National Environmental Survey & Noise Research

Presented To: REDAC E&E Subcommittee

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Date: 9 March 2021

Federal Aviation Administration

Topics

- **Neighborhood Environmental Survey (NES) - 45 minutes**
- **Noise Research - 45 minutes**
  - Aircraft Noise Impacts Research
  - UAS / AAM
  - Aircraft Source Noise Reduction Technology

Introduction

Noise Research Federal Register Notice

- FAA released a Federal Register Notice to provide an overview on the agency's noise research programs alongside the results of the Neighborhood Environmental Survey (the "Survey")
- We are seeking public comment on our research program and the survey results

Aviation Noise

- FAA recognizes that aircraft noise continues to be a challenge and we have a longstanding noise research program focused on the topic
- As a part of our research program, we decided to conduct a national survey to gather data to improve our understanding of the community response to aircraft noise
- Addressing aviation noise will require meaningful collaboration among all aviation stakeholders, and this includes the FAA

Focus

- This briefing will provide context for our research, present an overview of the Survey, and identify next steps as we review our noise policy and engage with stakeholders

Purpose and Motivation for Conducting the Survey

The FAA recognizes that aircraft noise continues to be a challenge

- As part of our longstanding noise research program to better understand the impacts of aircraft noise on human health and welfare, we decided that a new national survey should be conducted to gather data to improve our collective understanding of how communities are currently responding to aircraft noise

- The Survey is the first noise annoyance survey conducted by a US federal agency since the Federal Interagency Committee on Noise (FICON) performed an in-depth US Government agency review of human annoyance to noise in 1992

- FAA's goal for the Survey was to obtain updated information about the way people perceive aircraft noise

Overview

Neighborhood Environmental Survey

- The agency conducted a nationwide survey of over 10,000 people living near 20 representative airports regarding annoyance related to aircraft noise

- FAA conducted follow-up phone interviews with 2,000 of the respondents to obtain qualitative information regarding individual responses

- The responses to the survey were used to develop a nationally-representative “dose-response curve,” which is a tool that establishes the relationship between annoyance and noise exposure

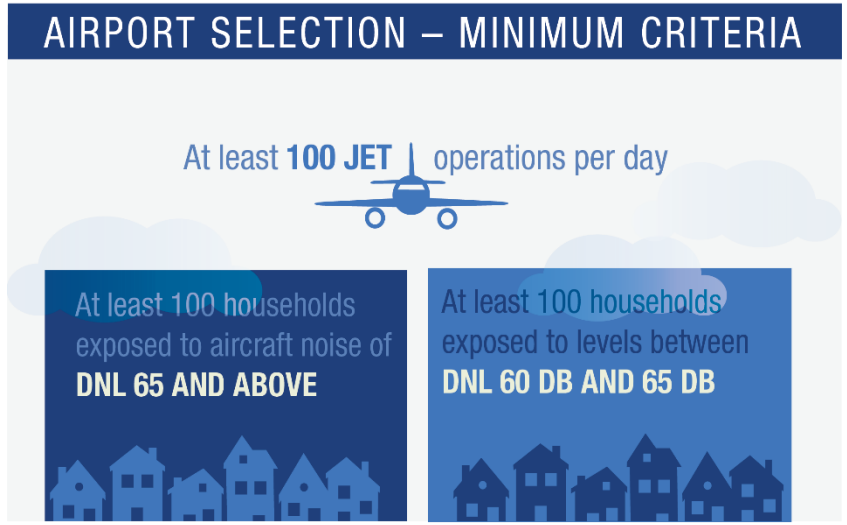
- ***Results***
  - The survey results show a substantial increase in public annoyance to aircraft noise compared to the data that FAA and other agencies currently rely on to inform noise policy, which was acquired in the 1970s

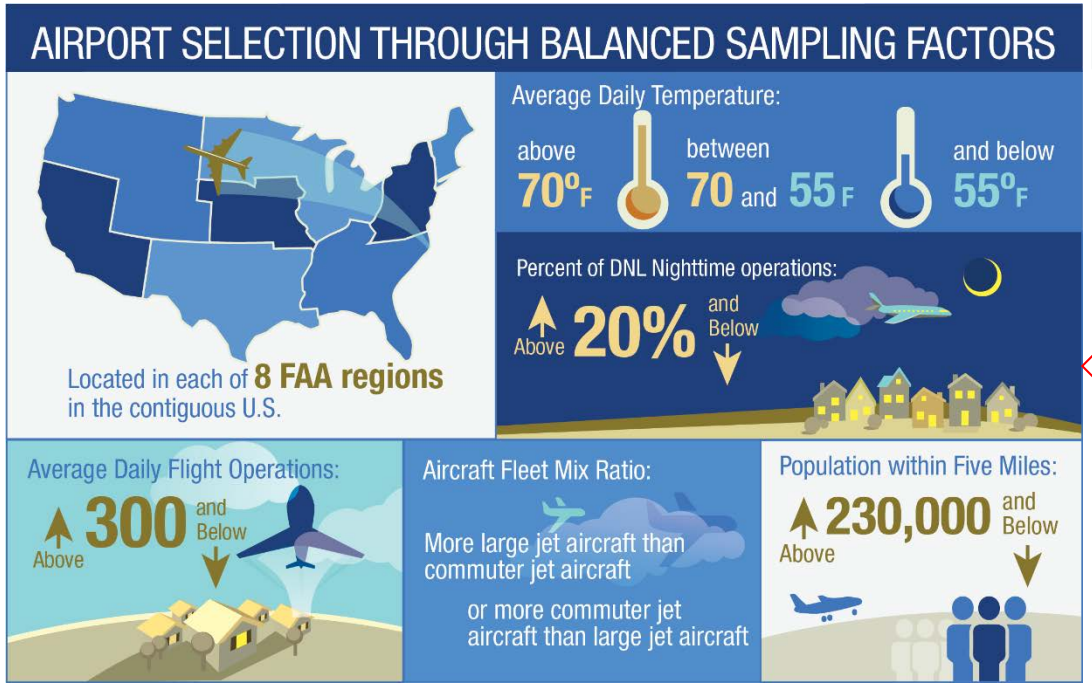
  - While the results of the survey bring forward new data, they are consistent with the observed trend of increasing noise concerns, and consistent with the results of more recent surveys conducted outside the United States

Methodology

Airport Selection:

- At the outset, the survey team assembled by the FAA determined to survey communities around a representative set of airports
- 16 airports were statistically chosen to represent configurations found at nation's airports as a whole
- Four additional critical airports were also included

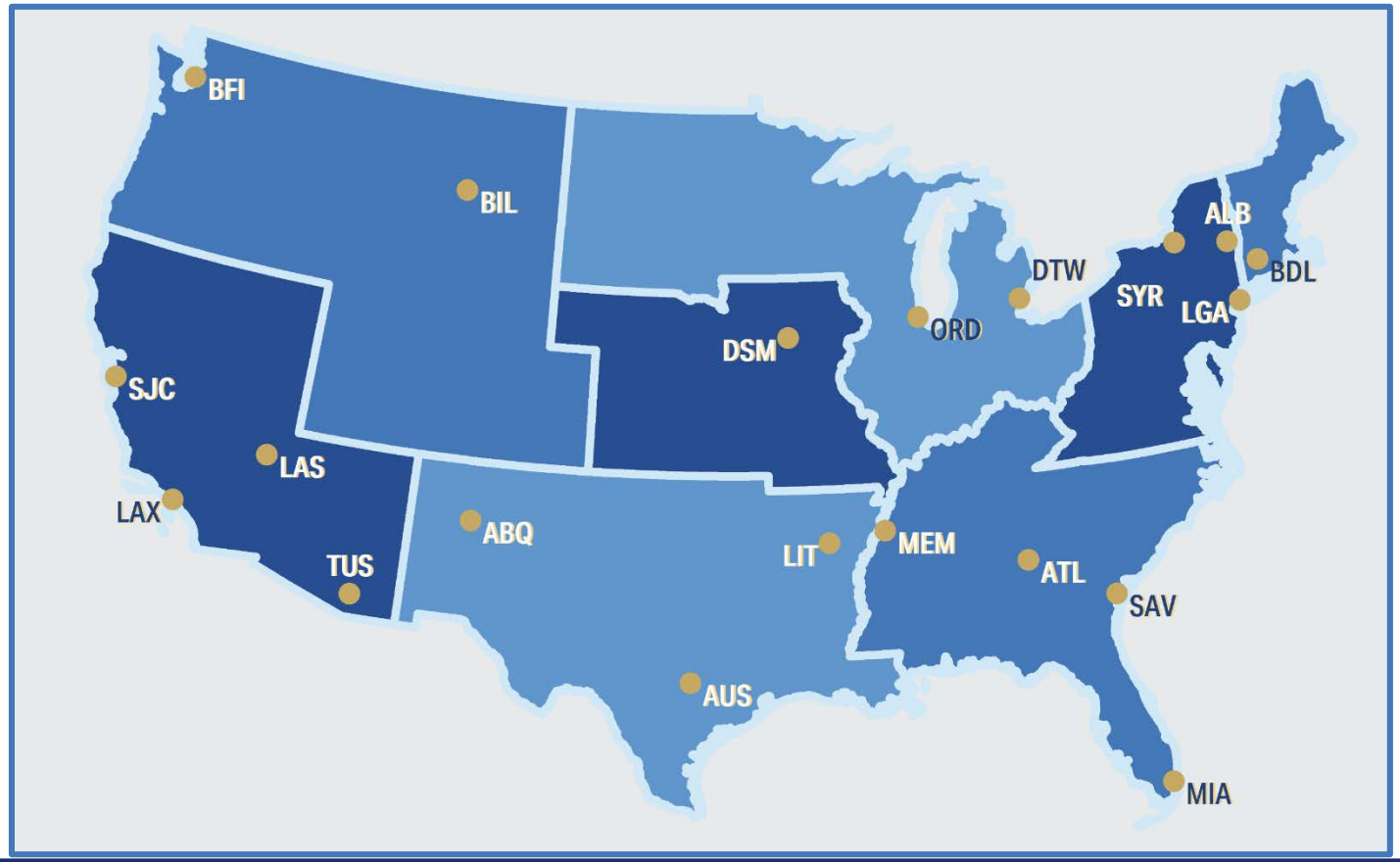




To ensure sufficient sampling, the following criteria were applied to determine eligible airports

Selected Airports

At the outset, the survey team assembled by the FAA decided to survey communities around a set of airports that represents the nation's airports as a whole



Airport Code	Airport
ABQ	Albuquerque International Sunport
ALB	Albany International
ATL	Hartsfield - Jackson Atlanta International
AUS	Austin-Bergstrom International
BDL	Bradley International
BFI	Boeing Field/King County International
BIL	Billings Logan International
DSM	Des Moines International
DTW	Detroit Metropolitan Wayne County
LAS	McCarran International
LAX	Los Angeles International
LGA	LaGuardia
LIT	Bill and Hillary Clinton National Airport / Adams Field
MEM	Memphis International
MIA	Miami International
ORD	Chicago O'Hare International
SAV	Savannah/Hilton Head International
SJC	Norman Y. Mineta San Jose International
SYR	Syracuse Hancock International
TUS	Tucson International

Methodology

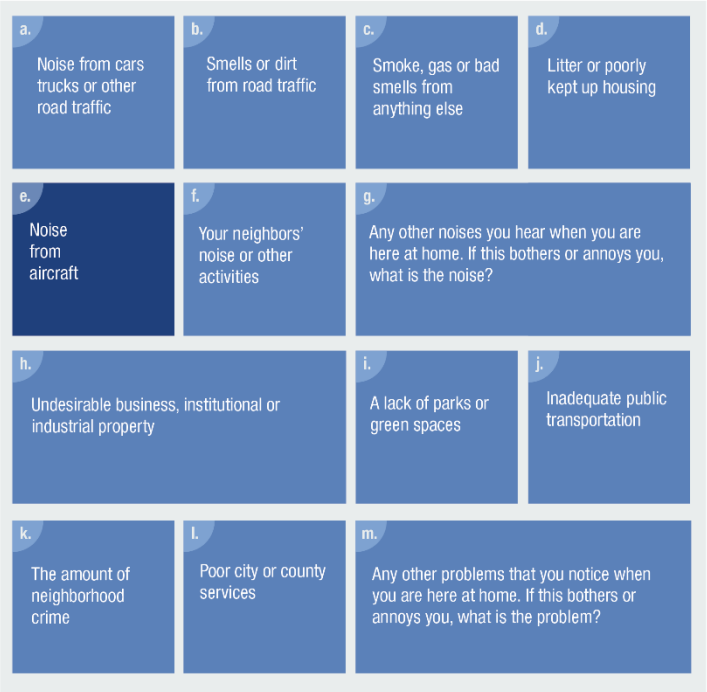
Survey Instruments:

- A **mail survey** was issued to participants around 20 airports experiencing a range of DNL noise exposure from aircraft

TOTAL NUMBER OF SURVEY RESPONSES	
DNL dB Categories	**Survey Respondents**
50-55	3,592
55-60	3,481
60-65	2,016
65-70	914
70+	325
Total	10,328

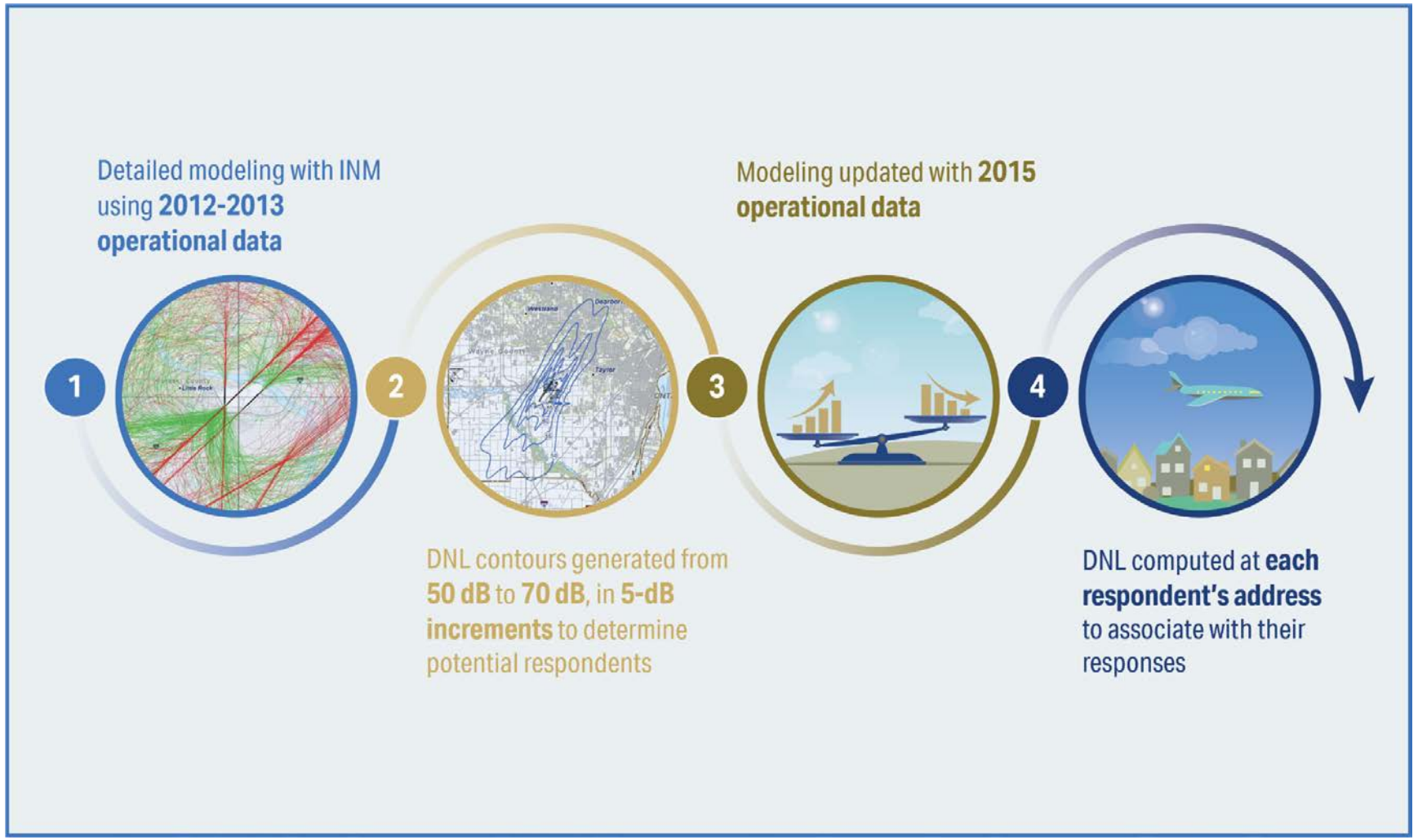
Rate each on a scale of 1-5, with 5 meaning **"most annoying."**

Thinking about the last 12 months or so, when you are here at home, how much does each of the following **bother, disturb, or annoy you?**



- Questionnaire used a five point scale of annoyance and top two levels (4 or 5 on the scale from 1 to 5) were combined to come up with number of people who are “highly annoyed”
- Since aircraft noise was one of 13 environmental concerns listed, the recipient did not know this was in fact an airport community noise survey
- A follow up **phone survey** was also issued to mail survey participants to gain further understanding why they were annoyed

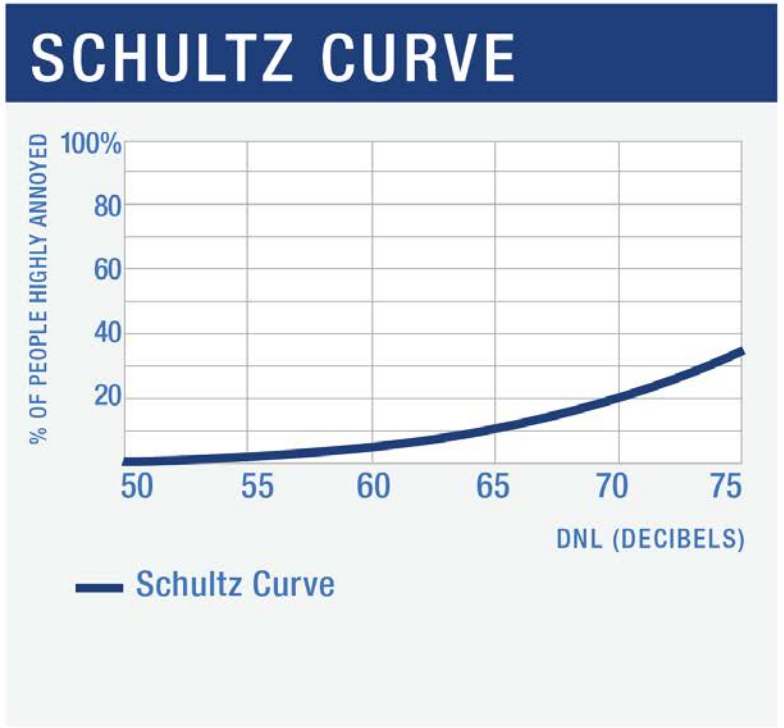
Determining DNL

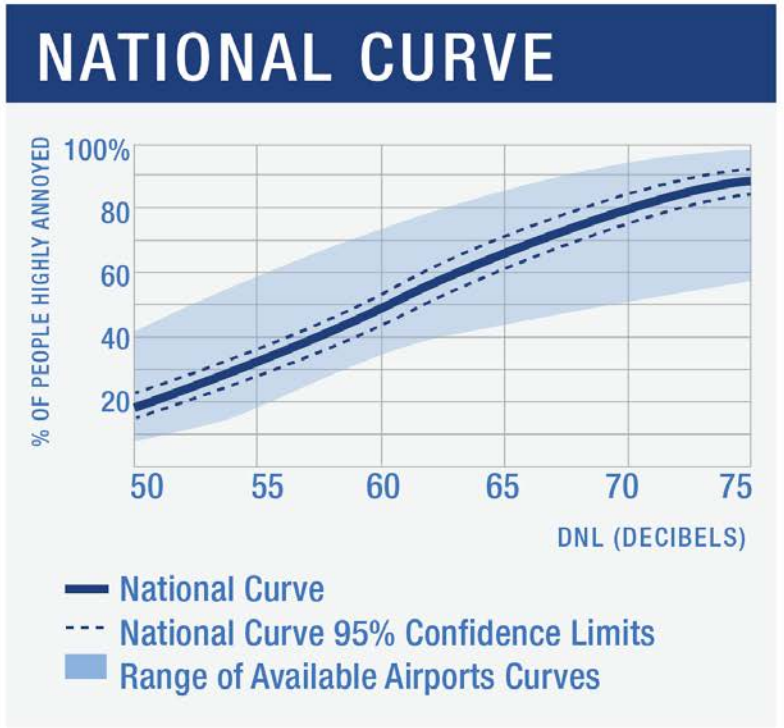


Aircraft Noise Annoyance Results

The NES results support an observed increase in Annoyance from Aircraft Noise:

- The results show a substantial increase in annoyance for the population living in the vicinity of airports
- The increase in annoyance is generally consistent across various levels of noise exposure





The new Survey was designed to use a consistent approach across each airport community surveyed. This has allowed for an enhanced ability to provide additional statistical information about the new results, such as the 95% Confidence Limits and range of results from each of the 20 airports, as shown on the plot above. This was not possible with the older Schultz Curve.

Phone Survey Analysis

Two thousand mail survey respondents participated in a follow-up phone survey which asked more detailed questions that were aimed at understanding the underlying reasons for annoyance to aircraft noise

- While informative, the findings do not have the same statistical robustness as the primary mail survey due to the voluntary nature of the sampling
- A detailed statistical analysis was conducted to identify why people are annoyed by aircraft noise

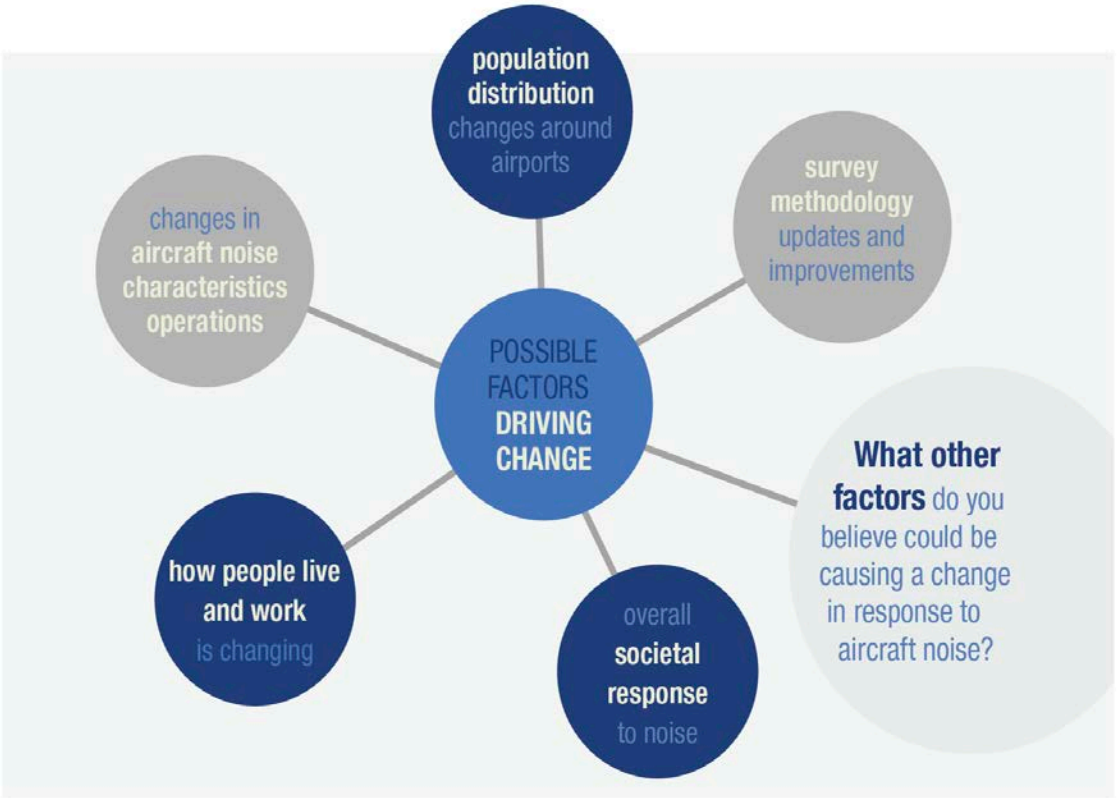
Phone survey respondents who have experienced being *"Startled," "Frightened,"* or *"Awakened"* by aircraft at home were most likely to be annoyed by aircraft noise.

Those who were bothered, disturbed, or annoyed by *"General Traffic Noise"* and *"Smells"* were also more likely to be annoyed by aircraft noise.

What do the Results Mean?

The results of the Neighborhood Environmental Survey show a substantial increase in the level of annoyance to aircraft noise relative to past surveys

- Multiple factors may be driving these changes and public input is requested to inform next steps
- Public and stakeholder feedback on these and other factors will be critical to informing FAA's understanding of the Survey results
- Taken together with the rest of the FAA's noise research program, FAA is seeking to establish a national dialogue on aircraft noise issues



Looking Forward

How will the FAA use the Findings from the Survey?

- The Neighborhood Environmental Survey provides data that quantitatively shows that substantially more people are highly annoyed by aircraft noise exposure than in the past
- The FAA will look at the NES findings alongside outputs from other noise research programs and inputs from public and stakeholder comment to inform future actions
- The ongoing research to understand the potential impacts to sleep and cardiovascular health should be particularly insightful

The results of the survey are an important element of a broader portfolio of research and community engagement to investigate and mitigate the impacts of aircraft noise

- The FAA intends to continue reviewing these research findings in combination with public and stakeholder feedback to inform research and policy priorities

Next Steps

Publishing the Federal Register Notice (Notice) is a key first step towards engaging in a conversation with aviation stakeholders about FAA noise policy

- FAA is encouraging the public and other stakeholders to review the Notice and Survey report, and provide constructive comments
- Please note that the Notice and the Survey report provide data that will be used in the upcoming discussion about policy, but is not policy in itself

Timeline

- ~~60~~ 90 day comment period on the Federal Register Notice (currently being extended)
- Review public comments and identify general themes
- FAA will concurrently identify next steps beyond the Notice and engage with stakeholders as we move forward
- Keep the public and stakeholders up to date as we make progress

Next Steps

Public Comment Invited

- The Notice invites public comment on FAA's noise research program, including the Survey
- Input on three questions is requested through a 60-day comment period
- To help provide additional information on aircraft noise, FAA's existing noise policy, and a detailed overview of the methodology and results of the Neighborhood Environmental Survey, a website has also been made available at www.faa.gov/go/aviationnoise

Factors that may be contributing to the **increase in annoyance** shown in the Survey results

Additional investigation or analysis on:

- Effects of Aircraft Noise on individuals and Communities
- Noise Modeling, Noise Metrics, and Environmental Data Visualization
- Reduction, Abatement, and Mitigation of Aviation Noise

Additional categories of **investigation, analysis, or research** that should be undertaken to inform FAA noise policy

Topics

- **Neighborhood Environmental Survey (NES) - 45 minutes**
- **Noise Research - 45 minutes**
  - Aircraft Noise Impacts Research
  - UAS / AAM
  - Aircraft Source Noise Reduction Technology

Today's Aircraft Noise Situation – Our Efforts

Effects of Aircraft Noise on Individuals and Communities

- Speech Interference and Children's Learning
- Neighborhood Environmental Survey
- **Health and Human Impacts Research**
  - **Impacts to Cardiovascular Health**
  - **Sleep Disturbance**
  - **Economic Impacts**

Public comment is critical to informing the FAA on setting research priorities for these programs

Effects of Aircraft Noise on Individuals and Communities

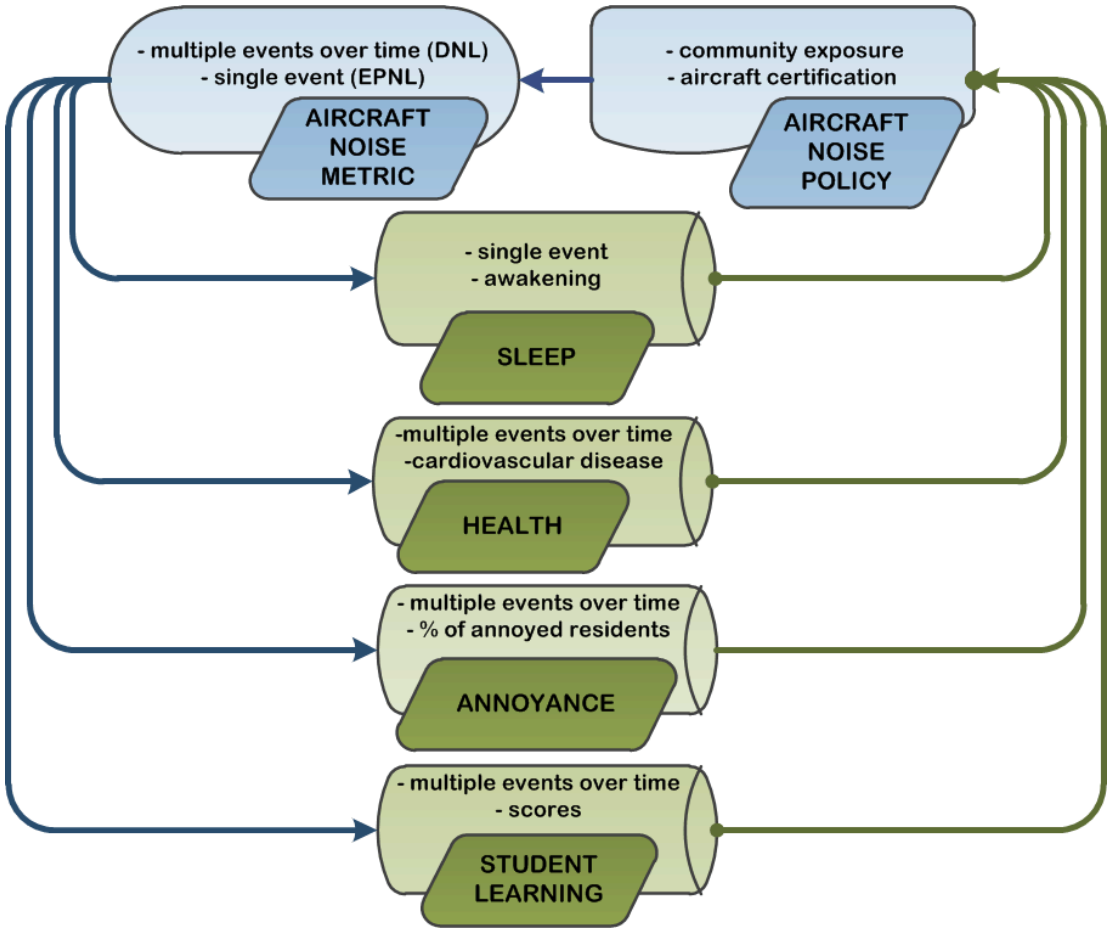
- Aviation Environmental Design Tool
- Noise Screening
- Environmental Data Visualization
- Supplemental Noise Metrics

Reduction, Abatement, and Mitigation of Aviation Noise

- Aircraft Source Noise Reduction
- Noise Abatement
- Noise Mitigation Research

See backup slides for additional information on health and human impacts research

Relationship between Noise Impacts Research & Policy



How should economic impacts and any tradeoffs in aviation growth and efficiency be managed against potential for health and welfare impacts from noise?

Blue - current policy

Green - on-going research

Discussion & Input

FAA Noise Impacts Programs (bricks):

- Neighborhood Environmental Survey
- Impacts to Cardiovascular Health
- Sleep Disturbance
- Economic Impacts
- Noise Metrics
- Community Outreach

Gaps (mortar):

- How can the findings from these programs best be assembled to inform options to address aircraft noise?
- Is additional research needed to inform the development of options to address aircraft noise?
- How can noise research best be targeted to finding implementable, cost-effective solutions to aircraft noise concerns?

Actions:

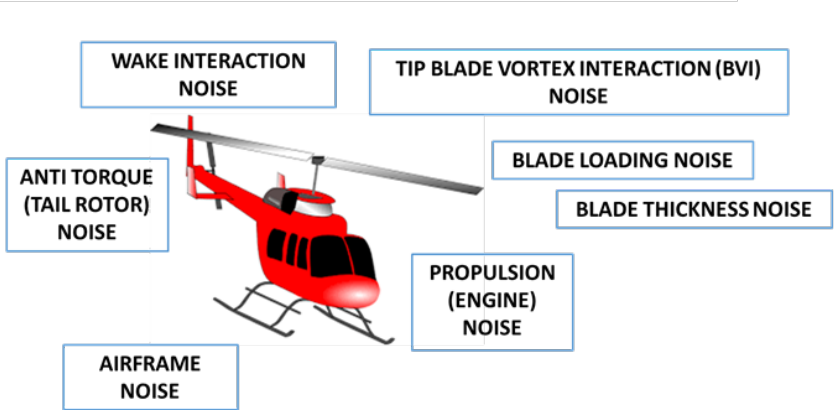
- Short Term Actions (<1 year)
  - *Collecting public comment and positions on factors related to aircraft noise concerns*
  - *Identifying research gaps that need to be filled to address aircraft noise issues*
- Longer Term Actions (1-3 years)
  - *Understanding tradeoffs to noise exposure, aviation growth and airspace system efficiencies*
  - *Establishing new noise policies informed by the entire portfolio of noise research, but adaptive enough to incorporate new findings and manage tradeoffs*

Topics

- **Neighborhood Environmental Survey (NES) - 45 minutes**
- **Noise Research - 45 minutes**
  - Aircraft Noise Impacts Research
  - UAS / AAM
  - Aircraft Source Noise Reduction Technology

Background & Context

Rotorcraft Noise



All noise sources contribute to acoustic signature – both at takeoff and during landing

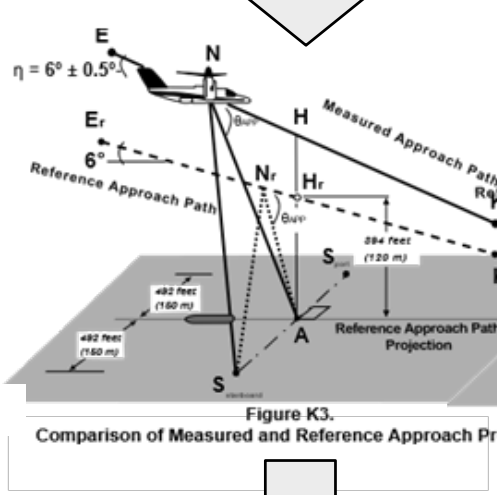


Figure K3.
Comparison of Measured and Reference Approach Profiles

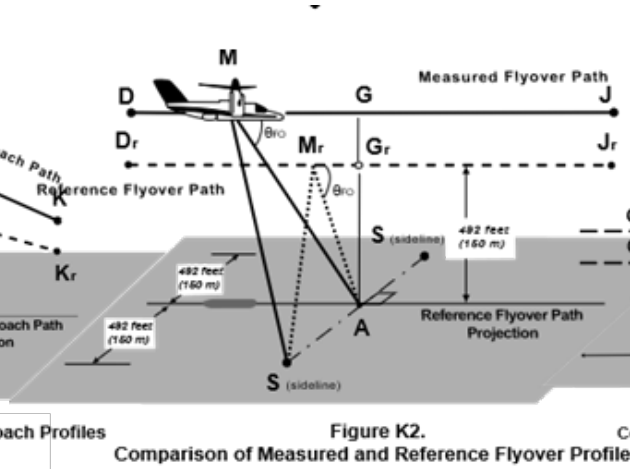


Figure K2.
Comparison of Measured and Reference Flyover Profiles

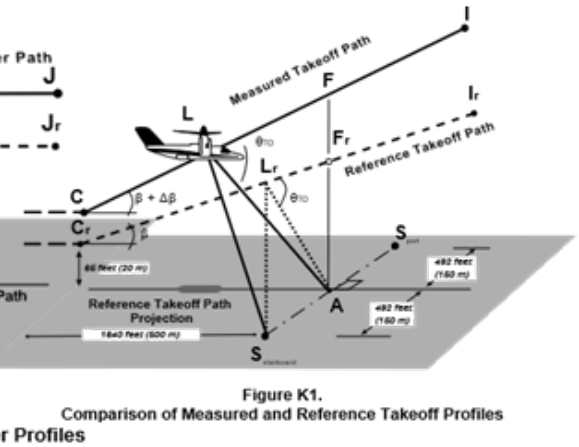
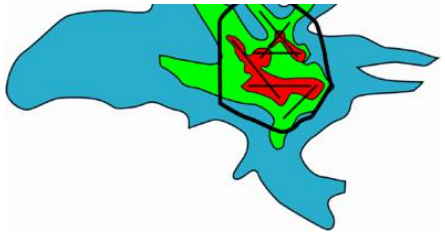


Figure K1.
Comparison of Measured and Reference Takeoff Profiles

Community Exposure



Community exposure set by aircraft types, operational tempo over day and night, and where people live.

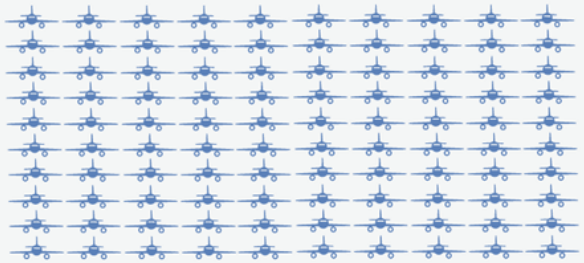
Background & Context

EQUIVALENT OPERATIONS FOR DNL = 65

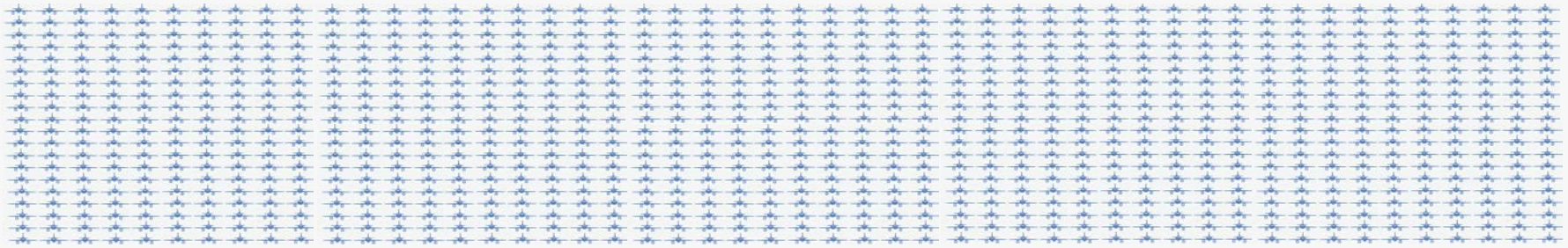
1 EVENT/DAY SEL 114.4 dBA = DNL 65

10 EVENTS/DAY SEL 104.4 dBA = DNL 65

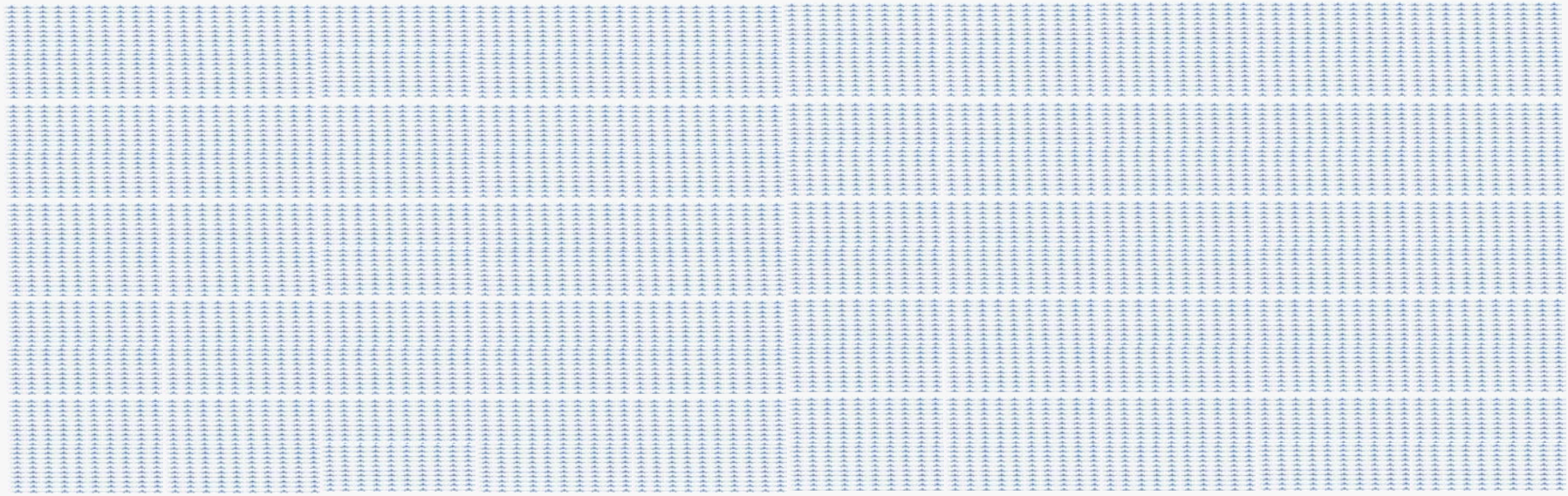
100 EVENTS/DAY SEL 94.4 dBA = DNL 65



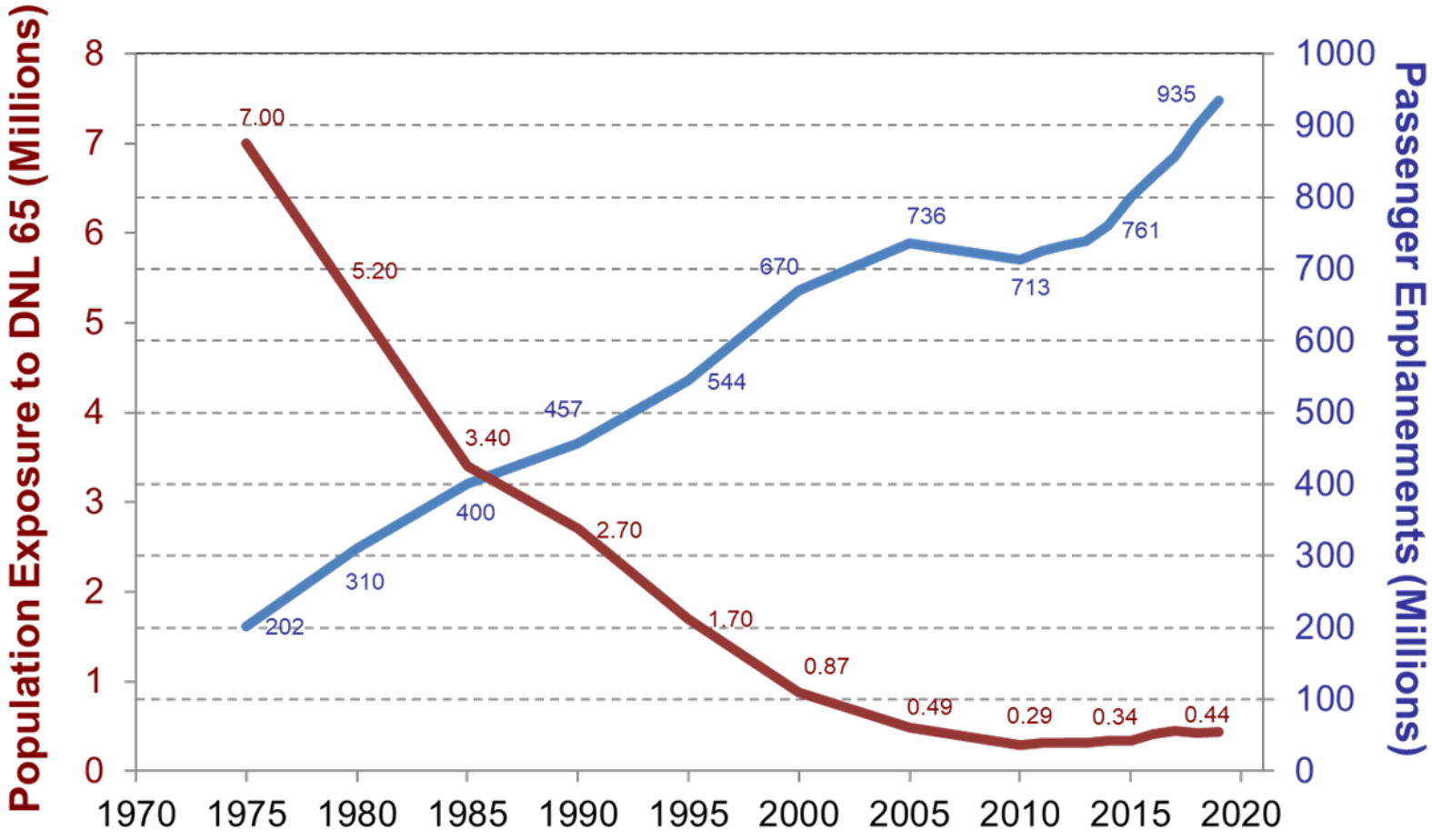
1,000 EVENTS/DAY SEL 84.4 dBA = DNL 65



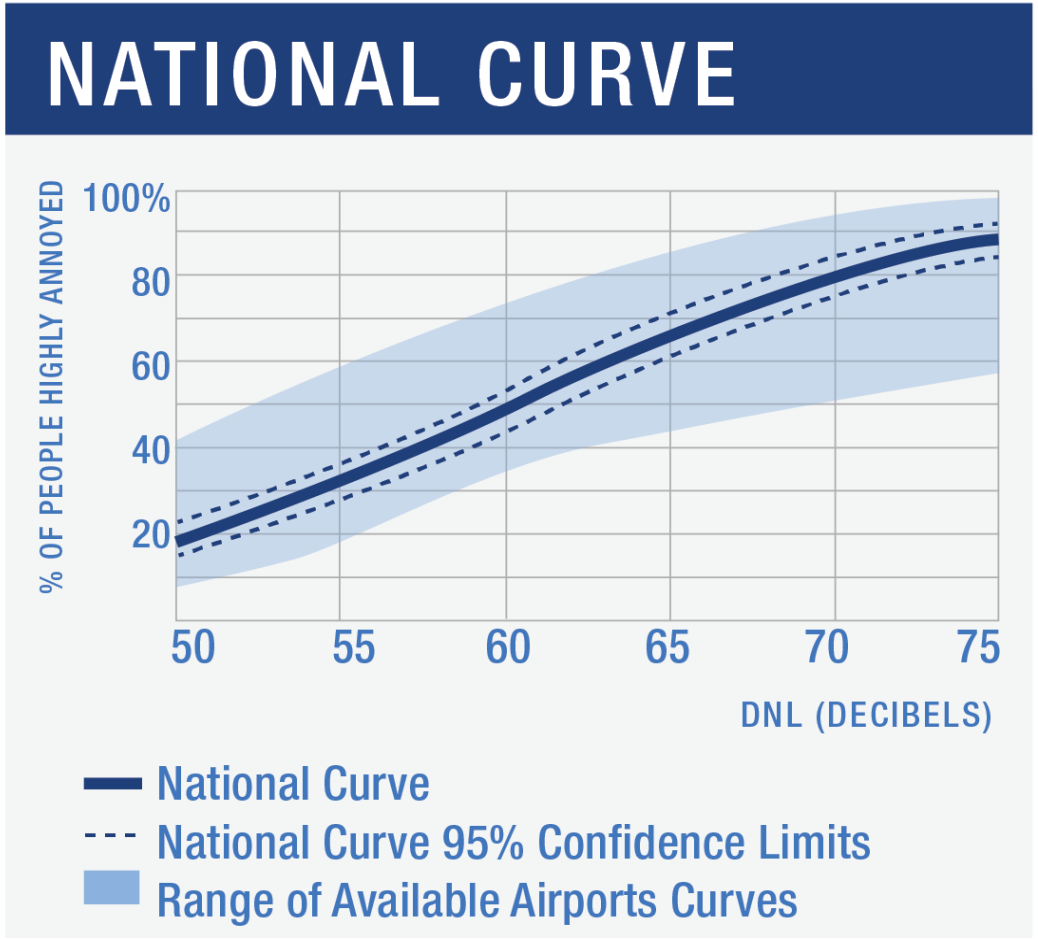
10,000 EVENTS/DAY SEL 74.4 dBA = DNL 65



Background & Context



Background & Context



Discussion & Input

FAA UAS/AAM Noise Research Programs (bricks):

- ASCENT Project 49
- ASCENT Project 61
- ASCENT Project 77
- Fly Neighborly
- Ongoing Noise Measurements

Gaps (mortar):

- How can the findings from these programs best be assembled to inform options to address UAS/AAM noise?
- Is additional research needed to accomplish this?
- What should we be doing to ensure that the FAA/public can consider possible impacts of operations that do not yet exist?
- How can noise research best be targeted to finding implementable solutions to UAS/AAM aircraft noise concerns?

Actions:

- Short Term Actions (<1 year)
  - *Data collection*
  - *Include UAS/AAM in FAA Noise Policy Review discussion*
- Longer Term Actions (1-3 years)
  - *Additional research*
  - *Rulemaking / Policy*

See backup slides for additional information on ASCENT Projects 49, 61, and 77

Topics

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- **Noise Research - 45 minutes**
  - Aircraft Noise Impacts Research
  - UAS / UAM
  - Aircraft Source Noise Reduction Technology

Aircraft Source Noise Reduction Technology – CLEEN Program

ASCENT-COE projects complement CLEEN; Details to be provided 10th March 2021

Aircraft Source Noise Reduction Technology - CLEEN Summary				
Programs	Period	Technologies	Benefits	Comments
CLEEN I	2010-15	Boeing: Ceramic Metal Composite Exhaust Nozzle	2.3 dB reduction re: hardwall	Tested on B787; TRL7
		Boeing: Adaptive Trailing Edge	1.7 dB reduction re: fixed Trailing Edge	Tested on B737; TRL7
		GE:Open Rotor Noise Tech	15 dB to Stage 4 in Wind Tunnel test and 1980's UnDuctedFan flight test experience	TRL6
		PW: Geared Turbo Fan Noise Tech	20 dB reduction in Wind Tunnel test and Certified product	TRL 8
CLEEN II	2016-20	Boeing: Compact nacelle	~0.8 dB aft fan duct compact nacelle	TRL7 Q3CY21
		Collins: Nacelle Tech	2 dB reduction estimated	Continue outside of CLEEN II, TRL 6 QCY24
		GE: Low Pressue Ratio Adv Tech	2dB novel liners; 1dB fan noise source reduction (Total: 3 dB reduction) est.	TRL6 Q4CY22
		Honeywell: Advanced Acoustics Fan and Liner Technologies	2.5 dB reduction est.	TRL 6 Q4CY22 (CLEEN II Option exercised)
CLEEN III	2021-25	To Be Anounced	Start date delayed due to COVID-19. Negotiations on-going.	Details to be provided 2nd day of REDAC meeting

Project #	Technology
Subsonic Aircraft	
50	Over-Wing Engine Placement Evaluation
55	Noise Generation and Propagation from Advanced Combustors
63	Parametric Noise Modeling For Boundary Layer Ingesting Propulsors
75	Improved Engine Fan Broadband Noise Prediction Capabilities
76	Improved Open Rotor Noise Prediction Capabilities
77	Measurements to Support Noise Certification for UAS/UAM Vehicles and Identify Noise Reduction Opportunities
Supersonic Aircraft	
42	Acoustic Model of Mach Cutoff
47	Clean Sheet Supersonic Aircraft Engine Design and Performance
59	Jet Noise Modeling to Support Low Noise Supersonic Aircraft Technology Development

CLEEN and ASCENT have enabled significant progress in aircraft noise reduction thus providing a solid foundation for needed reductions of future environmental foot print

For more information on CLEEN Projects:
https://www.faa.gov/about/office_org/headquarters_offices/apl/research/aircraft_technology/cleen/media/CLEENI_CLEENII_Projects.pdf

For more information on ASCENT COE Aircraft Technology Innovation Projects:
https://ascent.aero/topic/Aircraft-Technology/

Aircraft Source Noise Reduction Technology

Research Priorities and Potential Focus Areas – Subsonic LTO Noise

Subsonic Priorities and Research Focus			
Priority	**Areas of Research Focus - Potential**		
Engine			
Fan Exhaust Noise	3D Fan / OGV design	Novel liners (high noise suppression per unit area and volume)	Broad band noise reduction
Fan Inlet Noise	3D Fan design (low self-noise)	Novel liners (high noise suppression per unit area and volume)	
Jet Noise	Optimize for installed nozzle performance & noise	Provision for deep liner for combustor noise	
Combustor noise	Low noise combustor design	Combustor liner design	
LPT Noise	Cut-off LPT design	Higher solidity	LPT liner provision
Nacelle (Inlet, Exhaust) & Installation			
Inlet	Lip liners (incl. de-icing)	Novel liners (high noise suppression per unit area and volume)	
Exhaust system	Novel thrust reverser design	Novel liners (high noise suppression per unit area and volume)	
Jet/Flap interaction	High lift device integration		
Airframe			
Wing design	High A/R wing design	Optimized wing tip	
Landing gear noise	Streamline design	Minimize cavities	
High Lift devices	Simpler designs	Minimize cavities/openings	
Airframe	?	?	?

Discussion encouraged

Aircraft Source Noise Reduction Technology

Research Priorities and Gaps – Supersonic LTO Noise

Supersonic Priorities and Research Focus - LTO Noise			
Priority	**Areas of Research Focus - Potential**		
Engine			
Jet / Shock CellNoise	Mixer nozzle; Performance optimized variable area nozzle	Chevrons	Shock noise reduction (e.g., porous plug, variable area)
Fan Inlet Noise	Multi-stage fan w. or w.o. IGV design	Novel liners (high noise suppression per unit area and volume)	
Fan Exhaust Noise	Novel liners (high noise suppression per unit area and volume)	Combustor liner provision	Aft duct flow path optimization (M, Area etc.)
LPT Noise	Cut-off LPT design	LPT Liner design	
Combustor Noise	Combustor liner	Higher solidity LPT design	
Nacelle (Inlet, Exhaust) & Installation			
Inlet	Auxilary inlet optimization (performance, operability and noise)	Novel liners (high suppression per unit area and volume)	
Exhaust system	Novel liners (high suppression per unit area and volume)		
Jet/Flap interaction	High lift device integration	Shielding	
Airframe			
Landing gear noise	Less complex designs	Minimize cavities	
High Lift devices	Less complex designs	Minimize cavities	
Airplane L/D	Reduced landing speed		

Discussion encouraged

Aircraft Source Noise Reduction Technology

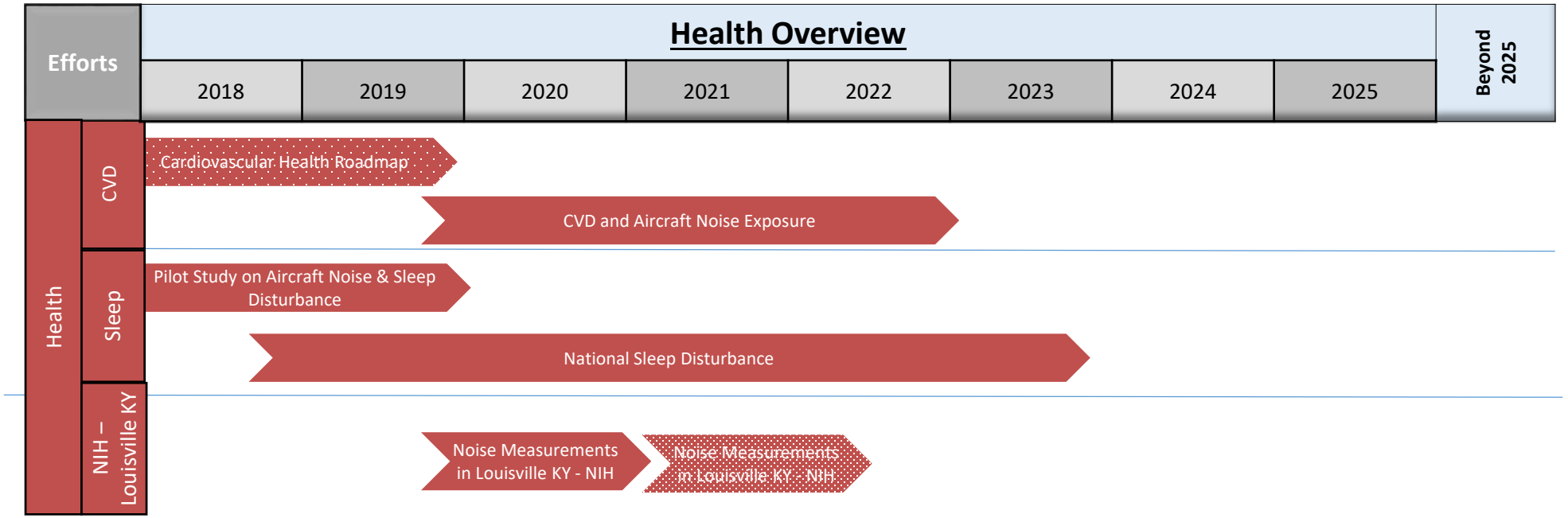
Research Priorities and Gaps – Supersonic En-route Noise

Discussion encouraged

Supersonic Priorities and Research Focus - En-route Noise			
Priority	**Areas of Research Focus - Potential**		
Aircarft Design			
Low Boom Design M1.4 (X-59 - LBFD)	Nose design	Area Rule design methods	Propulsion integration
Low Boom Design M1.8	Nose design	Area Rule design methods	Propulsion integration
Low Boom Design M2 and 2+	Nose design	Area Rule design methods	Propulsion integration
Mach cut-off	Atmospheric modeling	Caustics prediction	Propagation modleing

Backup Charts

Health Impacts Research Timeline



Cardiovascular Disease & Aircraft Noise

Objective: Evaluate associations between aircraft noise and cardiovascular outcome

Methods: Use existing health cohorts to evaluate link between health outcomes and noise exposure while accounting for wide range of factors

National longitudinal health cohorts:

- Medicare database
- Women's Health Initiative
- Nurses' Health Study /Health Professional Follow-up Study

Team: Research being conducted by Boston University

Reauthorization Connection: HR 302 § 189 – Study on Potential Health and Economic Impacts of Overflight Noise

Future work:

- **Utilize existing cohorts to determine if an association exists. The current cohort work will take 3 years.**
- **Seek additional cohorts that could be used to further examine association.**
- **Depending on the results, develop improved noise exposure metrics and policies**

Sleep-Disturbance Research & Implication

Objective: Inform future considerations regarding aviation noise in the U.S. by obtaining dose-response relationships between aircraft noise exposure and sleep disturbance

Goal: National field study: acquire current objective sleep disturbance data relative to varying degrees of exposure at many airports; 4-5 year effort

Team: Research being conducted by UPenn with support of FAA Office of Airports' Airport Technology Research (ATR) Program

Next Steps: Address comments received during Federal Register notice period and Complete U.S. Government data collection requirements (e.g. OMB and PRA)

NOTE: This project will be reviewed at the REDAC Airport Subcommittee

Future work:

- **Partner with other organizations and experts who have expertise on the subject matter**
- **Depending on the results, develop improved noise exposure metrics and policies**
- **Exploring information exchange and partnerships with the FAA Civil Aerospace Medical Institute (CAMI)**

ASCENT Project 49: Modeling of UAM Noise (Penn State)

Goals:

- Develop initial capability to predict UAM acoustics
- Improve understanding of UAM noise characteristics
- Identify noise reduction opportunities

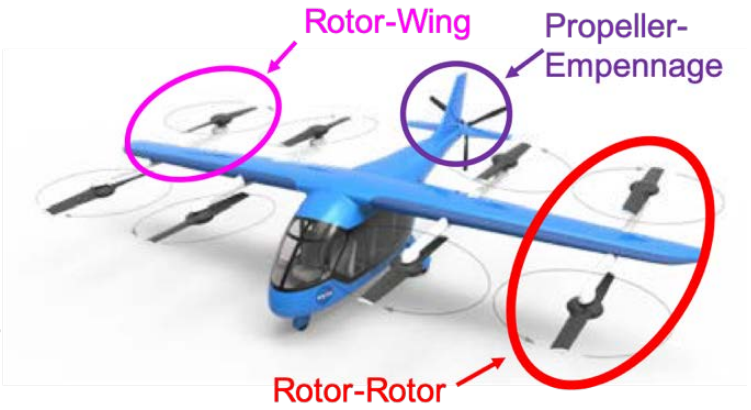
Approach:

- Build on success of helicopter noise prediction system developed under ASCENT Projects 6 & 38
- Tailor approach to the unique characteristics of UAM
  - PSU DEPSim for flight state of multirotor vehicles
  - Unsteady loading with CDI's CHARM
  - Increase efficiency of PSU-WOPWOP for many rotors
  - Generalize broadband noise models for UAM

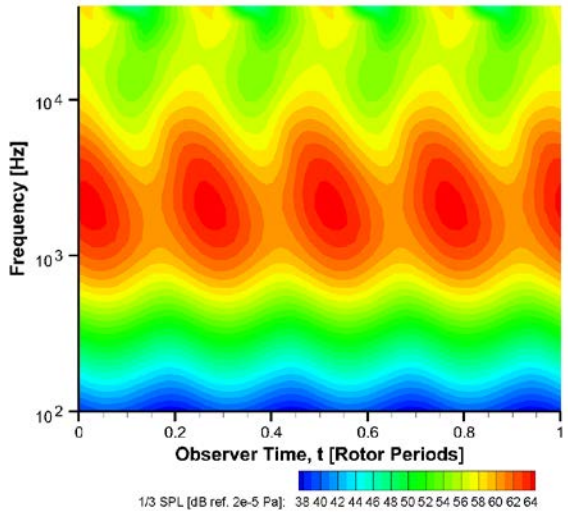
Status:

- PSU-WOPWOP implementation allows for analysis of time-varying broadband noise, which may be especially important for UAM due to the complex interactional aerodynamics
- A new UAM noise prediction capability is being developed
- Potential noise reduction designs will be investigated

NASA UAM Reference Vehicle



Lift + Cruise "Air-Taxi"



For more information on Project 49
https://ascent.aero/project/modeling-of-urban-air-mobility-noise-to-enable-innovative-means-of-noise-reduction/

Federal Aviation Administration

ASCENT Project 61: Noise Certification Streamlining (Georgia Tech)

Goals:

- Evaluate and improve the business process of noise certification
- Increase efficiency and flexibility in noise certification of both existing and future aircraft type

Approach:

- Quantitative assessment of noise certification process via System Engineering tools and methods
- Leverage knowledge of technical experts and specialists

Status:

- Through workshops, Georgia Tech continues to seek information from OEMs about improvements possible for noise cert
- Georgia Tech preparing noise cert framework within process flow models to simulate baseline and develop optional scenarios of improvement.
- Research in-progress.

ASCENT Project 77 MEASUREMENTS TO SUPPORT NOISE CERTIFICATION FOR UAS/UAM VEHICLES (Penn State)

Goals:

- Develop noise measurement and data analysis techniques for repeatable characterization of UAS and UAM noise
- Establish a database of UAS and UAM noise measurements across a wide range configurations and operating conditions
- Inform the development of noise certification standards and identify effective noise reduction opportunities through design and operation

Approach:

- Develop noise source separation for multirotor vehicles
- Leverage Project 49 predictions to determine effective experimental procedures before flight
- Investigate microphone types and installations
- Develop reconfigurable multirotor UAS
- Collect noise data on UAS and UAM vehicles

Status:

- Understand noise source components and flight dynamics
- Evaluate testing techniques and procedures
- Measure variety of designs to inform noise certification
- Identify quiet designs and quiet flight procedures

PSU Multicopter UAS

Beta Alia-250

For more information on Project 77
https://ascent.aero/project/measurements-to-support-noise-certification-for-uas-uam-vehicles-and-identify-noise-reduction-opportunities/

Federal Aviation Administration