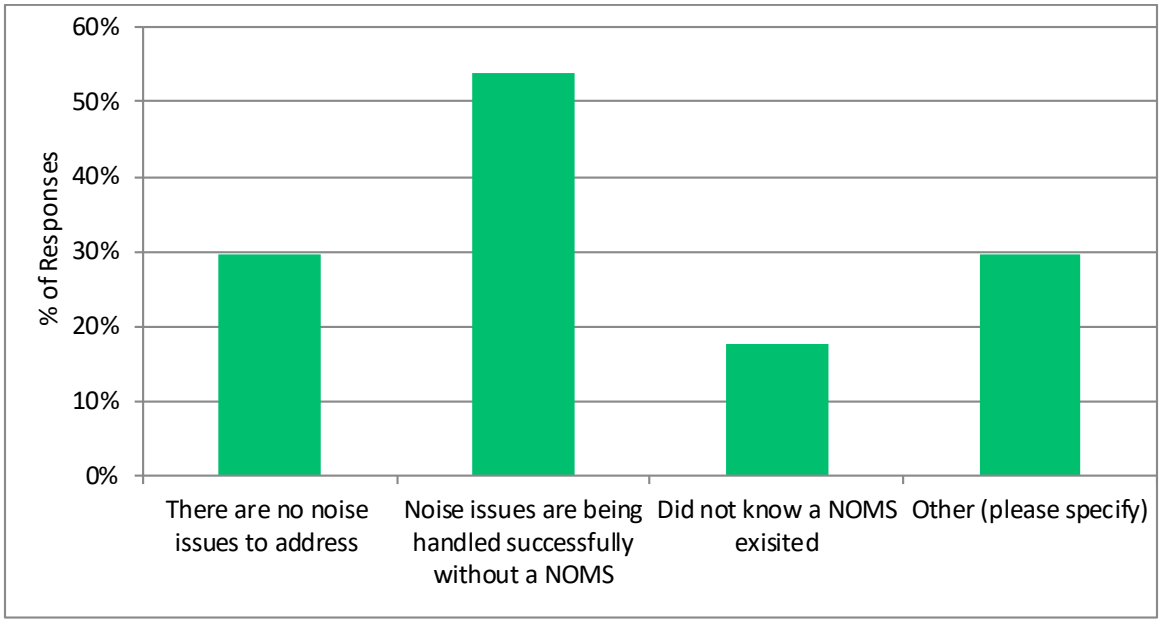
Figure G-4 Reasons Airports Evaluated the Procurement of a NOMS



Source: Landrum & Brown, 2021.

One hundred and eight (108) non-NOMS airports provided reasons for not having a NOMS. This information is presented in **Figure G-5*, Reasons Airports Have Not Evaluated the Procurement of a NOMS,*** with the percentages of responses received:

Figure G-5 Reasons Airports Have Not Evaluated the Procurement of a NOMS



Source: Landrum & Brown, 2021.

In addition to the above options, airports provided other reasons for not evaluating a NOMS, which include the following:

- Zero noise complaints;
- Few noise complaints;
- No noise issues;
- Airport is located in rural area;
- Most of the areas above DNL 65 are on airport property and are not residential areas;
- A NOMS is not requested by County Department of Public Works;
- Budgetary constraints;
- Monitoring, logging, and community involvement has been working successfully.

Over half of the airports answered that they would consider the evaluation of procuring a NOMS if complaints increased. Approximately 15% of airports would consider the evaluation of procuring a NOMS if there was political/public pressure to monitor aircraft operations and view aircraft noise and flight path data.

The airports that applied resources to handling noise complaints used various tools and methods to log, investigate, and respond to noise complaints. These tools and methods included:

- Coordinating flight data requests and noise incident reviews with local Air Traffic Control Tower (ATCT) or Terminal Radar Approach Control (TRACON) facility;
- Working directly with local ATCT to run radar/flight tracking report;
- Using County Information Technology department to run airport noise complaint database;
- Utilizing relationship with the FAA to track aircraft as well as public available radar tracking data;
- Using video to identify aircraft related to a noise complaint;
- Use online flight tracking website of nearest airport;
- Coordinate complaint investigation/response with nearest airport with a NOMS;
- Use hand-held noise meter to take aircraft noise measurements;
- Use Microsoft Excel for complaint logging;
- Use Flight Aware, Passur antenna, Aero Tracking, and Virtower flight tracking tools.

G.5 Other (Type B-3 & B-4) Airports

Among the three (3) **Type B-3** airports that procured, but did not complete their installation, one (1) responded. That airport had a relatively small number of noise complaints in 2019 (approximately 200).

After procurement, the system vendor could not comply with contractual requirements. In the end, funding and support for the NOMS was no longer available and the final installation was never completed.

Among the three (3) **Type B-4** airports that procured & installed a NOMS, but the system is currently not operable, one (1) responded. The airport felt that in the end, the NOMS provided no real benefits as the community thought the NOMS would help reduce noise. The NOMS was decommissioned in 2013.

Appendix H: Case Study Findings

H.1 Case Study Candidates

H.1.1 Purpose

The purpose of the case studies is to take a closer look at the factors involved when deciding whether a Noise and Operations Monitoring Systems (NOMS) is an appropriate tool to address airport noise issues or whether other tools and efforts are appropriate. The airport questionnaires identified several airports that would take part in this research project as case studies.

H.2.1 Selection Criteria

H.2.1.1 Airports Operating NOMS

It is understood that from the group of airports that operate a NOMS, those with low levels of noise complaints would relate better to airports that do not currently operate a NOMS (Primer's target audience). Airport questionnaire findings showed that common characteristics among airports that do not operate a NOMS are either not having a noise problem with zero noise complaints or having a manageable noise problem with relatively few noise complaints.

Note that some airports responded that they would participate as case studies, but also preferred to be anonymous. The criteria listed below were used to select the case study candidates from the group of airports that currently operate a NOMS:

- Currently operating a NOMS;
- Airports that responded "yes" to being in a case study;
- Airports that responded "no" to preferring to remain anonymous;
- Relatively low number of noise complaints;
- Selected case study candidates are not located in the same State;
- Selected case study candidates do not represent the same airport service type and size.

Table H-1*, Case Study Airport Candidates Operating a NOMS,* lists the airports that meet the criteria above in order of lowest to highest number of noise complaints. The reasons for procuring and installing a NOMS are also listed as reference. The Case Study Selection column shows three (3) proposed selections: a Medium-Hub Commercial airport, a Non-Hub Commercial airport, and a General Aviation airport. **Table H-2*, Case Study Airports Operating a NOMS,*** lists the airports that met the criteria above and were interviewed by the Research Team.

Table H-1 Case Study Airport Candidates Operating a NOMS

Case Study Selection	Airport Code	Airport Name (Categories)	State	Complaints in 2019	Reason for Procuring a NOMS
1	ACK	Nantucket Memorial Airport (Commercial, Non-Hub)	MA	102	Public request/pressure, proactive strategy, sponsor interest
2	DAL	Dallas Love Field (Commercial, Medium-Hub)	TX	200	Public request/pressure, proactive strategy
Alt. to 1	PVD	T.F. Green Airport (Commercial, Small-Hub)	RI	238	Legal requirement/agreement
Alt. to 2 (IAH)	IAH, HOU, EFD	George Bush Intercontinental Airport (Commercial, Large-Hub), William P. Hobby Airport (Commercial, Medium-Hub), Ellington Airport (Reliever)	TX	350	Proactive strategy
	DFW	Dallas-Fort Worth International Airport (Commercial, Large-Hub)	TX	539	NEPA mitigation requirement
3	TRK	Truckee Tahoe Airport (General Aviation)	CA	771	Public request/pressure, proactive strategy
Alt. to 3	SMO	Santa Monica Municipal Airport (Reliever)	CA	855	Legal requirement/agreement
	PDX	Portland International Airport (Commercial, Large-Hub)	OR	1,400	Public request/pressure, proactive strategy
	TPA	Tampa International Airport (Commercial, Large-Hub)	FL	3,795	Proactive strategy
	HPN	Westchester County Airport (Commercial, Small-Hub)	NY	74,177	Legal requirement/agreement, public request/pressure
	SAN	San Diego International Airport (Commercial, Large-Hub)	CA	185,771	Legal requirement/agreement, public request/pressure, proactive strategy
	LAX, VNY	Los Angeles International Airport (Commercial, Large-Hub), Van Nuys Airport (Reliever)	CA	LAX - 67,587 as of 8/2020 VNY - 148,641 as 8/2020	Legal requirement/agreement, public request/pressure
	ORD, MDW	Chicago O'Hare International Airport (Commercial, Large-Hub), Midway International Airport (Commercial, Large-Hub)	IL	ORD - 298,192; MDW - 7,588	Public request/pressure, proactive strategy

Source: Landrum & Brown, 2021.

Table H-2 Case Study Airports Operating a NOMS

Airport Code	Airport Name (Categories)	State
ACK	Nantucket Memorial Airport (Commercial, Non-Hub)	MA
IAH	George Bush Intercontinental Airport (Commercial, Large-Hub)	TX
SMO	Santa Monica Municipal Airport (Reliever)	CA

Source: Landrum & Brown, 2021.

H.2.1.2 Airports Not Operating NOMS

Airport questionnaire findings showed that most airports without a "noise problem" and noise complaint documentation would not justify the procurement of a NOMS. Therefore, from the group of airports that do not operate a NOMS, those airports that provide efforts to address a "noise problem" and log or document complaints would relate better to the target audience. In other words, airports that are handling noise issues without a NOMS can provide ideal information to the NOMS decision-making process and that noise issues may be handled without a NOMS. Lessons learned show that operating a NOMS is not required to handle airport noise problems and therefore, there are other tools and methods to handle airport noise problems. The proposed case study airports below will provide valuable information on how to handle airport noise problems without a NOMS.

The criteria listed below were used to select the case study candidates from the group of airports that currently do not operate a NOMS:

- Airports currently not operating a NOMS;
- Airports that responded "yes" to being a case study;
- Airports that responded "no" to preferring to remain anonymous;
- Airports that log or document the noise complaints;
- Selected case study candidates are not located in the same State;
- Selected case study candidates do not represent the same airport service type and size.

Table H-3*, Case Study Airport Candidates Not Operating a NOMS,* lists the airports that meet the criteria above, in order of highest to lowest number of noise complaints. Additional columns show whether an airport has or is evaluating a NOMS and the number of full-time staff in the noise office as references. The Case Study Selection column shows four (4) proposed selections: a Small-Hub Commercial airport and three (3) Reliever airports. **Table H-4*, Case Study Airports Not Operating a NOMS,*** lists the airports that met the criteria above and were interviewed by the Research Team.

Table H-3 Case Study Airport Candidates Not Operating a NOMS

Case Study Selection	Airport Code	Airport Name (Categories)	State	Complaints in 2019	Has evaluated or is evaluating a NOMS	Noise Staff
1 (GEG)	GEG, SFF	Spokane International Airport (Commercial, Small-Hub), Felts Field (Reliever)	WA	25	No	0
	RAL	Riverside Municipal Airport (Reliever)	CA	15	No	1
Alt. to 1	COS	Colorado Springs Airport (Commercial, Small-Hub)	CO	14	No	1
	BZN	Bozeman Yellowstone Int'l Airport (Commercial, Small-Hub)	MT	12	No	1
	EUG	Eugene Airport (Commercial, Small-Hub)	OR	12	No	0
2	HEF	Manassas Regional Airport (Reliever)	VA	11	Yes	2
Alt. to 2	GTU	Georgetown Municipal Airport (Reliever)	TX	10	No	0
Alt. to 3	PGV	Pitt Greenville Airport (Commercial, Non-Hub)	NC	10	No	0
	DAY	Dayton International Airport (Commercial, Small-Hub)	OH	10	No	0
	DAB	Daytona Beach International Airport (Commercial, Non-Hub)	FL	10	No	0
	SGU	St George Regional Airport (Commercial, Non-Hub)	UT	4	No	0
3	ISM	Kissimmee Gateway Airport (Reliever)	FL	4	No, but getting a flight tracking tool	4

Source: Landrum & Brown, 2021.

Table H-4 Case Study Airports Not Operating a NOMS

Airport Code	Airport Name (Categories)	State
COS	Colorado Springs Airport (Commercial, Small-Hub)	CO
HEF	Manassas Regional Airport (Reliever)	VA
GTU	Georgetown Municipal Airport (Reliever)	TX
ISM	Kissimmee Gateway Airport (Reliever)	FL

Source: Landrum & Brown, 2021.

H.3 Case Studies of Airports Operating a NOMS

H.3.1 Nantucket Memorial Airport, MA (ACK)

H.3.1.1 Background

Nantucket Memorial Airport (ACK) is a Commercial, Non-Hub airport located on the southern side of the Island of Nantucket, MA. The airport proprietor is the Town of Nantucket. ACK is the second-busiest airport in the state of Massachusetts behind Boston Logan International Airport. ACK's top passenger markets are Boston, MA, New York, NY, Hyannis, MA, and Washington, DC. The airport has three (3) runways and the majority of aircraft operations include 3% Air Carrier, 61% Air Taxi, and 36% General Aviation[18]. **Table H-5, *ACK Statistical Highlights,*** presents some basic information about the airport.

Table H-5 ACK Statistical Highlights

Statistical Category	Quantity
Number of Operations (2019)	77,960
Number of Enplanements (2019)	126,610
Number of Noise Complaints (2019)	102
Number of Noise Staff	1

Source: Landrum & Brown, 2021.

H.3.1.2 Key Findings

During the late 1980's, scheduled Air Taxi (i.e. Part 135 Commuter) flights operating predominantly under Visual Flight Rules (VFR) flew over various parts of the island and generated a substantial volume of noise complaints. To try to remedy the low and annoying (not necessarily loud) piston aircraft overflights, a group of homeowner associations collaborated with airport staff and staff from the local FAA Air Traffic Control Tower (ATCT) to develop voluntary VFR noise abatement flight corridors. The airport had a process to track the number of flights on a monthly basis, but without sufficient information to understand where on the island the noise problems existed or to identify the type of aircraft operation that generated a noise complaint, noise complaints were simply logged without in-depth investigation.

In 1988, the airport included a flight tracking tool as a noise mitigating measure in a Part 150 Airport Noise Compatibility Study with the objective to identify VFR aircraft information and flight tracks. A passive antenna was then installed to track flight operations. In 2014, the passive antenna system was replaced by a partial NOMS product (a system without noise monitors) and supplemented with ATCT recordings and historical weather data. The airport procured a stand-alone hand-held noise meter to measure ground noise from Auxiliary Power Units (APU). The system is used to monitor flights in general, noise abatement flight procedures, and runway use. This system was procured by using airport funds.

[18] FAA Air Traffic Activity System (ATADS) for 2019.

In recent years, airport operations have shifted from VFR propeller aircraft operations to Instrument Flight Rules (IFR) jet aircraft operations. This shift in aircraft operations brought on new challenges related to IFR corridors and ground noise, which the airport has less control of compared to VFR corridors.

Relative to the staffing plan, the airport established that a major component of the Environmental Coordinator position was to address and manage the noise program, which included the operation of the NOMS.

The Nantucket Memorial Airport Commission meets monthly and airport staff reports on noise complaint statistics and noise issues. Airport noise-related information is published on the airport website and in airport newsletters, and the airport does provide an online flight tracking platform for public use. As shown on Table H-5, the airport received 102 noise complaints in Fiscal Year 2019 via postal mail, phone, e-mail, and the airport website noise complaint form. Airport staff was able to respond to 95% of those complainants.

Once the partial NOMS became operational, the relationship between the airport and the community improved because airport staff responded to aircraft noise complaints and inquiries with more certainty and provided accurate and factual information about aircraft operations. The partial NOMS allowed the airport to focus its resources more appropriately and efficiently to the noise issues where it has ownership or the ability to influence.

H.3.1.3 Lessons Learned

Airport staff explained the importance of preparing a document describing the minimum system performance specifications and features needed to accomplish the airport's objectives. Additionally, the staff believes that all airports recipients of Airport Improvement Funds (AIP) would benefit from at least a flight tracking system to not only use in addressing aircraft noise issues, but in also using aircraft operations information for airport planning. Lastly, the public has access to various tools that provide aircraft operations information. Airport staff should have their own aircraft operations information tools for community engagement.

H.3.2 George Bush Intercontinental Airport, TX (IAH)

H.3.2.1 Background

George Bush Intercontinental Airport (IAH) is a Commercial, Large-Hub airport located approximately 16 miles north of downtown Houston, TX. The airport proprietor is the city of Houston, TX. IAH is the second-busiest airport in the state of Texas behind Dallas-Ft. Worth International Airport. IAH's top passenger markets are Denver, CO, Chicago, IL, Los Angeles, CA, Dallas, TX, and Atlanta, GA. The airport has five (5) runways and the majority of aircraft operations include 61% air carrier, 26% itinerant General Aviation, and12% air taxi[19]. **Table H-6*, IAH Statistical Highlights,*** presents some basic information about the airport.

[19] FAA Air Traffic Activity System (ATADS) for 2019.

Table H-6 IAH Statistical Highlights

Statistical Category	Quantity
Number of Operations (2019)	478,070
Number of Enplanements (2019)	21,905,309
Number of Noise Complaints (2019)	376[20]
Number of Noise Staff	1

Source: Landrum & Brown, 2021.

H.3.2.2 Key Findings

Prior to Runway 08L/26R opening in 2003, IAH received very few aircraft noise complaints, which warranted minor and simple complaint logging and responding tools. However, for approximately one year prior to the Runway 08L/29R opening, the airport proactively planned for the procurement and installation of a NOMS. One staff member was assigned the project management tasks associated with the NOMS installation and development of an airport noise office. Once Runway 08L/26R opened, air traffic flew over several residential areas resulting in thousands of noise complaints, extensive community engagement efforts, and lawsuits. An additional staff member was added to the noise office to address the overwhelming number of noise complaints. The high number of noise complaints continued for approximately three years. Since then, the implementation of a robust community engagement and education strategy and the reduction in aircraft operations have led to a reduction in noise complaints to more manageable levels. The airport staff publishes the number of complainants and complaint statistics, but not on the airport's website.

During the planning period of the NOMS procurement, IAH opted to not include permanent noise monitors to minimize cost and system complexity, but purchased two portable noise monitors, which are deployed to residents on request.

Airport staff considers working with the NOMS to be fairly simple and effective. IAH noise office staff appreciates using the system's data viewing tools like pivot tables and flight tracking to research and respond to noise complaints. Airport staff outside of the noise office also use some of the system tools to view airport operational data. However, relaying NOMS information to the public is challenging at times because the public does not believe the NOMS information.

H.3.2.3 Lessons Learned

Having factual information about your airport's aircraft operations – as opposed to generalized assumptions – is essential when responding to noise complaints and engaging the community. Without technical tools, some community members may provide information such as aircraft altitude or number of flights per day that are overstated. Additionally, the speed in which systems gather, process, and display aircraft operational data allows staff to respond to noise issues equally as fast without needing to contact third parties like FAA Tower staff or airline staff. At one point, the NOMS was temporarily out of service for months.

[20] The complaint count includes IAH, William P. Hobby Airport (HOU), and Ellington Airport (EFD) noise complaints.

During this time, staff had to contact third parties for information and their lengthy response time delayed staff's response to the public.

H.3.3 Santa Monica Municipal Airport, CA (SMO)

H.3.3.1 Background

Santa Monica Municipal Airport (SMO) is a General Aviation - Reliever airport located approximately 12 miles west of downtown Los Angeles, CA. The airport proprietor is the city of Santa Monica, CA. SMO has a single runway and aircraft operations include 5% air taxi, 59% Itinerant General Aviation, and 36% Local General Aviation[21]. **Table H-7, *SMO Statistical Highlights,*** presents some basic information about the airport.

Table H-7 SMO Statistical Highlights

Statistical Category	Quantity
Number of Operations (2019)	77,280
Number of Noise Complaints (2019)	855
Number of Noise Staff	1

Source: Landrum & Brown, 2021.

H.3.3.2 Key Findings

SMO was one of the first airports in the U.S. to install a NOMS in 1967. The NOMS was installed to enforce a single event noise limit for aircraft departure and arrival noise levels. The system printed noise event information and aircraft operations information such as the aircraft registration number and time of operations were handwritten on a paper log. Once California implemented its "California Airport Noise Regulations" in 1973, which required California "noise problem" airports to produce the 65 dB Community Noise Equivalent Level (CNEL) noise impact boundary, the NOMS was used to validate the CNEL 65. These primary functions of the NOMS continue to be performed today. Because the airport issues fines to pilots who exceed the noise limits, an important NOMS feature is to capture an aircraft's registration number. To supplement the capturing of the registration numbers, the airport installed video cameras near the runway.

In 2017, the airport upgraded the NOMS by installing new software and replacing the outdated permanent noise monitors. Unlike other airports that install a single noise meter at each permanent monitoring site, during the upgrade, SMO opted to install two side-by-side noise meters at two monitoring sites to ensure the recording of noise limit violations. One of the side-by-side monitors acts as a secondary backup in case the primary monitor fails. During the NOMS upgrade and vendor selection process, selecting the system that would most effectively fulfill the least-loss-of-data requirement became a challenge.

[21] FAA Air Traffic Activity System (ATADS) for 2019.

However, according to staff, the selected system has proven to be very effective. The noise monitoring equipment that the airport installed over the years was procured with airport funds.

Historically, jet aircraft noise had been the large contributor to noise complaints. However, at the end of 2017 the runway was shortened preventing larger jet aircraft to operate at SMO effectively reducing the number of jet aircraft operations and noise complaints. As jet aircraft operations decreased, the community shifted the focus of the noise complaints to propeller aircraft operations. Although the low sound level from propeller aircraft operations at times does not register noise events at the airport monitors, the airport continues to receive noise complaints about these relatively quieter aircraft. The airport provides an online tool for the public to view near-live and historical replays of aircraft operations, view noise levels at the noise monitors, and submit noise complaints. The SMO Airport Commission oversees airport operations and noise issues and meets ten times per year.

After decades of legal action and community protest against the airport, the airport announced in 2017 that SMO will close completely in 2028 to be replaced by a complex with a park, recreational facility, and other non-aviation uses.

H.3.3.3 Lessons Learned

Proper planning for the NOMS Request for Proposal (RFP) is essential to ensure that a system not only fulfills current needs, but also future needs. Switching vendors and performing major component upgrades can cause system-use disruptions and can temporarily increase staff workload. Therefore, a thorough RFP preparation process that includes language relative to current and future system requirements will minimize the risk of not having the right system tools in the future, which may lead to contract renegotiations or the installation of a new system by a new vendor. To supplement the RFP planning process, the airport hired a consultant that provided detailed NOMS specifications that addressed SMO's specific technical needs. The staff believes that adding support by a consultant who specializes in NOMS specifications, operation, and acceptance testing is fundamental to successful NOMS selection, procurement, and installation processes.

In addition to a thorough RFP planning process, staff recommends that airports that are evaluating the procurement of a NOMS or flight tracking system have clear goals in mind relative to addressing airport noise issues. Every airport's noise issues and airport staff's responses to the community are different. NOMS vendors generally know how to address noise issues, but their products and services need to be in line with the airport's noise abatement and community engagement goals.

H.4 Case Studies of Airports Not Operating a NOMS

H.4.1 Colorado Springs Airport, CO (COS)

H.4.1.1 Background

Colorado Springs Airport (COS) is a Commercial, Small-Hub airport located southeast of Colorado Springs, CO. The airport proprietor is the city of Colorado Springs. COS is the second-busiest airport in the state of Colorado behind Denver International Airport. COS's top passenger markets are Dallas, TX, Denver, CO, Phoenix, AZ, Las Vegas, NV, and Chicago, IL.

The airport has three (3) runways and aircraft operations include 10% air carrier, 11% air taxi, 54% General Aviation, and 25% Military[22]. Peterson Air Force Base (PAFB) is located on the north side of the airport and is a major tenant. **Table H-8*, COS Statistical Highlights,*** presents some basic information about the airport.

Table H-8 COS Statistical Highlights

Statistical Category	Quantity
Number of Operations (2019)	135,431
Number of Enplanements (2019)	828,429[23]
Number of Noise Complaints (2019)	14
Number of Noise Staff	1

Source: Landrum & Brown, 2021.

H.4.1.2 Key Findings

COS is a case study airport that does not operate a NOMS, although staff logs noise complaints. Complaints are generally submitted by phone and email. However, complaints are not published or shared on the airport website. Due to the low number of noise complaints on the order of only a few per month, COS feels that noise issues are handled successfully without a NOMS. Most of the current noise complaints are a result of military operations from PAFB. Commercial operations are also increasing as a result of increased Frontier and Southwest Airlines operations. If noise complaints were to increase and pressure from the public and/or political area forced them to monitor aircraft operations and/or to view noise and flight track data, a NOMS might be considered in the future.

COS has been very successful with working with local and regional jurisdictions and local developers to update zoning ordinances, implement avigation easements, and restrict residential development. Additional measures are also in the works. The airport created the Airport Advisory Commission (AAC) which meets monthly to review all land use development projects and to discuss noise issues. A recent Airport Land Use Compatibility Study proposes a limit on residential development to ensure the airport is protected from future incompatibilities. A newly annexed area will establish zones to limit residential development, require development between DNL 60 and 65 to require construction methods to reduce interior noise to DNL 40, avigation easements, reduced lighting impacts, and rental/real estate disclosures.

[22] FAA Air Traffic Activity System (ATADS) for 2019.

[23] FAA Passenger Boarding and All-Cargo for U.S. Airports for 2019

H.4.1.3 Lessons Learned

Airport staff expressed the importance of education as being the key to success in the handling of noise issues. For example, a local developer is a member of the AAC to provide a development perspective regarding land use issues; developers with potential land use projects are invited to meet directly with airport staff and the ACC to discuss their projects and the impacts and concerns that airport noise has on residential development close to the airport. Through this effort, a large residential development near the airport is incorporating some noise mitigation efforts, not currently required by local codes, but recommended in the draft compatibility plan.

H.4.2 Manassas Regional Airport, VA (HEF)

H.4.2.1 Background

Manassas Regional Airport (HEF) is designated as a National General Aviation - Reliever airport located approximately 30 miles southwest of Washington, D.C. The airport proprietor is the city of Manassas, VA. HEF has two runways and aircraft operations include 54% itinerant General Aviation, and 46% local General Aviation[24]. **Table H-9*, HEF Statistical Highlights,*** presents some basic information about the airport.

Table H-9 HEF Statistical Highlights

Statistical Category	Quantity
Number of Operations (2019)	85,701
Number of Noise Complaints (2019)	11
Number of Noise Staff	2

Source: Landrum & Brown, 2021.

H.4.2.2 Key Findings

HEF's noise environment involves operations by fixed-wing and helicopter flight schools and also involves corporate jets, including on hush-kitted Gulfstream II. The airport has voluntary noise abatement procedures, which coincides with strict climb rates (ARSENAL 5 Departure), which takes into account air traffic from Dulles International Airport (IAD), approximately 16 miles north of HEF. Since 2007, the airport has received an average of 20 aircraft noise complaints per year. Noise complaints can be submitted online via the City's public issue reporting system. Approximately 80% of noise complaints are related to helicopter traffic, medical and law enforcement operations flying relatively low on flight corridors between airports and around the D.C. region. In addition to the City's complaint database, staff uses off-the-shelf electronic spreadsheets developed in-house to log and document noise complaints. Staff reports the number of aircraft noise complaints but does not publish complaint statistics online.

[24] FAA Air Traffic Activity System (ATADS) for 2019.

In recent years, airport staff used the IAD public online flight tracking tool to investigate aircraft operations. However, HEF currently has its own flight tracking tool to investigate aircraft operations and also partners with the ATCT to receive feedback on flights that may not be available on third party platforms.

Prior to procuring the flight tracking tool, the airport used grant funding to procure a noise meter, which was used to monitor aircraft operations. The transfers and analysis of data was challenging, however. Staff reached out to an airport that operated a NOMS to receive information about the factors associated with the NOMS including cost. Given the high cost of a NOMS and the relatively small noise issues, the procurement of a NOMS could not be justified.

Two of the most challenging aspects of handling noise issues are informing the public that helicopters are allowed to fly at relatively low altitudes and handling repeat complaints by the same individuals when no new information can be provided to them that will resolve their complaints.

H.4.3.3 Lessons Learned

When responding to community members who complain often, staff should provide information about aircraft operations – although it may be repetitive – in a customer-service-based honest and engaging way and try to connect with the complainants so they feel understood.

For airports that are beginning to develop their noise programs, understand that noise programs generally do not show signs of noise reduction from the onset. It takes time for noise programs to mature and become effective. Staff should invest time and effort into engaging the various types of pilots that fly into and out of their airports and engaging ATCT staff to assist in the utilization of noise abatement procedures. Lastly, if funding for a NOMS cannot be secured, staff should research other sources that may provide pieces to a noise monitoring system, such as a city's complaint tool or a larger airport's flight tracking tool.

H.4.3 Georgetown Municipal Airport, TX (GTU)

H.4.3.1 Background

Georgetown Municipal Airport (GTU) is a General Aviation - Reliever airport located approximately 28 miles north of downtown of Austin, TX. The airport proprietor is the City of Georgetown, TX. GTU has two runways and aircraft operations include less than 1% Air taxi, 47% Itinerant General Aviation, and 53% local General Aviation[25]. **Table H-10*, GTU Statistical Highlights,*** presents some basic information about the airport.

[25] FAA Air Traffic Activity System (ATADS) for 2019.

Table H-10 GTU Statistical Highlights

Statistical Category	Quantity
Number of Operations (2019)	112,296
Number of Noise Complaints (2019)	10
Number of Noise Staff	1

Source: Landrum & Brown, 2021.

H.4.3.2 Key Findings

Historically, GTU has received very few aircraft noise complaints over the years largely in part to the airport's small noise footprint. Recently, however, GTU received noise complaints on a bi-weekly basis, sometimes multiple calls about the same event from neighbors, especially during the summer months, and when aircraft are using the crosswind runway. GTU's main noise issues involve a wide range of issues including low-flying fixed-winged aircraft and helicopters, aircraft in the touch-and-go and landing patterns, aircraft departing Class D airspace, training flights, and large business jets. When the crosswind runway is in use, citizens who normally do not hear or see aircraft overhead become alarmed from aircraft noise.

GTU's noise issues are currently being handled successfully without a NOMS. However, the airport is in the process of securing airport funds to procure a flight tracking system that will provide information for staff to respond noise complaints and inquiries and to provide the necessary statistical information to justify future airport projects and improvements. The flight tracking system will provide staff with the date, time, and location of aircraft. In combination with system's address locator tool, staff will be able to inform the complainant about specific flights. Since the GTU ATCT is closed during nighttime hours, the system will also provide an accurate way to count the number of aircraft operations.

The airport procured a hand-held noise meter recently to perform aircraft noise measurements at noise sensitive areas around the airports. Aircraft noise event levels are not automatically correlated to aircraft noise events as is the case with a NOMS. Staff had to keep hand-written notes about the noise event, and then query the flight tracking system to find the aircraft operation that likely created the noise event. With this noise measurement data, staff was able to inform residents on actual aircraft noise levels gathered by a calibrated device as opposed to phone apps or other tools that are not calibrated.

The airport's most difficult challenge associated with addressing aircraft noise issues is land use management. Unfortunately, due to the way that county land is regulated, residential land use was allowed right up to the airport's north and northwest fence lines. To the southwest of the airport, residences are approximately 2,000 feet from the fence line. At these distances, aircraft fly directly over houses in very close proximity to the ground.

H.4.3.3 Lessons Learned

Accurate data is very important when engaging the public and explaining aircraft operations. The public can easily access aircraft noise apps and online flight tracking tools, but those tools are not calibrated.

Also important is the ability to explain the differences between types of aircraft and the reasons why all aircraft do not fly in the same airspace.

Another issue is the fact that staff receives calls about aircraft that are outside GTU airspace and all the staff can do is refer the caller to the Flight Standards District Office (FSDO). The complainant feels like staff is simply passing the issue to someone else and really does not care to respond to them.

For airports evaluating the procurement of a NOMS or flight tracking system, the staff suggests obtaining a tool that is cost effective and provides simple tools that will provide a time stamp of flights over a given location. Additionally, staff suggests that airports maintain updated noise contours maps that clearly identify the airport's noise exposure boundaries in case a more comprehensive FAR Part 150 Noise Compatibility Study is necessary.

If an airport performs a FAR Part 150 Study and the DNL 65 contour reaches residential land use, then the airport can apply for federal funding for a full NOMS.

H.4.4 Kissimmee Gateway Airport, FL (ISM)

H.4.4.1 Background

Kissimmee Gateway Airport (ISM) is a Reliever general aviation airport located in Kissimmee, FL. The airport proprietor is the City of Kissimmee. The airport has two (2) runways and the majority of aircraft operations include 50% transient general aviation and 48% local General Aviation[26]. **Table H-11*, ISM Statistical Highlights,*** presents some basic information about the airport.

Table H-11 ISM Statistical Highlights

Statistical Category	Quantity
Number of Operations (2019)	133,583
Number of Noise Complaints (2019)	4
Number of Noise Staff	4*

*Noise abatement duties are shared among staff
Source: Landrum & Brown, 2021.

H.4.4.2 Key Findings

ISM's noise environment involves fixed-wing and helicopter flight schools as well as helicopter and World War II vintage aircraft sightseeing operations. In 2018, the airport received a significant amount of aircraft noise complaints due to the primary runway's rehabilitation project, which moved air traffic to the secondary runway and over residential areas. Other than noise complaints during the runway rehabilitation project, the airport mostly received noise complaints about aircraft operations three to five miles away from the airport. When responding to these aircraft noise complaints, the airport had little information to provide to the complainant about the aircraft operation.

[26] FAA Air Traffic Activity System (ATADS) for 2019.

Since ISM installed a flight tracking system in 2021, staff has been able to pin-point the location of the aircraft associated with the noise complaints and provide this information to the complainant. The flight tracking system was procured by the airport's operations and maintenance budget from airport funds. The airport does not have staff specifically dedicated to a noise office, so noise abatement duties are shared by staff.

One of the challenges that staff faces when dealing with noise complaints is complainant education. Therefore, airport staff often needs to inform complainants about aspects, such as how aircraft are allowed to fly, when the airport is allowed to be open, and why law enforcement and medical flights are allowed to operate under special flight rules.

The airport currently logs complaints in a complaint form binder where staff inputs information about the complainant, complaint, and response. The level of complaints is relatively low and currently, staff does not feel the need to move to an electronic complaint format.

In addition to the flight tracking feature, the airport also uses the system to count the number of aircraft that cross the primary runway to monitor and coordinate possible safety issues with the FAA. The airport selected their particular system partly to monitor aircraft operations to address noise issues and partly to monitor runway crossings to support future taxiway planning and airport growth. Additionally, because the ATCT is closed during nighttime hours, the system allows the airport to log an accurate count of total airport operations.

H.4.4.3 Lessons Learned

Gathering sufficient information to fully address a noise complainant's needs was challenging, because at times the sources of information were not readily available or accessible. The flight tracking system provided an accurate and efficient way to investigate and gather noise complaint response information at an office setting or from remote access (home), which was a useful option in case staff had to quarantine due to COVID-19 illness or contact tracing.

Public education is key, especially on the positive aspects of airport operations and noise abatement. Airports should invest the time and resources to inform the public on the types of activities airports support such as the local economy, law enforcement and medical operations, the use of quieter aircraft, and the monitoring of noise abatement procedures to minimize aircraft noise to the extent possible.

Appendix I: NOMS Vendor Discussion & Summary of Findings

I.1 Objectives

The objective of the discussions with the Noise and Operations Monitoring Systems (NOMS) vendors was to gather information on the future of NOMS within the next 20 years and to discuss issues that impact airports relative to NOMS procurement, installation, operation, and support.

I.2 Focus of Discussions

The focus of the discussion was based on four main areas. Each of the main areas had multiple questions that were asked of each vendor. It should be noted that not all of the vendors answered all of the questions.

Per Airport Cooperative Research Program (ACRP) guidelines, the names of the NOMS vendors within this discussion were to remain anonymous, and this task will only describe the vendors' perspective in terms of future developments and issues that impact airports. This task was dependent on the vendor's willingness to participate in discussion and be forthcoming about future noise monitoring needs and development, which vendors may withhold as a competitive advantage. It should be noted that all of the vendors were very open regarding the future of their product and the industry.

The main areas of discussion are presented in the following sections and are, as follows:

- What are the benefits from operating a NOMS?
- How will inclusion of new aircraft such as Urban Air Mobility (UAM) and/or Unmanned Aerial Vehicles (UAV) broaden NOMS utilization?
- Discuss how future software development and technology will enhance NOMS functionality;
- Other issues that impact airports or system installations.

I.3 Vendor Database Development

I.3.1 Background

A total of nine (9) vendors were identified that supplied NOMS worldwide. One-on-one discussions were held with seven (7) of the major worldwide vendors. No discussions were held with two (2) of the vendors. One airport had a custom self-built system and the other vendor had only a few NOMS and was phasing out of the business. It was decided that no useful information could be gathered by discussions with these vendors regarding the future of NOMS. It should also be noted that only five (5) of the vendors currently have installations at U.S. airports, but the Research Team felt that valuable input could be obtained from all vendors.

All told, seven (7) of the vendors operate 89 NOMS, plus an additional 40 hybrid NOMS operated by Virtower at airports throughout the U.S. It should also be noted that all of the vendors identified supply software, but not all the vendors provide the noise monitoring hardware.

I.3.1.1 U.S. Vendors

The vendors based within the U.S. and the number of systems they operate includes:

- Virtower LLC (U.S.-based with 40 U.S. systems);
- L3Harris Technologies (U.S.-based with 32 U.S. systems);
- Vector Airport Systems (U.S.-based with 9 U.S. systems);
- HMMH (U.S.-based with 3 U.S. systems);
- Other (U.S.-based with 1 U.S. system).

Virtower currently operates 40 U.S. systems, L3Harris currently operates 32 U.S. systems, Vector operates nine (9) U.S. systems, and Harris Miller Miller & Hanson, Inc. (HMMH) operates (3) U.S. systems. Minneapolis-St. Paul International Airport (MSP) currently operates its own system with software written internally. All of these vendors operate NOMS exclusively with in the U.S.

I.3.1.2 International Vendors

The vendors based outside the U.S. and the number of systems they operate includes:

- ACOEM/01dB (France-based with 0 U.S. systems);
- Casper Aero (Netherlands-based with 6 U.S. systems);
- Envirosuite Ltd. (Australia-based with 38 U.S. systems);
- TopSonic (Germany-based with 0 U.S. systems).

ACOEM/01dB currently operates no U.S. systems, but has numerous installations throughout Europe and Asia. Casper Aero currently operates six (6) U.S. systems and has numerous other installations throughout Europe. Envirosuite Ltd., formerly known as EMS B&K, operates (38) U.S. systems and has numerous installations throughout Europe, Asia, Middle East, and Africa. TopSonic currently operates no U.S. systems, but is found throughout Europe and has some Asian installations. Of the International vendors, only Casper and Envirosuite operate NOMS within the U.S.

I.4 NOMS Vendor Discussion Points

I.4.1 What are the benefits from operating a NOMS?

I.4.1.1 From a vendor's perspective, what benefits do airports experience by getting a NOMS?

Almost all of the vendors presented the same list of benefits with regard to operating a NOMS. The list included:

- Factual information;
- Ability to develop new procedures;
- Ability to monitoring the implementation of new procedures;
- Tracking trends with changes in operations;
- Obtaining a complete picture on how the airport operates;
- Better airfield awareness;
- Public relations using noise, operations, and complaint data;
- Use of data for internal billing;
- Compliance with National laws - in some countries permission to operate an airport is linked to the installation of a NOMS;
- Use in 3rd party apps such as the FAA's Integrated Noise Model (INM) / Aviation Environmental Design Tool (AEDT), SoundPlan, etc.;
- To answer community questions;
- Data collection for future airfield development such as new runways;
- Data can be used to develop a compensation plan for impacted people;
- Data can be used to develop a balance between operations and noise;
- Better social responsibility;
- Ability to use different metrics;
- Ability to have different tools for different communities;
- Building environmental capacity;
- Building stakeholder engagement;
- Build trust and be transparent, use the facts to help people understand the issues.

I.4.1.2 For an airport with no documented or perceived noise impact, how would you explain to them that a NOMS might be beneficial?

Many of the answers given above to describe the benefits of a NOMS also fit the reasons given to airports as to why it is beneficial to acquire a NOMS. They mention it is not just for noise, one vendor saying that it is not just the noise or "N" part of NOMS, but it can be used more for the "OMS" part of NOMS. It can be used for billings, tracking operations, baggage handlers, determining operational efficiency, and developing operational awareness of how an airport operates. It can also be used for better public relations more than anything and it is good marketing for the airport. It allows an airport to know the who, what, where, and when related to aircraft operations. It can also be used to document a major change at the airport, such as the introduction of a major new aircraft (F-35) or the change due to the addition of a new runway.

I.4.1.3 How are airports using a NOMS and NOMS data/output outside of normal use, i.e. most unique application of a NOMS?

Several vendors offered unique uses of NOMS, including:

- Tracking operational changes due to Covid-19;
- Use by a non-airport operator to track flights from several nearby airports;
- Several military airports in Europe that offer up nearly all data on-line – very open and transparent;
- An airport in South America that uses NOMS to maximize daily operations by finding a balance between aircraft operations and noise per aircraft;
- Used to support a legal requirement to meet certain noise levels at many locations or the airport pays a fine;
- One airport used it to predict when F-16s were returning to an airport so the public knew when to go outside and watch them;
- Emergency Locator Transmitter (ELT) Beacon (ELT) for the detection of where aircraft are or for crash detection;
- Monitoring unauthorized crossing of active runways;
- Monitoring ground traffic into or out of a specific airport area;
- YVR used it to reduce delays for aircraft getting deiced;
- LHR used it to determine why some A380 aircraft on arrival could not make the first high-speed taxiway exit;
- FRA airports used it to determine why some earlier A320 aircraft were louder than others.

I.4.1.4 Do you believe that it is beneficial for airports to show NOMS data on-line in all cases?

All the vendors agreed that it is beneficial for airports to show NOMS data online, but with a few exceptions. Sometimes too much detail may not be beneficial. Openness and transparency helps to build trust and goodwill. However, it was also important to be careful so data cannot be misinterpreted. They believe that having this data available to the public will not only reduce noise complaints, but it will also increase the quality of the noise complaints they do receive. The airport needs to be more open or the public will think they are trying to hide something. Also keeping in mind airports are competing with many phone apps which tend to give sub-standard data. One vendor stated it was best to avoid showing "N" registration numbers, especially for general aviation aircraft. Corporate aircraft can often have fake or blocked registrations.

I.4.1.5 Do you provide multiple levels of your NOMS software such as a "basic" system that is scalable allowing clients to choose the right level for their budget?

All the vendors mentioned that they can offer a low-cost basic system and can add "modules" or features to the system to increase the value and flexibility of the system per the client's request. Several vendors only offered a low-cost basic system. Some venders seemed to more advanced with the development of a modular and scalable system. One vendor thinks a modular system will be the way of the future. Another vendor mentioned their systems are geared more toward billing using flight track data and can be upgraded with a camera system for better data capture and the option to add noise monitors. They do not yet offer any sort of complaint management system.

I.4.1.6 Do you feel you can offer a NOMS to airports that requires little or no use of airport staff?

All the vendors, with one exception, offer a hosted system to minimize the need for an airport staff/noise office. Several vendors exclusively offer a hosted system, while the rest of the vendors offer both options. One vendor noted that in some countries like China and Israel, the data must remain in the country and a hosted system would not be allowed. One vendor mentioned that more and more airports did not want to own a system and instead only wanted to subscribe and pay a fee for the data they want without all the hassles of owning.

I.4.2 How will inclusion of new aircraft such as Urban Air Mobility (UAM) and/or Unmanned Aerial Vehicles (UAV) broaden NOMS utilization?

I.4.2.1 Related to an airport NOMS installation, do you have plans to include UAM/UAV monitoring in future installations?

The vendors here had varying responses for this evolving industry.

One vendor said they are deeply involved with and are already layering in features for the inclusion of Urban Air Mobility (UAM)/Unmanned Aerial Vehicles (UAV). This will involve a fundamental change, as the focus will be on the large number of vehicles flying point to point vs. the traditional airport focus on arrivals/departures. In addition, they think it will not be an issue of noise levels, but more visual pollution and privacy issues.

One vendor said they are holding a "wait and see" attitude and are waiting for the industry to evolve. Once the requirements were clear, deployment would occur. Another vendor believed it would be mostly for tracking package delivery and personal taxis, thus likely not much of a concern for airports.

One vendor mentioned that they will update their system to detect and track UAM/UAV as soon as the government determines the frequency to be used by these aircraft.

Still, several other vendors were heavily involved in UAM/UAV planning, including one that was working to help define policy. They said it would fit right into their system as an additional aircraft using a new aircraft ID.

Another vendor stated they will consider it when asked to do so by an airport.

UAM/UAV was considered a new industry, so overall the responses varied across all of the vendors.

I.4.2.2 How many years before your system would be able to offer UAM/UAV monitoring?

One vendor stated soon and another within 5 years UAM/UAV should be in common use. It likely would be for package vehicle first, followed by people vehicles and they stated they are already working on the technology. Another vendor thought it would be more like a 5-10 year timeframe. The other vendors did not offer up a timeline.

I.4.2.3 How do you view the inclusion of UAM/UAV aircraft in your NOMS?

All of the vendors mentioned that the inclusion of UAM/UAV aircraft would be a separate UAM/UAV module within their NOMS. They would include it as a new aircraft type, although there would be nuances needed to incorporate it into NOMS. They mentioned they will have to build new aircraft registries to recognize aircraft ownership. One vendor also thought that this would be a move away from airports only NOMS and would include cities and new droneports. That also brought up an issue of funding as it would need to move away from the FAA-centric model that currently exists. They stated that this would also move more away from ownership of a system to a fee-based subscription system. One vendor mentioned it might be an add-on to a city noise module that they already offer, since it would be required to be detected within a city and classified in a way that a city has different noise sources from an aircraft.

I.4.2.4 Do you think that some airports might be more interested in only UAM/UAV monitoring in a NOMS?

Multiple vendors thought there could only be a UAM/UAV monitoring system. Cities might have a lot of interest in a stand-alone system, although one vendor thought a city may rely on an airport to provide that service. Another vendor highlighted that the City of Sunnyvale, CA presently has a NOMS, but is not an airport.

I.4.3 Discuss how future software development and technology will enhance NOMS functionality.

I.4.3.1 Besides the potential for UAM/UAV monitoring discussed earlier, what new software might be available to airports using NOMS in the near future?

All the vendors seemed to be working on new software enhancements/concepts for the future. These included increased use of cloud storage, more use of Virtual Noise Monitors (VNMTs), and more and better metrics linked to personal well-being. One vendor said they had many new and interesting updates coming soon, but was unwilling to share specific details. However, they did say it would include more automation and more business intelligence.

I.4.3.2 Besides the potential for UAM/UAV monitoring discussed earlier, what new technology might be available to airports using NOMS in the near future?

Vendors offered up many thoughts on new technology coming soon, including the increased use of tablets and other mobile platforms, better radar data capture rate, air quality/emissions monitoring, cheaper Noise Monitoring Terminals (NMTs), increased use of active Automatic Dependent Surveillance-Broadcast (ADS-B) transmitters, less reliance on passive transmitters, and fully live (no delay) public displays of data.

I.4.3.3 What do you feel is the software and/or technology needed most in a NOMS today?

Many ideas were offered up here from the vendors, including the need for real-time data feeds, better data quality, in that System Wide Information Management (SWIM) data is tolerable, but improvement is needed, better ability to track RNAV/RNP procedures, enhanced ability to do "DIY" (do it yourself) or self-service noise complaint monitoring, more accurate noise prediction models, more effective tools to communicate with the public, improved reports to make informed decisions, higher quality data from the source, and advanced noise/flight track correlation rate. One vendor mentioned the need for more modularity, the current lack of soundscape mapping, and the need to develop different user profiles for all users with tailored access granted for various modules including noise, operations, billing, baggage, wildlife, forecasting, gate management, flight delay management, etc. One vendor mentioned that low cost and 100% capture rate on tracking is the way of the future and is what airports want.

I.4.3.4 What new NOMS features do you see NOMS having in the future?

The thoughts and ideas provided here included the ability to offer emissions monitoring (especially particulates), to offer the ability to offer the public a means to better understand the data, and to provide much cheaper systems so more airports are willing to purchase.

One vendor mentioned that having every aircraft (anything that flies) equipped with an ADS-B receiver will create better situational awareness for pilots and will allow better real time communication between airports and pilots using new technology (not texting). Pilots could automatically make real-time decisions to minimize noise and air quality impacts on the ground, (i.e. an autopilot to minimize noise). Routes, thrust, profiles could be adjusted, and ground routes could be flown to minimize ground impacts.

One vendor wanted better identification of aircraft events at the source. They are working with another vendor to develop a mini array of microphones at each NMT. The NMT would be able to detect the difference between aircraft and ground sources using both vertical and horizontal noise detection.

Another vendor mentioned the ability to track Instrument Landing System (ILS) approaches by aircraft type, which is a new feature coming out.

Another vendor foresaw more community portals, more centralized databases for use by multiple users, and the broadening of environmental parameters.

I.4.4 Other issues that impact airports or system installations.

I.4.4.1 Are NOMS installations and data/output in other parts of the World such as Europe and Asia different than in the United States?

Almost all of the vendors presented some ideas to this list. Obviously, of the six (6) worldwide vendors, four (4) of them are not headquartered in the U.S. and two (2) of those do not have any U.S. systems at the present time. The list of differences included:

- Outside the U.S. airports placed more emphasis on compliance and fines;
- Inside the U.S. airports were more about complex stakeholder engagement;
- Data privacy laws are much stricter in Europe;
- Data output more of an issue for the Swiss/Germans – a minor data anomaly is a major issue;
- Missing data is more of an issue in Europe than in the U.S.;
- Noise regulations are much stricter;
- Europe has more procedures to monitor and more requirements to track;
- Monitoring is a more complex process due to government and airport requirements;
- Every European country has different issues;
- Every European country has different radar data service providers;
- The European public demands more NMT – at every house and don't care about cost;
- Virtual NMT not in use as of yet in Europe;
- Virtual NMT would not be allowed in at least one country in Europe since it would require an independent agency to verify the data;
- India and China clients are very different from European clients in terms of contractual factors;
- Clients in Korea and Taiwan want full data service contracts;
- China wants to own the software, own the source code, and wants nothing in the cloud;

- Other parts of Asia want to own the system, but want nothing to do with operating the system;
- Europe has better situational awareness of using data;
- Europe tends to require more data details;
- European airports and the public demand more data to be available on-line.

I.4.4.2 Are their components (software, technology, data output) of a NOMS used in other parts of the World such as Europe and Asia that could useful to systems in the United States?

Most vendors could not offer up any thoughts on what U.S. systems might be missing, although one vendor mentioned that Europeans shared data well above the level shared in the U.S. and the U.S. might learn something from that. Another vendor did mention that many cities in Europe are required to map city noise and for airports close to a city, the mapping of noise from both the city and airport are combined. Another vendor mentioned that airports in Canada and Europe tend to have more personalized and focused data.

I.4.4.3 What do you foresee as the biggest hurdles with a NOMS installation in the United States?

Almost all of the vendors added some ideas to this list, keeping in mind that 2 of the vendors do not have any U.S. systems at the present time. The list included:

- Availability of funding for a system – especially for a smaller airport;
- Need to find a good local or regional partner for installation and NMT maintenance;
- Need to have local or regional presence for support;
- Requests for Proposals (RFP) are often unclear as to what an airport truly wants;
- Consultants often "recycle" specs and the airport does not know the difference. Vendors tend to know which consultant did which spec for an airport;
- NMT site selection is a challenging process in U.S. This was an issue raised by several international vendors especially those based in Europe and Asia. They said in Asia, NMT are mostly installed on private property and require negotiation with individual property owners and often times a payment. In the U.S., usually NMT are installed on public property, i.e. parks, schools, rights-of-way, etc. This usually involves negotiations with only a few parties and no payment required beyond any necessary permits;
- Tough to find a good acoustical site for NMT;
- Many have issues with obtaining local permits for NMT installations especially if many jurisdictions are involved;
- Right now, a main issue is with the pandemic – some airports are starting to ask for money back;

- Some airports calling to have billing systems integrated so landing fees can support city budget deficits;
- Radar interface, especially in Europe and Asia.

I.4.4.4 Please describe the lessons learned from a NOMS procurement, installation, testing, operations, and support.

Vendors had many things to say here. One vendor speaking mostly about non-U.S. installations stated that one should assume that the money is not used wisely and many times a system is installed and just left to rot. They recommend a push for full maintenance options to keep it running and with the aid of a strong local partner. First to help with the installation and afterwards to keep up with the maintenance.

For installation, the ability to have a good, fast internet connection is a key for many installations.

Another vendor mentioned that this is an industry that relies on low-bids and it always ends up being a "race to the bottom." They blamed generic specs for a lot of the problems and it equates to a system having way more features than an airport wants or needs.

Another vendor mentioned that the preparing the specifications and procurement process is taking way too much time to implement and many times the system cost is too much for an airport – both in the purchase price, but also the labor costs required to operate the system.

Still, another vendor took a more general approach. Every system is different, every airport is different, and they all need a different approach. They have different software requirements and all the bid/tender requirements are different. There is way too much standard information in the spec (90%) and only about 10% is tailored to the airport. More effort should be taken to tailor the requirements to the airport's needs.

The last vendor mentioned that during procurement, the airport should not start with the idea that they only want to measure noise. They should decide what their system will be used for and what their noise management program will look like, and then work down to the basics of what they actually need in a system. Focus on the program and system needs and then develop a specification tailored to those needs.

Lastly, another vendor states that airports are less concerned with receiving the best system, but rather they concentrate on "checking all the boxes" in the procurement process. They also stated that the procurement process takes too long – and it is long everywhere in the world. Airports (or their consultants) tend to over specify the system requirements. Airports want the best system and a low price, but the two do not tend to go hand-in-hand. They state that installation is a long process, especially for the NMT. Obtaining radar data is also a large issue. In the U.S., it is easy with one source, but in Europe, each country and each airport is different and requires separate negotiations with local Air Traffic Control (ATC). Airports also have issues with receiving the right reports. Reports should be tailored for each airport and the needs of their public. Finding the right complaint management system is also an issue. This vendor thinks European airports are much more demanding when it comes to system support. They all think all airports are special and different.

I.4.4.5 What are the biggest airport concerns or requests related to a NOMS procurement, installation, testing, operations, and support?

Vendors summarized the biggest airport concerns below:

- Airports really do not want to spend money on something they do not want;
- If they do spend money on a system, they want the system to be inexpensive;
- Airports never seem to know which department handles the procurement, but many times it is outside the full control of the airport or the department asking for it;
- Airports want to spend less on NMTs and use more virtual NMTs (U.S. only);
- System specifications tend to have a lack of knowledge about radar surveillance;
- System specifications need more specific information about noise and community relations;
- Smaller airports tend to think a system is too expensive and too complex to operate with limited funding and staffing;
- #1 issue for U.S. airports is that they do not receive adequate support from the vendor.

I.4.4.6 Are you aware of instances where the operation of a NOMS is a shareable cost/shared venture between the airport and local communities/municipalities?

When presented with this question, most vendors thought it was an interesting concept and could happen in the future. One vender knew of a small airport in Thailand that has a joint venture system between an airport and an airline. The airline runs the airport and the local community demanded the system.

I.4.4.7 In addition to the NOMS, do you offer the manpower to support the day-to-day operation of the NOMS to assist airport that do not have the staff to do so?

Having a hosted system would allow the vendor to do most of the work that airport staff would normally be required to do. An airport could run a noise program with minimal staff. Most of the vendors offer a hosted system as an option to airports. Some only offer a hosted system, one vendor is transitioning to a hosted system, and one vendor does not yet offer a hosted system but is hoping to in the future. Another vendor offers a hosted system and believes it is the way of the future, as airports do not want to own and staff a system, but would rather pay a fee for a subscription service to obtain the data they need.

Appendix J: Noise Monitor Installation & Maintenance Guide

J.1 Introduction

The objective of a Noise and Operations Monitoring Systems (NOMS) and the installation of portable and permanent Noise Monitoring Terminals (NMT) is to monitor noise levels generated from aircraft operations. Using data collected by the NMTs, a NOMS can quantify aircraft noise exposure around the airport and compare noise levels with standard noise annoyance criteria and modeled noise contours. The noise levels can be used to inform airport stakeholders on the measured noise exposure in noise sensitive areas, to justify mitigation measures, and to minimize the noise impact on these areas.

J.2 NMT Overview

A sound level meter is an electronic instrument that measures sound pressure levels. A sound level meter in an integral part of the noise monitor of an NMT. They are produced by several different manufacturers and can vary in quality and noise collection capabilities. Sound level meters are divided into two classes: Class 1 and Class 2. For the purposes of monitoring noise at airports, it is required that Class 1[27] instruments are used due to their wider frequency range and tighter tolerance.

Noise monitors are just one component of a very comprehensive suite of tools used to understand aircraft noise impacts. Measuring sound levels provides:

- Aircraft and non-aircraft sound levels at a specific location for the time period measurements were made;
- Historical records and historical trends of the sound levels at a specific location.

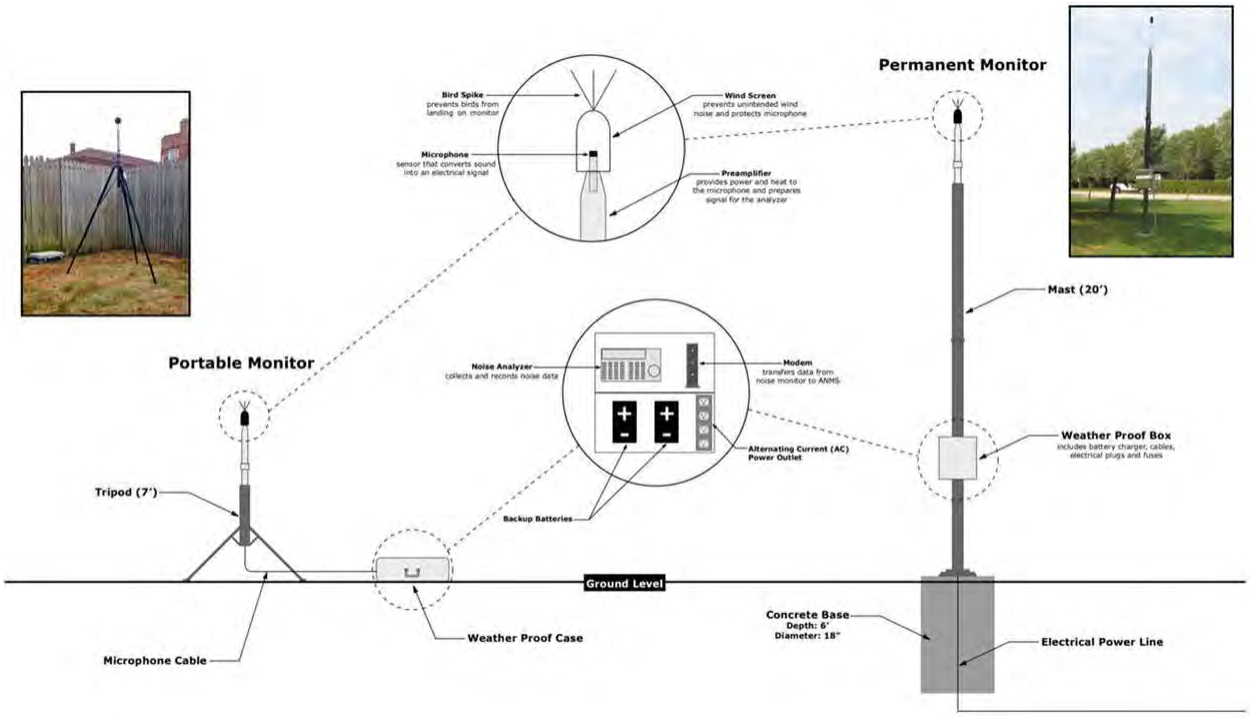
The following sections provide an overview on NMTs and the important considerations in the process of installing noise monitors.

J.2.1 NMT Types

There are two (2) types of NMTs that can be utilized within a NOMS. Permanent NMTs are fixed long-term equipment that measure, record, store, and transmit noise data and are specifically designed for independent outdoor monitoring. Portable NMTs are ideal for short-term, yet continuous, sound level measurements. The portable noise monitors enable data to be recorded at locations where long-term monitors cannot be installed or where the measurement objective does not require permanent monitoring. A diagram of portable and permanent NMTs are presented in **Figure J-1*, Schematic of Portable and Permanent NMTs*.**

[27] Based on ARP 44721, Section 3.1.1.

Figure J-1 Schematic of Portable and Permanent NMTs



Source: NMT Schematic courtesy of the Chicago Department of Aviation (2021).

J.2.2 NMT Components

There are certain NMT components that will be in both permanent and portable noise monitors, and some components are specific to each respective type of NMT.

J.2.2.1 Permanent and Portable NMT Components

- *Noise meter* – This is the device that measures the pressure in sound waves in order to recognize them as noise events. The type of device required for this is a Class 1 sound level meter. This is determined by specifications outlined by the International Electrotechnical Commission (*IEC) 61672-1:2002*. Meters in this category will be able to measure sound pressure, LAeq, and peak sound pressure.
- *Microphone* – The microphone picks up the differences in pressure created by sound waves and transmits this information through the preamplifier via the microphone cable to the noise meter. The microphone must be up to the specifications of *IEC 60651* Type 1 to conform to standards in use with Class 1 sound level meters.
- *Microphone cable* – The microphone cable in use must have the ability to reliably transmit the pressure changes in sound waves, as picked up by the microphone transferred through the preamplifier to the noise meter.

- *Preamplifier* – The preamplifier amplifies low level signals to line level. This will allow for the information of pressure of sound waves to be translated as audible noise by the noise meter.
- *Microphone housing, windscreen, and bird spike* – These devices serve as protection for the microphone, preamplifier, and microphone cable connection. The windscreen shields the microphone from gusts of wind, allowing it to filter out actual noise that is generated by aircraft or the surrounding community. The bird spike prevents avian related interference with the microphone.
- *Backup battery* – The backup battery serves as an external power source to keep the noise meter running while A/C power or solar rays are unavailable.
- *Wireless modem* – A wireless (cellular) connection is typically the medium of communication with the NMT, replacing outdated telephone serial modems ("Dial-Up"). The modem transmits the data files generated by the noise meter, to a centralized server that can upload the files to a program which interprets the raw noise data for analysis. Wireless modems can also be used to communicate with the NMT to perform analysis or maintenance functions.

J.2.2.2 Permanent NMT Components

- *Mast (retractable, bi-folding, or other)* – The mast is used to mount and operate the noise meter equipment. It can be engineered metal with lowering capability for microphone service. Wooden utility poles can also be adapted to serve as an equipment mast.
- *Cabinet* – The cabinet is where the noise meter, power connections, microphone cable, backup battery, and modem are located. This cabinet should have the ability to be locked securely and be weatherproof for a variety of conditions.
- *Concrete base* – The concrete base will have the required electrical connection in conduit with four (4) bolts to mount the mast onto. It must be level and have a diameter large enough to accommodate the base of the mast.
- *Electrical power meter* – This meter will be used to determine the amount of energy that is being used by the noise meter and associated equipment. It is typically located within a few feet of the concrete base.
- *External A/C power shutoff* – This is an electrical breaker box located outside of the cabinet, either attached to the cabinet or an electrical power meter. It serves as a way to safely shut off power to the devices inside the cabinet for maintenance.
- *Grounding wire for mast/cabinet* - The ground wire is attached to the mast and cabinet and runs into the ground below the concrete base. Its purpose is to absorb any electrical shock from a lightning strike or other phenomena and to distribute the power safely into the ground without affecting the noise meter or other devices.
- *Mast adapter to microphone mount* – This adapter may be used on certain masts, which will allow the mast to be connected to the microphone housing via the microphone mount.

- *(Solar): Solar panel and power cables* – The solar panel is mounted on the mast near the top of it and is angled to face the sun depending on geographical location. The power cables deliver the energy generated by the sun to the solar controller.
- *(Solar): Solar power controller* – This controller has the ability to safely distribute power from the solar panel to the noise meter and other devices in the cabinet. It also sends power to the 12v backup batteries.
- *(Solar): Dual backup 12v batteries* – The backup batteries serve as a way to power the site reliably during times of limited sun exposure during daytime hours due to weather or at night.

J.2.2.3 Portable NMT Components

- *Tripod and ground stakes* – This is used to support the microphone mount and microphone housing in order to prevent the microphone from falling over.
- *Weatherproof box* – The weatherproof box is used as a safeguard to withstand harsh outdoor conditions while protecting the noise meter and associated equipment inside to allow for uninterrupted reporting.
- *Chain and lock for weatherproof box* – The chain and lock help to keep the noise meter secured when in use at a remote site.
- *Electrical extension cord* – The extension cord powers the site from a local power outlet, which also stores energy in the backup batteries.

J.2.3 Data Collection Features

- *Leq and A-weighted frequency* - Leq or LAeq is the equivalent continuous sound pressure level. It is the constant noise level that would result in the same total sound energy being produced over a given period.
- *Reports* – After the raw noise file is sent from the noise meter to the server, a program will interpret this data and produce a numerical report on it. For example, reports such as these can be used to determine high levels of aircraft or community noise at certain times of day.
- *Flight data*- When using a noise meter network in conjunction with air traffic radar data, new metrics can be seen highlighting what aircraft affect a community at what time of day. This information can also display air traffic altitude, speed, and position in relation to the location of the noise meter.
- *Clock settings* – When collecting data, it is important to determine at what time the noise meter should report to the server. Standardizing all noise meters to Coordinated Universal Time (UTC) is a common act done to maintain consistency.
- *Ambient noise level* – The ambient noise level is the noise level that is typical at the site where the noise meter is located without any aircraft or significant community noise taking place.

- *Noise thresholds and continuation period* – The threshold is set as a certain noise level that must be exceeded in order for a noise event to be created by the noise meter. The continuation period relates to this as it is a set time duration that must occur in order for the exceedance of the threshold to be considered an event. There also must be a set time duration of noise levels to be below the prescribed threshold in order for the noise event to have a definite beginning and end.

J.3 Site Selection

Selecting locations for the NMTs (permanent or portable) should be one of the first steps in the installation process. Depending on the airport's ownership by local governments or private authorities, locations for all monitors will vary. Typically, NMTs should be installed in the relative flight path of air traffic on approach or departure from the airport at which the monitors are intended for use. With these ideas in mind, it is important to determine policies as to how the sites should be selected. Additional guidance can be found in Society of Automotive Engineers (SAE) ARP4721/1.[28] The criteria below include some starting points for location selection that can be supplemented by other criteria identified by the airport owner/sponsor.

- Proximity to Flightpaths;
- Proximity to Existing NMTs;
- Ambient Noise Levels;
- Permanent vs Portable NMT Deployment;
- Policy Considerations;
- Technical Considerations.

J.3.1 Portable NMT Deployment

Portable NMTs are deployed to collect data at locations that are temporary, in areas that cannot be served by a permanent location, special request, noise studies, or to validate data from other NMTs.

Portable NMTs can be placed at locations on Alternating Current (A/C) power or can be powered by solar or batteries depending on the duration of the deployment. If powered solely by batteries, power consumption calculations should be performed to determine how often batteries should be changed to avoid data loss.

Portable units are versatile relative to placement. Items to consider when choosing a location and unit deployment include the following:

- **Security** – Portable unit equipment boxes can be locked and chained to a structure (tree, pole, gate etc.). However, microphone, microphone cables, and tripod can remain vulnerable;

[28] Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4721, Monitoring Aircraft Noise and Operations in the Vicinity of Airports.

- **Placement** - Microphone should be in an open area away from tree coverage or other obstructions;
- **Ambient Noise** – Undesired noise sources should be kept at a distance for best data collection. Air conditioning units, traffic, and community noise can vary throughout data collection time period and can thus effect data. The ambient noise level can be measured by the NMT and calculated as the noise level that occurs 90% of the time (L_{90})[29];
- **Noise Event Threshold** – At most locations, the noise event threshold should be set at 7 to 10 dB higher than the ambient noise[30];
- **Access** – In the event of service needs, available access should be considered;
- **Connectivity** – If modems are not used to connect and download data for a measurement, manual downloads will be needed;
- **Calibration** – Portable NMTs are designed to be relocated frequently and can lose calibration during transport. Microphones should be calibrated with certified pistonphone or acoustical calibrator (depending on equipment type) upon set up at each location.

J.3.2 Proximity to Flightpaths

In order for noise events to be properly recorded and correlated with aircraft operations, the NMTs should be located in an area that will have frequent flyovers of arriving or departing aircraft. For flight track analysis and the evaluation of noise abatement alternatives, the NMTs should be placed in specific flight corridors or where the noise abatement alternative is most critical. Lastly, if specific communities have a concern about aircraft noise or file regular complaints, NMTs can be located in these areas on a permanent or temporary basis.

J.3.3 Proximity to Existing NMTs

When selecting locations for new NMTs, consideration should be given to the proximity of the NMT relative to other existing or planned NMTs. Potential sites should be located at a minimum of one (1) nautical mile[42] away from other NMTs to provide different noise exposures.

J.3.4 Ambient Noise Levels

In order to improve the accuracy of correlating aircraft noise events, NMTs should be placed in areas with relatively low ambient noise levels. Ideally, there would be no exposure to other noise sources or intermittent high noise levels. NMTs should be located where ambient noise is minimized to maximize effectiveness of the monitoring system.

[29] "Sound Level Descriptors", U.S. Department of Transportation, Federal Highway Administration, https://ntlrepository.blob.core.windows.net/lib/79000/79300/79315/FHWA-HEP-17-053.pdf

[30] The Noise Event Threshold level and NMT distance apart are based on experience and engineering judgement. The Noise Event Threshold level is set after an in-the-field evaluation.

J.3.5 Permanent vs Portable NMT

Determining whether a noise monitor site should be permanent or portable depends on the application to which the data will be used. Permanent noise sites are typically near community centers such as parks, schools, or on parkways in neighborhoods and are used to cover a larger area of aircraft noise. These sites may be connected to a power source via an electric company in conjunction with a backup battery or may be solar powered through a large panel and backup batteries. Portable noise sites can be used to determine location eligibility for a permanent noise site location based on the governing entity's reaction to the collected data. Portable sites are typically powered through a power connection via extension cord to a power outlet used in conjunction with a backup battery.

J.3.6 Policy Considerations

Policy Considerations ensure the fair placement of NMTs and help to select the general area for placement of the NMTs. Placement should be based on an equal distribution among communities surrounding an airport. In addition, consideration should be given to an equal placement of monitors off each runway end and certain consideration may also be given to placement of NMTs based on the local terrain. Residential areas affected by aircraft traffic are first priority, followed by schools, parks, or recreation areas. Commercial or industrial areas are not considered as desirable locations for NMTs. The focus should remain on noise-sensitive areas for the quantification of aircraft noise impacts and in addressing noise complaints.

J.3.7 Technical Considerations

Once a general area for placement of a noise monitor has been considered, Technical Considerations help determine where exactly the noise monitor should be placed. The monitor needs to be located away from any reflective surfaces (large building or solid surfaces, trees or other sources of wind noise) that might affect the measurements and should be located with good line-of-sight to an aircraft, so no shielding of noise occurs. Ultimately, the site location should not be located in the vicinity of existing electrical service lines to avoid high installation costs.

The following guidance is provided in ARP 4721, Section 3.1.2:

The issue is addressed in ARP 4721 Section 3.1.2. In ARP 4721 the following guidance is given: "Microphone Height: The microphone for permanent noise monitoring purposes in a fixed system shall be placed at least six (6) m above the ground level or at least three (3) m above neighboring rooftops, whichever is higher above the ground. Where a rooftop location is necessary, location near the center of a flat roof is preferred to ensure that reflection effects are more-or-less uniform throughout the measurement duration. Portable or temporary noise monitoring may use microphone heights ranging from 1.2 to six (6) m in height or higher as necessary to meet the obstruction criteria presented in the next paragraph. In the case where a portable system is used in parallel with a permanent microphone for purposes of validation of system data (per Section 5.8, Part 2), the portable microphone shall be at the same height as the permanent microphone. Obstructions in the Sound Field: There should be no solid objects within a conical region around a microphone that would significantly interfere with the measurement of the sound from an aircraft. The conical region is one with its apex centered on the

microphone and extending upwards to a height of at least 13 m above the microphone. The included conical angle is 90°."

The site should also provide good access in order to permit routine maintenance and calibration of the unit, as needed. A long-term easement should ensure that the site will not have to be relocated within the next several years. NMTs in areas slated for redevelopment or in/near a reserved transit corridor are not considered desirable locations. Sites should also be located away from any electromagnetic radiation sources to minimize signal interference. Lastly, the site should be located in a secure area to provide adequate space for provision of security.

J.4 Maintenance Requirements

When installing a new NMT, it is important for the airport to understand the Maintenance Requirements of the NMT and incorporate these aspects into the management of their NOMS. The NMTs require both preventative maintenance as well as regular corrective repairs. The airport needs to consider if this is something that can be handled in-house or if contractors will be used to perform these duties.

- **Security** – Site security is crucial to the successful daily reporting of the noise meter. A secured and tamper-proof cabinet and secured mast should be used to prevent any interference of data recording. If the NMT is located in area with major security concerns, the NMT site can be secured with fencing and a locked gate.
- **Insects & rodents** – Proper measures must be taken to ensure the cabinet and mast are secure from wildlife threats. Protective shielding at the base of the mast may be used to prevent rodent infestation while bug traps may be set to prevent the colonization of a variety of insects within the site.
- **Tree and landscaping growth** – Trees and other obstructions must be considered when performing maintenance at a site. The mast must be able to be lowered without interference from tree branches and the cabinet must be accessible and free from obstructions for a technician to safely perform the maintenance required.
- **Corrosion and lubrication** – Due to weather exposure, locks, hinges, and other metal parts that move about the mast or cabinet must be lubricated regularly to prevent corrosion damage to the site.
- **Vandalism** – The cabinets and masts must be checked regularly for vandalism. If the site is vandalized with graffiti, a standardized cover-up paint color must be used to impede on these activities.
- **Traffic protection / visibility** – The site must be located somewhere where it can be safely accessed without being a danger to pedestrians or traffic.
- **Microphone calibration** – The microphone must be calibrated on a regular basis to ensure the data being collected is not unusable or skewed by any factor. Noise meters have a set decibel level that they are calibrated to. The calibrator will emit this set decibel level to which the noise

meter will recognize the calibration and display an offset of how skewed the reported data previously was.

J.5 Procurement

Below are some key items that can assist an airport in the creation of their procurement documents. These items can be used as guidelines that can be tailored to each individual airport and may vary based on the local codes/regulations.

J.5.1 Microphone Height

The microphone should be mounted with its axis of vertical symmetry. The microphone height should be placed at least six (6) meters above the ground level or at least three (3) meters above neighboring rooftops, whichever is higher above the ground[31]. No obstructions which influence the sound field from the aircraft should exist within three (3) meters of the microphone. The mounting pole used for the microphone should include a tilting mechanism to present the microphone at or near ground level for servicing and calibration.

The tilting mechanism should be operable by one person safely, and the mounting pole and tilt mechanism should be of materials and design to withstand the weather and exposure of the local weather environments.

J.5.2 Clock

Clock or time is used to correlate noise data with aircraft radar data. The remote site noise monitor internal clock should be synchronized to the central system clock, such that the remote site clock and central clock do not differ by more than plus or minus two (2) seconds at any time. Central site communication should report the comparison of remote site clock and central system clock on a daily basis. The system should automatically adjust for Daylight Savings Time and leap years. Respondents should describe how the system clock will synchronize with the radar system clock. Respondents should also describe the time standard to be used to set the master clock (National Institute of Standards and Technology (NIST), Global Positioning System (GPS), etc.).

J.5.3 Data Transmission Requirements

Data Transmission from the NMTs to the central location should be continuous for near real-time display or should provide for intermittent download. The transmission hardware and software should provide for a resolution of at least 0.1 dB in all data and for appropriate validity checking of all transmitted data. Data download from NMTs should be done at least once per day, and more frequent downloads may be included. At the airport's discretion, as commanded from the central computer site, noise data should be collected real-time for observation in the noise office. During such real-time reporting, normal collection, storage, and downloading of data should not be interrupted. Provision should be made for

[31] Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4721, Monitoring Aircraft Noise and Operations in the Vicinity of Airports, Section 3.1.2 Microphone Requirements.

indicating calibration status and specific periods of lost data caused by memory overflow, power loss, or equipment malfunction. In the event of power loss or failure to pass a calibration test, the NMTs should initiate communication with the central station and report the malfunction. Such communication should be repeated on a regular basis until the central system acknowledges receipt of the information. All data transmission should include error checks to verify quality of data transmitted.

J.5.4 Backup Electrical Power

Each NMT should provide backup electrical power of sufficient capacity to allow full operation of the site for at least three (3) days, with seven (7) days preferred. Respondents should identify any additional costs associated with backup power longer than three (3) days. Said system should be self-resetting after any power failure. Further, all stored data should remain in the system and be retrievable for a period of at least 30 days after loss of power. In the event of a loss of power, NMTs should provide indication of such to their central computer. This latter requirement is not in effect if loss of power and loss of telephone communication occur simultaneously (however, once telephone/wireless communication is re-established, the NMT should report the power loss). The central computer will give an alert to system users if communication has been lost with the remote unit.

The remote unit should have provision for the manual application of external power from a battery to allow continued operation when main power cannot be restored in three (3) days. Provision for this external battery should be accommodated within the site enclosure and the NMTs should include auto-restart capability should there be an interruption of power.

J.6 Additional Resources

An airport can also refer to the following documents for more information on NMTs. These documents also referenced in **Appendix A: Literature Review.**

1. *Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4721, Monitoring Aircraft Noise and Operations in the Vicinity of Airports: Part 1 System Description, Acquisition, and Operation & Part 2 System Validation, 2007.*

   This SAE ARP provides guidance for monitoring aircraft noise and operations in the vicinity of airports using either a portable or unattended monitoring system. Part 1 provides guidance on the components, installation, and administration of permanent systems and guidance on the analysis of data collected from the temporary monitoring of aircraft noise. Part 2 provides detailed statistical methods for assessing the uncertainties associated with system measured data.

2. *International Standards Organization (ISO) 20906:2009, Unattended Monitoring of Aircraft Sound in the Vicinity of Airports, 2009.*

   ISO 20906 is solely for permanent airport noise monitoring systems and is generally similar to ARP 4721. ISO 20906 provides guidance in the following areas, including performance specifications for instruments, requirements for the installation and operation, requirements for monitoring the sound of aircraft operations, requirements for the quantities to be determined

to describe the sound of aircraft operations, requirements for data to be reported, and procedure for determining the expanded uncertainty of the reported data.

Appendix K: Noise Management Program Development Guide

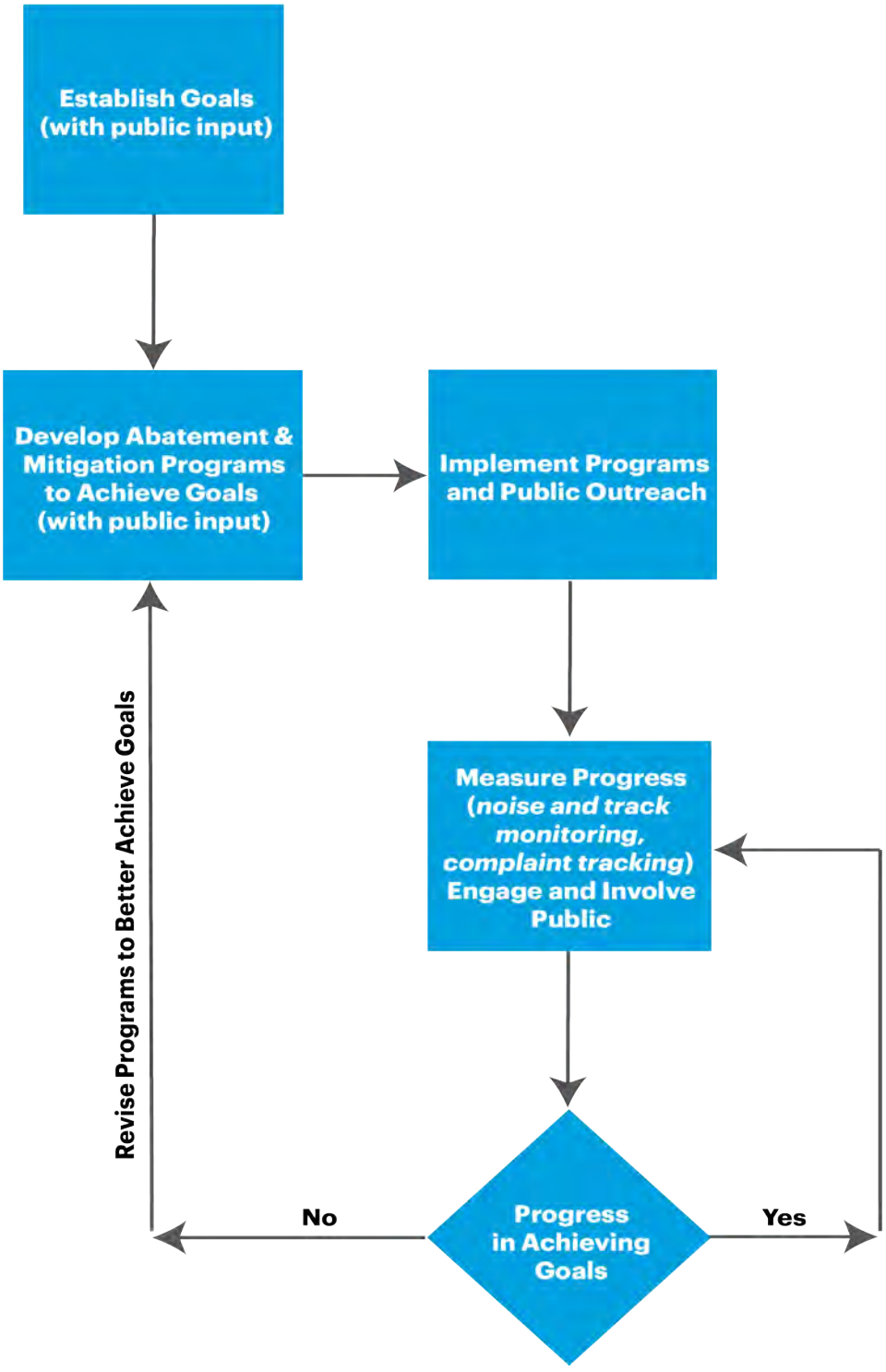
K.1 Introduction

This guide is provided to assist in the development of an airports noise management program. It is presented as a two-level program. First, there is the overall airport noise management program of which the noise monitoring system is a component. Secondly, there is the management of the noise monitoring system itself. The information in this guide is based on the Research Team member experience working with airport noise issues and a Noise and Operations Monitoring Systems (NOMS). This experience includes assisting dozens of airports with NOMS specifications, NOMS installation and acceptance testing, NOMS updates and training, noise analysis, noise measurements/modeling, noise monitor site selection, and development of noise management programs. Additionally, by working closely with airports, Research Team members have observed best-in-class noise management programs and lessons learned.

An airport's overall noise problem is highly unique to a particular airport; this discussion is meant to be general in terms and suitable for a major metropolitan airport or a smaller general aviation airport. There may be any number of issues that a noise management program attempts to manage, including large numbers of noise complaints, pressure from the community to change operations and local opposition to airport development programs, and threats of or initiation of legal action. The term, "manage" airport noise, is used here in the true sense of actively managing the situation using modern management tools. Unfortunately, once airport noise problems start, they often will continue to require ongoing management to seek community cooperation and allow the airport to meet the region's air transportation needs.

An airport noise management program can be defined as a process shown in **Figure K-1*, Airport Noise Management as a Process***. The steps of the management process are to set goals, develop noise mitigation and noise abatement programs, implement noise abatement programs and public outreach programs, measure program progress and compliance/performance using the NOMS, periodically review progress and maintain or modify programs as needed, and engage stakeholders. In the overall context of the noise management program, the NOMS is the means of generating data to assist in the development of programs and measurement of progress to achieving the airports objectives. The NOMS is much like a business accounting system. Accounting does not produce any revenue but is essential in determining the success of the business and providing data to grow or manage problems. A NOMS by itself does not reduce noise, but is a key tool to analyzing problems, developing programs, and measuring the success of those programs.

Figure K-1 Airport Noise Management as a Process



Source: Landrum & Brown, 2021.

K.2 Managing the Operation of the Noise Monitoring System

Challenges that airports may face once a NOMS is procured include the allocation of qualified staffing resources (existing staff or new hire) and noise management training of staff. A NOMS is an effective noise monitoring and public outreach tool when operated by staff with the right combination of technical skills and software skills that can extract data from the system and convey information to stakeholders in clear and useful ways. Historically, the employment field of airport noise management has not been populated by a vast number of qualified candidates. Airports have generally had difficulty hiring staff to expand noise management offices or to backfill open positions. Potential staff may have an aviation background but not a background in aviation noise and community relations. Vendors generally provide NOMS training to understand the use of all system features. However, this type of training is limited and often does not include training on how to use the system to develop and monitor actual noise abatement procedures and supplement a noise management program.

A NOMS is a tool that is operated by trained staff that are a part of a proactive and innovative noise management program. Airports should view noise management as an important and valued environmental practice area and should allocate the proper amount of recruiting, compensation, and incentives (conference attendance, training/education, positive working environment, etc.). Additionally, airports should provide staff training and guidance associated with the application of a NOMS in order to address the airport-specific noise issues and the development of a noise management and public outreach programs.

The following subsections will address the needs in the key areas of office setup, staffing, developing policies and procedures, training, reporting, NOMS operation, and community relations.

K.2.1 Noise Office Setup

This section describes the physical aspects of the noise office workspace. Considerations include space for meetings, including small conference type meetings or small public meetings (Note that the COVID-19 Pandemic required many business and public meetings to take place virtually online in 2020 and 2021. At the time of this research, it is unclear to know whether virtual online meetings will become the norm or a secondary option to face-to-face meetings). This will dictate the need for wall monitors or projection screens, workspace or cubicles for staff, locations of printers, plotters, servers, and storage space. If the airport has other space set aside for conferences or public meetings, then only the workspace for staff, equipment, and storage needs to be accommodated. The number of staff is addressed in the next section. When considering the staff workspace, it is common for staff to have workstations with a computer and commonly two large (at least 24-inch) video monitors. Additional equipment includes printers, data servers, an air traffic radio console and recorder, and possibly a large-scale plotter. Storage requirements include usual office supplies, noise monitor consumables (windscreens, spare parts, portable noise monitors, if any, etc.), file cabinets, and sufficient wall space for several aerial maps of the airport and the nearby communities affected by aircraft noise.

K.2.2 Noise Office Staffing

The number of the noise office staff is not a fixed number. Generally, at minimum, staff would include one noise officer/manager and one technical staff. It is not recommended that the noise officer fulfill both roles of the office manager and technical operation of the NOMS because the number of technical

staff will vary with the complexity and output (complaint response, report production, number of community meetings, etc.) of the noise management program. At airports with strict noise rules, like noise limits, operating restrictions, and noise fines, the office staff may include 4 or 5 full-time positions. Airports with less rigorous data analysis requirements may require fewer positions. Often, the noise office will be called upon for making or developing presentations, brochures, or online reports including mappings and charts. The number of staff will ultimately depend on how much product is expected each month. The skill sets desired cover a wide range of needs. Ideally staff with have technical skills for operating the NOMS, troubleshooting the field measurement equipment, producing default system reports, developing custom reports including complex database queries, developing written reports, brochures, and presentations, responding to noise complaints (need for strong customer service skills), and making presentations to management and the public. Additionally, staff should understand airspace procedures and understand how and why aircraft utilize airspace in order to help the public understand the relationship between flights over their homes and flight procedures. To hire and retain an individual with all of the skills above is a challenging task in itself.

A noise office works best with a team of people whose skills mesh into a cohesive unit that is oriented towards high quality production. An additional task to consider is whether public relations/communications will be a part of noise office staff tasks or fulfilled by another group within the airport. This affects the skills needed in the noise office and the number of staff. In general, the public relations/communications for a noise office start-up may be handled by the noise officer and/or the airport manager.

K.2.3 Noise Office Policies & Procedures

Every noise office should develop a Policies and Procedures Manual (PPM) to standardize methods within the office. The following outlines the contents needed in the PPM:

- **Noise Complaints** – Airports should have policies in place on whether complaints will be taken real-time, recorded on voice mail, or tabulated from online complaint entry. Note that some airports do not respond to each complaint while others provide personal call backs for each complaint. If complaints are answered live on telephone or telephone calls are returned to complainers, there needs to be clear policies on how to interact with the caller and there must be policies in place for dealing with callers that use inappropriate tone or language, including threats of any kind, and reporting such incidents to airport management and local or Federal law enforcement. Additionally, for complaint reporting purposes, airports should have policies relative to the number of days allowed for complaint response and whether one complaint entry (call, email, online entry, etc.) equals one complaint, or whether multiple noisy events identified in a complaint entry equal to multiple noise complaints.
- **Reporting Requirements** – A noise office may want to publish regular reports for internal and public use. Generally, these are done on a monthly and annual basis and may include complaint summaries, noise abatement procedure performance metrics, flight track map summaries, and measured noise level summaries. Standardized report formats should be used.
- **Workflow Procedures** – The most important aspect of a NOMS is that it is "healthy" with maximum uptime. Meaning, that it is collecting the correct amount of data and that it performs the internal processes necessary to maintain all of the system functionalities and features

agreed upon in the system specifications, procurement, and maintenance contract. Current NOMS are more stable compared to systems in the past, requiring less system health oversight by airport staff. However, system health checks should be a primary function of noise staff and procedures to perform these checks should be developed in coordination with the system vendor. Procedures should describe tasks to perform when data gaps appear, including field monitor troubleshooting when noise measurement anomalies occur or when connection is lost. Additional workflows should include data grooming to verify that noise-to-flight track correlation is correct and that the system calculates noise metrics correctly.

Other workflow procedures should include standard methodologies to produce the reporting requirements.

- **File Management** – Current systems will generally store data remotely on servers hosted by system vendors or in the cloud. Some airports will store data on their own servers. In any case, a staff member should verify at least weekly that backups of the airport data are being stored at the appropriate location depending on the system setup. The system vendor should have a standard report that documents file status and backup status.
- **Personnel Policy** – Airports will have policies in place and documented in the PPM. The noise office should have policies in place for adjusting staff responsibilities when someone is on sick leave, vacation, or is absent for any other reason (jury duty, maternity leave, etc.). The policy should clearly describe who covers for whom and what tasks can be delayed if a staff shortage occurs, as well as what tasks cannot be delayed and should be of the highest priorities (daily system health check and complaint response, for example).

K.2.4 Noise Office Training

NOMS training is often considered only just prior to the NOMS becoming operational. This initial training generally covers basic system functionality and brief exercises using NOMS features; it is often not sufficient in terms of providing staff the knowledge to customize system utilization in order to monitor and report on the airport's specific noise abatement procedures (runway use, flight procedures, violations, etc.).

First, for a new system, the vendor training can be overwhelming, with too much information provided over too short a period of time. Second, there will always be a need for advanced training to cover more complex tasks in the system such as data grooming and noise metric calculations. Finally, the airport needs to recognize that there ultimately will be turnover in staff. If there is a staff of one, essentially all of the system experience walks out the door if that person leaves. There needs to be a policy in place on how to train new staff. The various aspects of staff training are presented as follows:

- **Develop Noise Office Training Manual** – This manual should be part of the deliverable from the system vendor(s). It should include all of the topics described below.
- **Initial On-Site Training** (1-2 weeks) – Initial on-site training needs to cover the following topics:
    - Terminology and noise metrics;

- Federal and State noise regulations;
- Office management;
- Development of report packages;
- System operation relative to that airport's noise management program;
- Customer service / Live complaint response;
- Portable noise monitoring (if applicable);
- Preparing information for the public;
- Public speaking/presentations.

While this training is key and is very important, it may overwhelm the noise office staff with a large amount of information. It should have as much hands-on experience as possible, with live airport data (as opposed stored data from another airport) and "cheat sheets" for reference for later use. Even with this effort, there will be a need for continuing or advanced on-site training on a biannual or annual basis.

- **Advanced On-Site Training** (1-2 weeks) - Advanced training, which is ideally conducted annually, should go over all materials included in the initial training and more advanced topics. This should be customized to fit the needs of the airport and may include the following topics:
  - **Query building** – It is preferred that a noise office should have at least one staff member that can build advanced database queries. For example, a query to know the average airline Sound Exposure Level (SEL) for the month of June including only night flights for operations on a particular runway by airline. An alternative is to have a service contract with the vendor or consultant to provide this support.
  - **Monitoring noise abatement procedures** – This is usually a mapping function to track aircraft that fall within or outside the desired flight corridors or runway use. This may include advanced query building.
  - **Noise complaint handling** – This is one of the most resource-intensive tasks within a noise office where complaints are frequent. The advent of phone apps to submit aircraft noise complaints means that airports may receive thousands of noise complaints in a short amount of time. In this case, responding to every complaint within a brief turn-around period would be challenging, if not impossible. Advanced training could be provided to develop and manage automated methods in order to respond to a large quantity of noise complaints.
  - **Noise modeling techniques** – Noise modeling is usually done by consultants outside the noise office, but the noise contours are typically loaded into the NOMS so that contour mapping can be done, sometimes with complaint locations or flight tracks shown.
  - **Equipment and system maintenance** – The noise monitoring system includes a great deal of hardware and software. In general, the software maintenance is done by the system vendor, but the staff should be able to monitor and ensure the vendor is doing

the job. The noise office staff is usually the first line of effort to diagnose hardware problems. They may do so by completing simple tasks such as verifying power is on, verifying the modem as operational, rebooting of hardware including modem, and possibly swapping out spares for major system components. Staff should be familiar and practiced on these tasks.

- **GIS training** – Airport NOMS are becoming more dependent on Geographic Information System (GIS) tools to analyze data. While many airports have separate GIS departments, the extent to which noise office staff can use the NOMS built-in GIS capabilities to perform spatial database analysis determines how powerful the system will be. The system vendor can provide some GIS training and it may be useful for selected staff to take GIS courses at a local college or online. These courses are widespread and are very useful for staff training.

- **Supplemental Support** (as required) – Every airport is unique. Staff, the vendor, or consultants may need to supplement the basic system operation. This may include setting up portable noise monitors, downloading portable noise monitor data, interacting with FAA regarding flight track acquisition, developing brochures for public distribution or the airport website, as well as responding to airport management requests for special studies.