FUTURE OF AVIATION

Advancing Aerial Mobility through Technology, Sustainability, and On-Demand Flight

Wednesday, August 3, 2022

San Francisco International Airport

Berkeley Institute of Transportation Studies

Environmental Impacts: Weather, Noise, Visual Pollution, and Land Use Privacy

Moderator

Paul Wheeler
WSP

Panelists

Ryan Biziorek
Arup

Timothy Middleton
HMMH

Brendan Reed
San Diego International Airport

Colleen Reiche
EY-Parthenon

BRENDAN REED A.A.E.

DIRECTOR OF AIRPORT PLANNING & ENVIRONMENTAL AFFAIRS

SAN DIEGO COUNTY REGIONAL AIRPORT AUTHORITY

- Oversees policies concerning airport site planning, airport land use compatibility, corporate sustainability, environmental compliance, and noise abatement
- Co-Chair of the AAAE Emerging Aviation Technologies Working Group
- North American representative on ACI World Environment Standing Committee
- Developing a “Regional AAM Strategy” in partnership with the San Diego Association of Governments and other community stakeholders.

COLLEEN REICHE PH.D

SENIOR DIRECTOR EY-PARTHENON

- Lead a UAM Market Study for NASA ARMD
- Recently completed a prototype weather camera platform technical evaluation for the FAA
- Lead experiment design for assessing implications of eVTOL flight ride quality on passenger comfort using a flight simulator for a NASA study
- Developed an AAM Weather Roadmap for NASA synthesizing and visualizing key ongoing and planned research, development, policy, standards, and regulatory activities in AAM weather that will likely help enable UML-4 operations.

CHRIS FERNANDO

ADVISOR AND ADVANCED AIR MOBILITY CONSULTANT

- Led multiple large contracts and engagements with the Federal Aviation Administration (FAA), the Volpe National Transportation Systems Center (Volpe), the Airport Cooperative Research Program (ACRP), and the National Aeronautics and Space Administration (NASA)
- Currently supporting client engagements focused on AAM integration for FAA, airports and state/local regions
- Adjunct professor at Florida Institute of Technology teaching a course on the ecosystem of UAM.
- Co-Host of the No U-Turn Podcast with Basil Yap and Ravi Singh

RYAN BIZIOREK

ASSOCIATE PRINCIPAL - AMERICAS EAST GEOGRAPHY ACOUSTICS, AV, THEATER, AND EXPERIENCE DESIGN LEADER - ARUP

- Experience in terminal buildings, environmental noise analysis, public address and audiovisual systems design, and Urban Air Mobility noise policy and simulations.
- Contributes to the operation and development of the Arup SoundLab, a virtual reality room where clients can experience in 3-D an existing or future acoustic environment.
- Licensed private pilot and Part 107 drone pilot with multi-engine, instrument, commercial, and high-performance rating.

TIMOTHY MIDDLETON C.M.

Principal Consultant HMMH

- Fifteen years of airport management, noise abatement, and environmental compliance experience.
- Thought leader at HMMH fostering community acceptance of new aircraft entrants into the airspace that includes Advanced Air Mobility (AAM), and electric vertical take-off and landing (eVTOL) aircraft.
- HMMH AAM projects
  - Human Response to UAM for NASA
  - Noise Assessment in Support of Part 135 for FAA
  - NASA SBIR Phase 2: AAM Community Integration Tool
  - UAM Modeling in AEDT for FAA/NASA

PAUL WHEELER

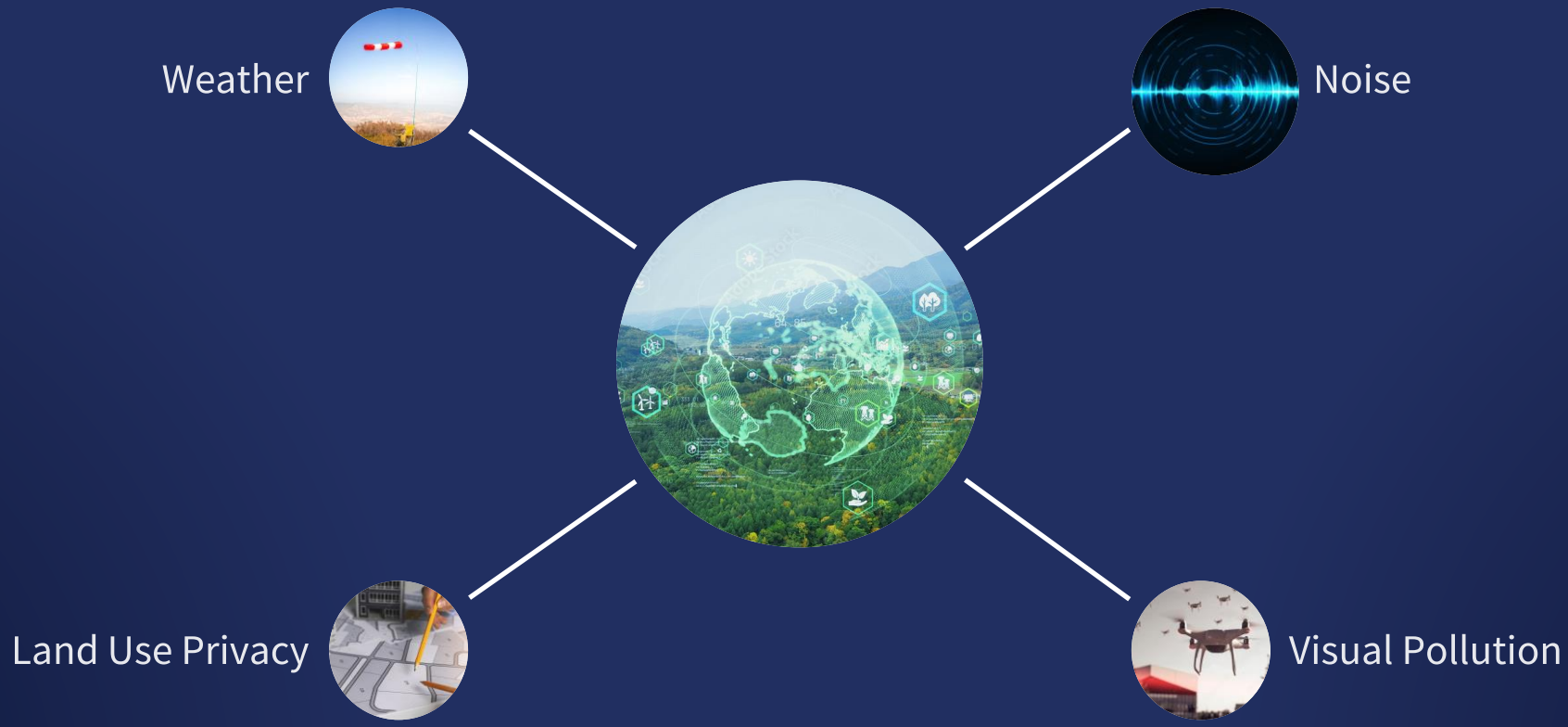
Principal Consultant, Director, Aerial Innovation WSP USA Inc.

- 24 years experience in surface and air transportation industries.
- Led ACRP Report 243 (03-50) - An Airport-Centric Study of the Urban Air Mobility Market
- Leading Utah AAM Integration Study
- Recognized by Commercial UAV Expo and InterDrone as one of the top UAS visionaries.

Participate!

- *Navigate to Slido.com*
- *Use meeting code #2637125*
- *Select the Room - Looper*

AAM ENVIRONMENTAL IMPACTS

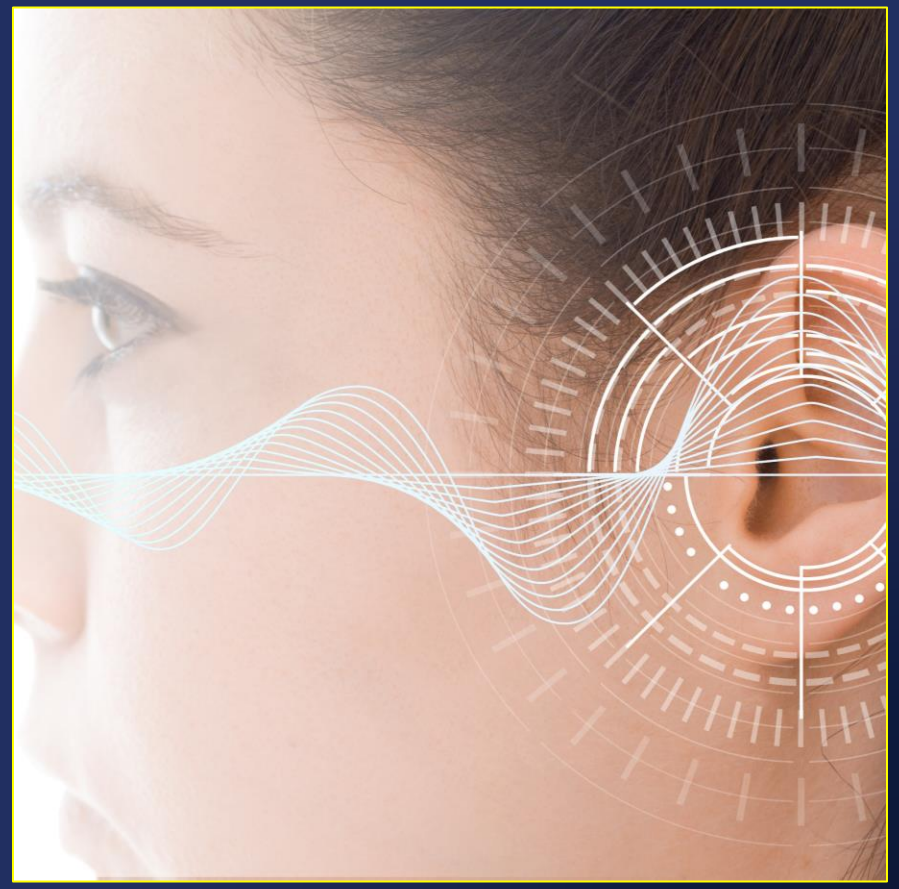


WEATHER INFLUENCE ON AAM

- AAM aircraft are smaller and more sensitive to many types of adverse weather than larger planes.
- Operations occur at lower altitudes, within the complex and currently undersampled atmospheric boundary layer.
- Flights will operate closer to urban environments than commercial aviation.

NOISE CONSIDERATIONS FOR AAM

- Public Perception
- Noise Level and Type
- Federal, State, & Local Policies



VISUAL POLLUTION CONSIDERATIONS FOR AAM

- Sky as a Natural Resource
- Balance Convenience with Quality of Life
- What will be the Aesthetic Impacts of Low-Level Aircraft On Views and/or Natural Environment?

LAND USE & PRIVACY CONSIDERATIONS FOR AAM

- Mitigate and Address Privacy Concerns
- Multimodal Integration
- Impacts and Modifications to Current Policies
- Flight Paths To/From Vertiports

Disclaimer

- The views expressed by the presenters are their own and not necessarily those of Ernst & Young LLP or other members of the global EY organization.
- These slides are for educational purposes only and are not intended to be relied upon as accounting, tax, legal or other professional advice. Please refer to your advisors for specific advice.
- EY refers to the global organization, and may refer to one or more, of the member firms of Ernst & Young Global Limited, each of which is a separate legal entity. Ernst & Young LLP is a client-serving member firm of Ernst & Young Global Limited operating in the US.

Potential Adverse Weather Disruptions

- Operations
  - Reduced Throughput
  - Delays
- Service Supply
  - Cancellations
  - Diversions
- Passenger Comfort
  - Extreme Temperature
  - Bumpy Flights
- Community Acceptance
  - Noise Implications
  - Safety Perception
- Infrastructure
  - Vertiport Planning
  - Data Outages
- Traffic Management
  - Mitigation Initiatives
  - Decreased Spacing

Addressing AAM Weather Needs

Development and deployment of new sensors and technology can address AAM weather needs and improve forecasts.

- Weather sensors can be placed on aircraft to collect airborne observations, like those currently used on commercial aircraft.
- Advisory systems such as weather cameras, “backyard” weather stations and radar networks can provide raw and processed information.
- Satellite observations can provide a useful “top-down” view, especially in areas with limited surface sensors.

EY | Building a better working world

EY exists to build a better working world, helping to create long-term value for clients, people and society and build trust in the capital markets.

Enabled by data and technology, diverse EY teams in over 150 countries provide trust through assurance and help clients grow, transform and operate.

Working across assurance, consulting, law, strategy, tax and transactions, EY teams ask better questions to find new answers for the complex issues facing our world today.

About EY-Parthenon

EY-Parthenon teams work with clients to navigate complexity by helping them to reimagine their ecosystems, reshape their portfolios and reinvent themselves for a better future. With global connectivity and scale, EY-Parthenon teams focus on Strategy Realized — helping CEOs design and deliver strategies to better manage challenges while maximizing opportunities as they look to transform their businesses. From idea to implementation, EY-Parthenon teams help organizations to build a better working world by fostering long-term value.

EY-Parthenon is a brand under which a number of EY member firms across the globe provide strategy consulting services. For more information, please visit ey.com/parthenon.

US SCORE no. 16519-221US
2206-4056190

ED None

ey.com

What do we know about noise from novel aircraft?

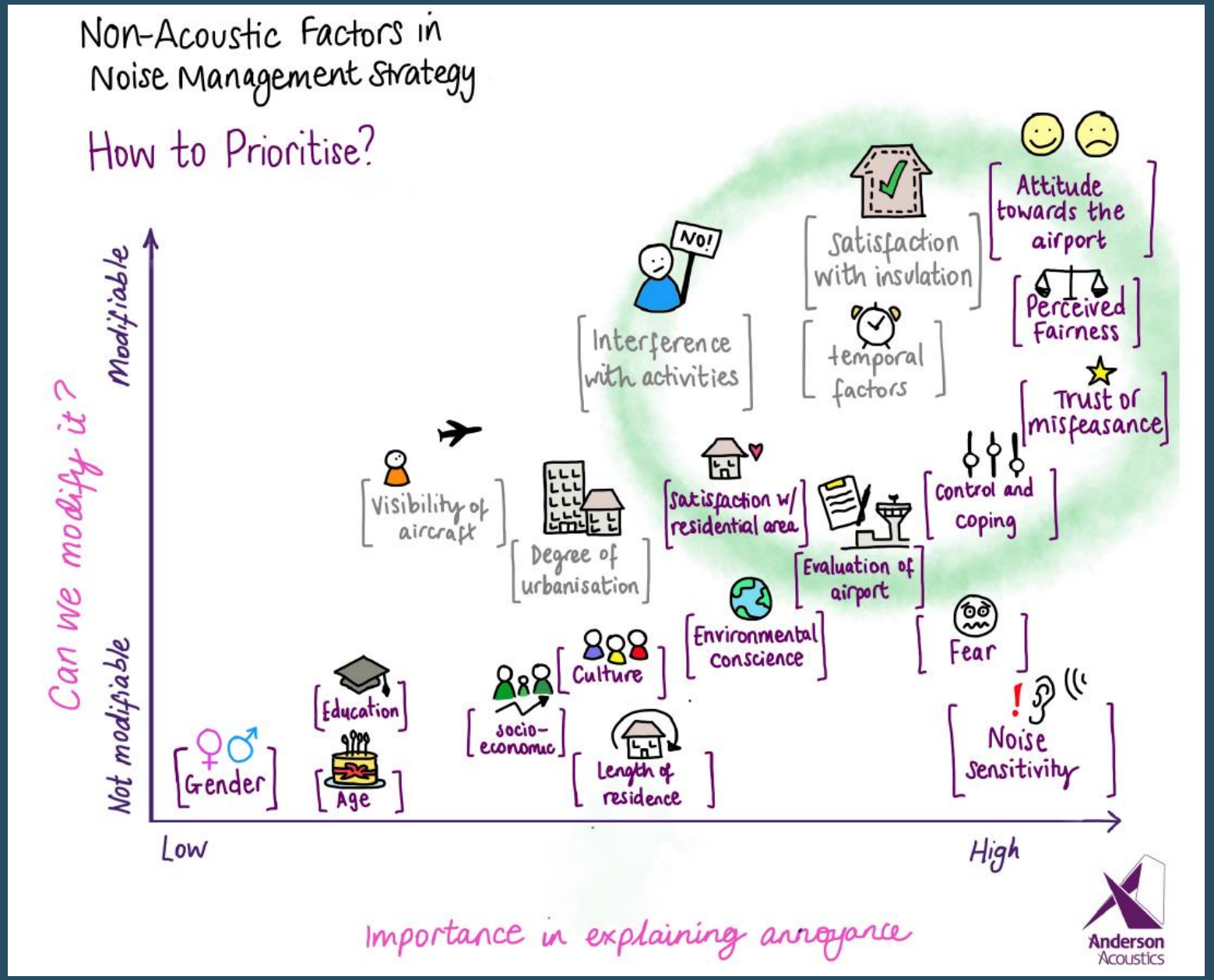
Traditional noise metrics that have been proposed and/or used:

- DNL, as defined by FAA Order 1050.1F
- SEL, the Sound Exposure Level, for individual events
- LAmax, the maximum A-weighted level, for individual events
- OASPL or Lmax, the maximum overall sound pressure level, for individual events
- One third octave spectra at sensitive receptors
- Number of Events
- Non-Acoustic factors will play a vital role in acceptance

Noise Issues to Consider

How loud will these aircraft be?

- Decibel levels may be “quieter” than existing helicopters
- Current lack of data on the noise of the proposed eVTOL aircraft
- Multiple propellers will generate a unique noise signature
- The noise of AAM may be bothersome and annoying to residents (subjective)
- Community understanding could lead to acceptance
- Not pure loudness, but other aspects of audibility will be important.



What are non-acoustic factors?

Source: Heathrow, 2018

Non-acoustic factors: strength and modifiability

Non-acoustic Factors	Strong	Intermediate	Weak
Modifiable	• Attitude toward the source • Choice in insulation • Choice in compensation (personal) • Influence, voice • Perceived control • Recognition of concern • Trust	• Avoidability • Choice in compensation (societal) • Expectations regarding future of the source • Information (accessibility and transparency) • Predictability of noise situation • Procedural fairness	• Media coverage and heightened awareness to noise • Social Status
Non-modifiable	• Age (<55) • Income • Individual sensitivity to noise • Past experience with the source	• Duration of residency • Fear related to the noise source • Home ownership • Use of airport services	• Age (>55) • Awareness of negative consequences • Children • Education
Unsure (need to be examined)	Conviction that noise could be reduced or avoided by others	• Benefits from airport (personal, societal) • Cross-cultural differences • Country of origin	

Source: Vader, 2007

Non-acoustic factors: strength and modifiability

Non-acoustic Factors	Strong	Intermediate	Weak
Modifiable	• Attitude toward the source • Choice in insulation • Choice in compensation (personal) • Influence, voice • Perceived control • Recognition of concern • Trust	• Avoidability • Choice in compensation (societal) • Expectations regarding future of the source • Information (accessibility and transparency) • Predictability of noise situation • Procedural fairness	• Media coverage and heightened awareness to noise • Social Status
Non-modifiable	• Age (<55) • Income • Individual sensitivity to noise • Past experience with the source	• Duration of residency • Fear related to the noise source • Home ownership • Use of airport services	• Age (>55) • Awareness of negative consequences • Children • Education
Unsure (need to be examined)	Conviction that noise could be reduced or avoided by others	• Benefits from airport (personal, societal) • Cross-cultural differences • Country of origin	

Source: Vader, 2007

Potential Concerns with AAM

Flight Paths & En-Route Operations

- Multimodal Integration
- Equity (e.g., impact of operations)
- Air congestion/Ops Tempo
- Noise and Visual Pollution
- Privacy
- Air traffic over sensitive land uses

Vertiports

Multimodal Integration and Ground Congestion

Equity (e.g., gentrification)

Approach Congestion/Ops Tempo

Noise and Visual Pollution

Cross-Cutting Issues

Equity and Affordability

Safety

Privacy

Equity

Where a vertiport gets placed could have huge implications for:

- Environmental impacts
  - Fight paths to/from a vertiport
  - Vertiport vicinity
- Affordability of Services
- Access for People with Disabilities
- Gentrification and displacement
- Allocation of limited public resources

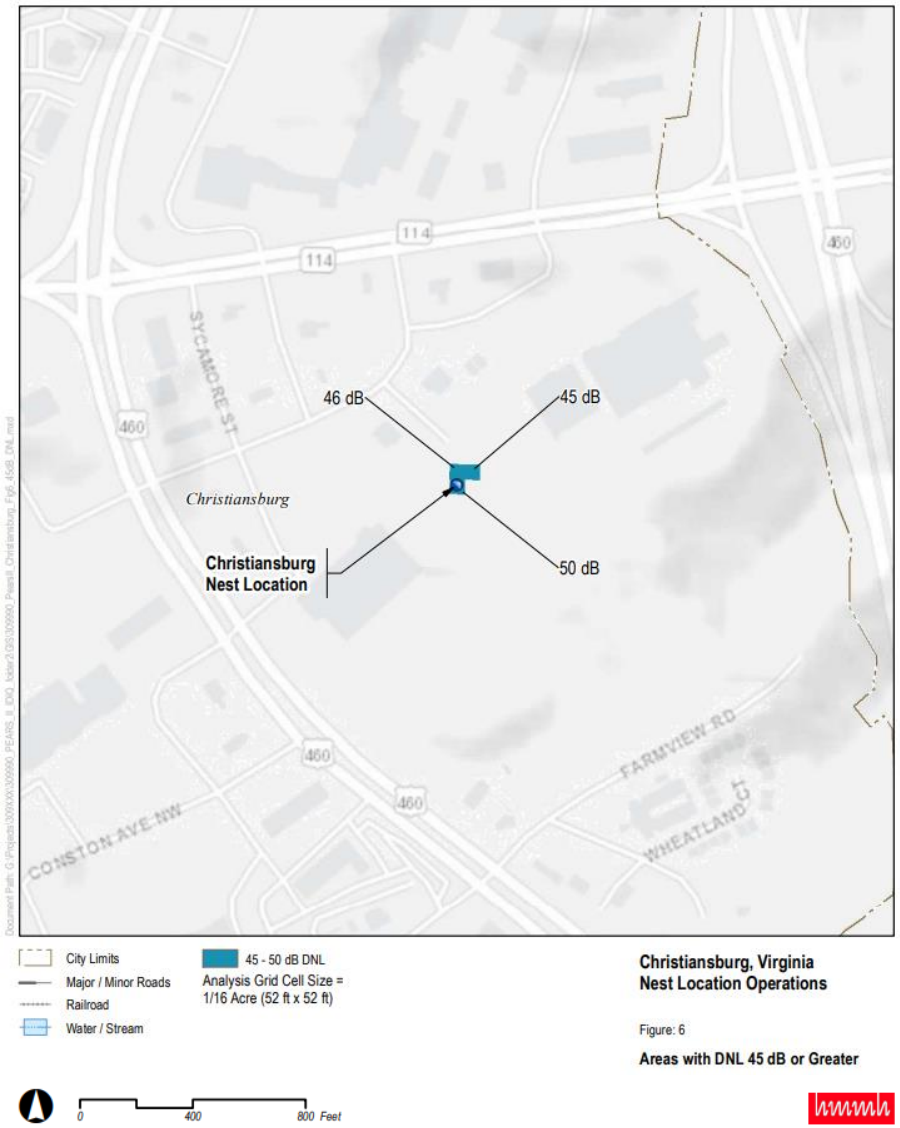
Community Acceptance

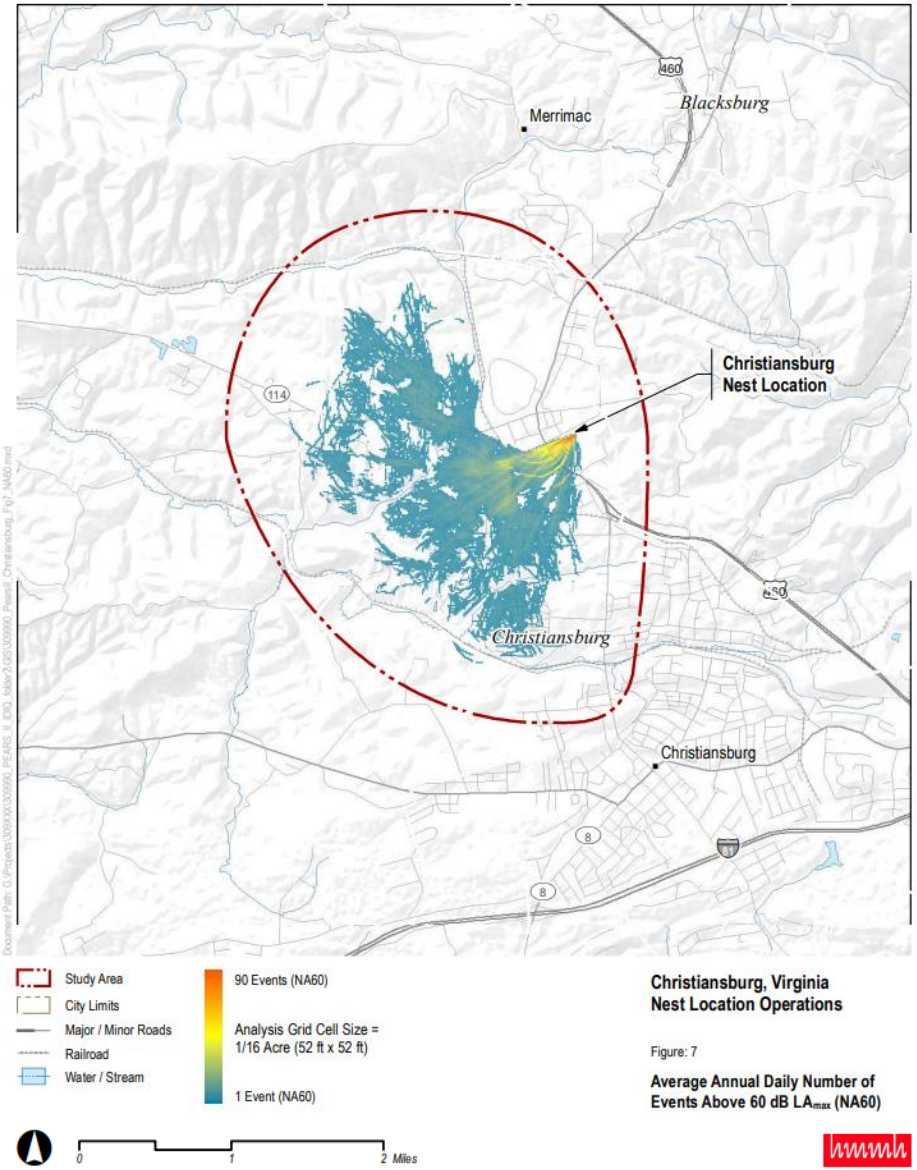
- Stakeholder engagement must go beyond current best practices
  - Planning is at the core of a successful approach
  - Early identification of key stakeholders is critical
  - Clear messaging tailored to stakeholder groups is required
- Production of AAM-related materials is important
  - Strategic use of social and traditional media should also be considered
- Auralization provides stakeholders a means to hear the experience prior to implementation

Noise Assessment in support of Part 135 for FAA

- Noise analysis of the proposed activity was conducted based upon computer simulations of projected delivery operations from the two delivery stations of an Unmanned Aircraft (UA), produced by the aircraft operator.
- Using available noise measurement data collected for the Unmanned Aircraft in various operating states.
- Results of the noise analysis in terms of the Day-Night Average Sound Level (DNL) and Numbers of Events Above 60 dB LAmax (NA60) for Average Annual Daily Operations (AAD).

Wing Christiansburg





Source: HMMH, 2021

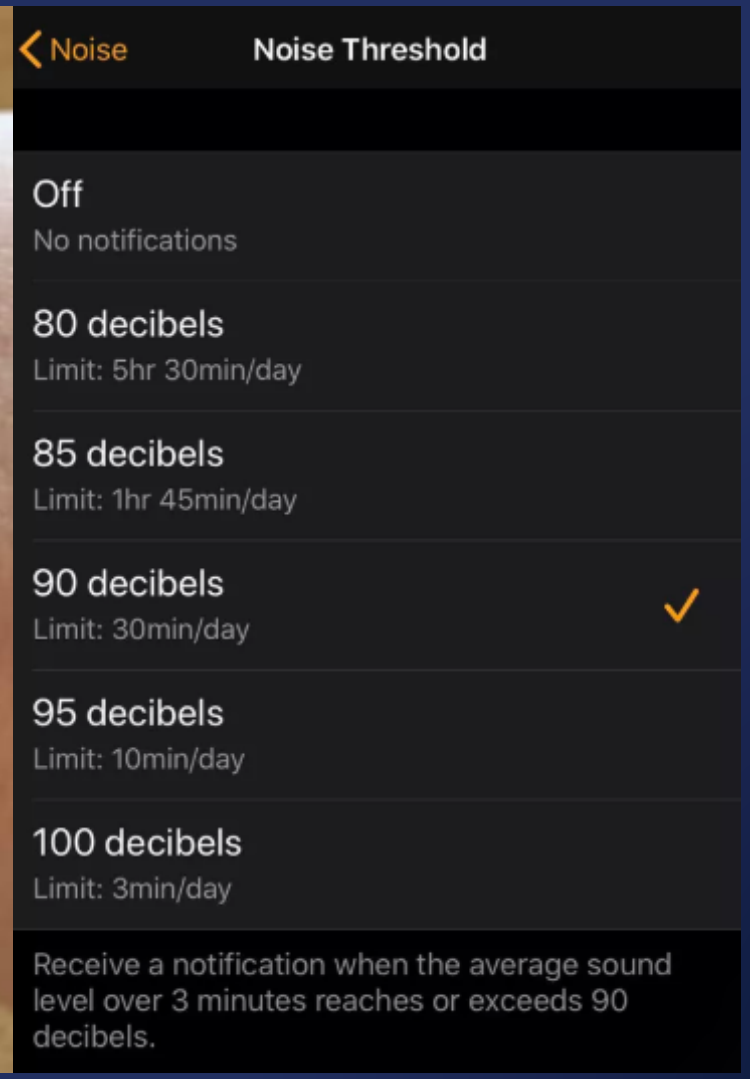
FUTURE OF AVIATION

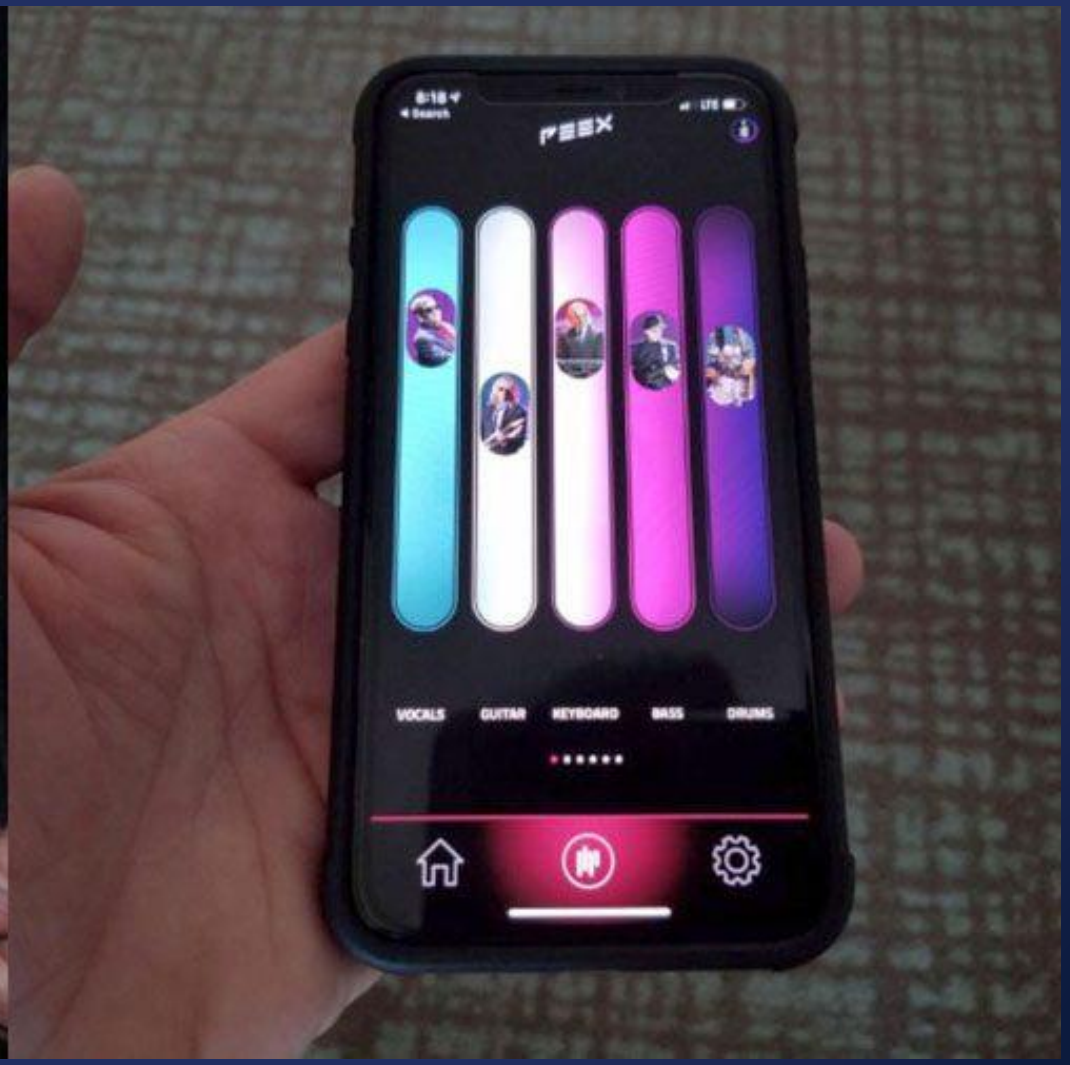
Advancing Aerial Mobility through Technology, Sustainability, and On-Demand Flight

FUTURE OF AVIATION

Advancing Aerial Mobility through Technology, Sustainability, and On-Demand Flight

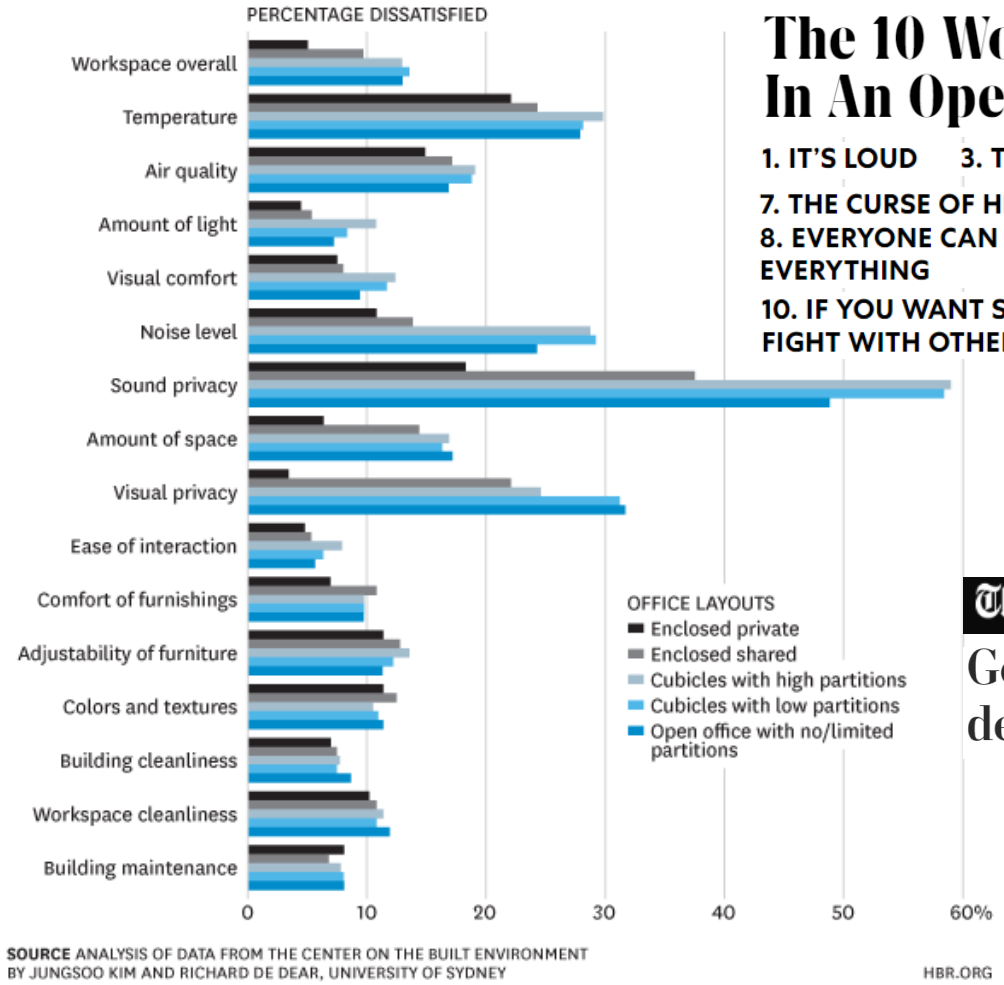

Noise
4:20
54 dB
30
80
120
OK
Long-term exposure to sounds at this level should not


Noise
Noise Threshold
Off
No notifications
80 decibels
Limit: 5hr 30min/day
85 decibels
Limit: 1hr 45min/day
90 decibels
Limit: 30min/day
95 decibels
Limit: 10min/day
100 decibels
Limit: 3min/day
Receive a notification when the average sound level over 3 minutes reaches or exceeds 90 decibels.



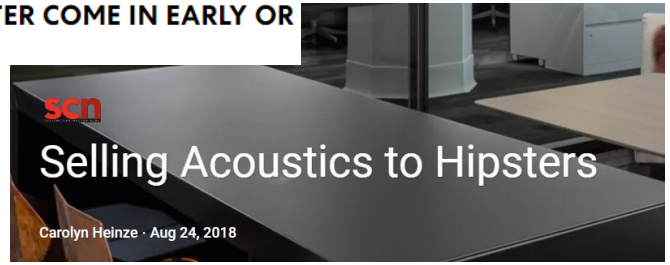
FUTURE OF
AVIATION

Advancing Aerial Mobility
through Technology, Sustainability,
and On-Demand Flight



The 10 Worst Things About Working In An Open-Office In Your Words

1. IT'S LOUD
3. THERE'S ABSOLUTELY NO PRIVACY
7. THE CURSE OF HEADPHONES
8. EVERYONE CAN HEAR EVERY CONVERSATION ABOUT EVERYTHING
10. IF YOU WANT SOME PRIVACY, YOU BETTER COME IN EARLY OR FIGHT WITH OTHERS FOR SPACE

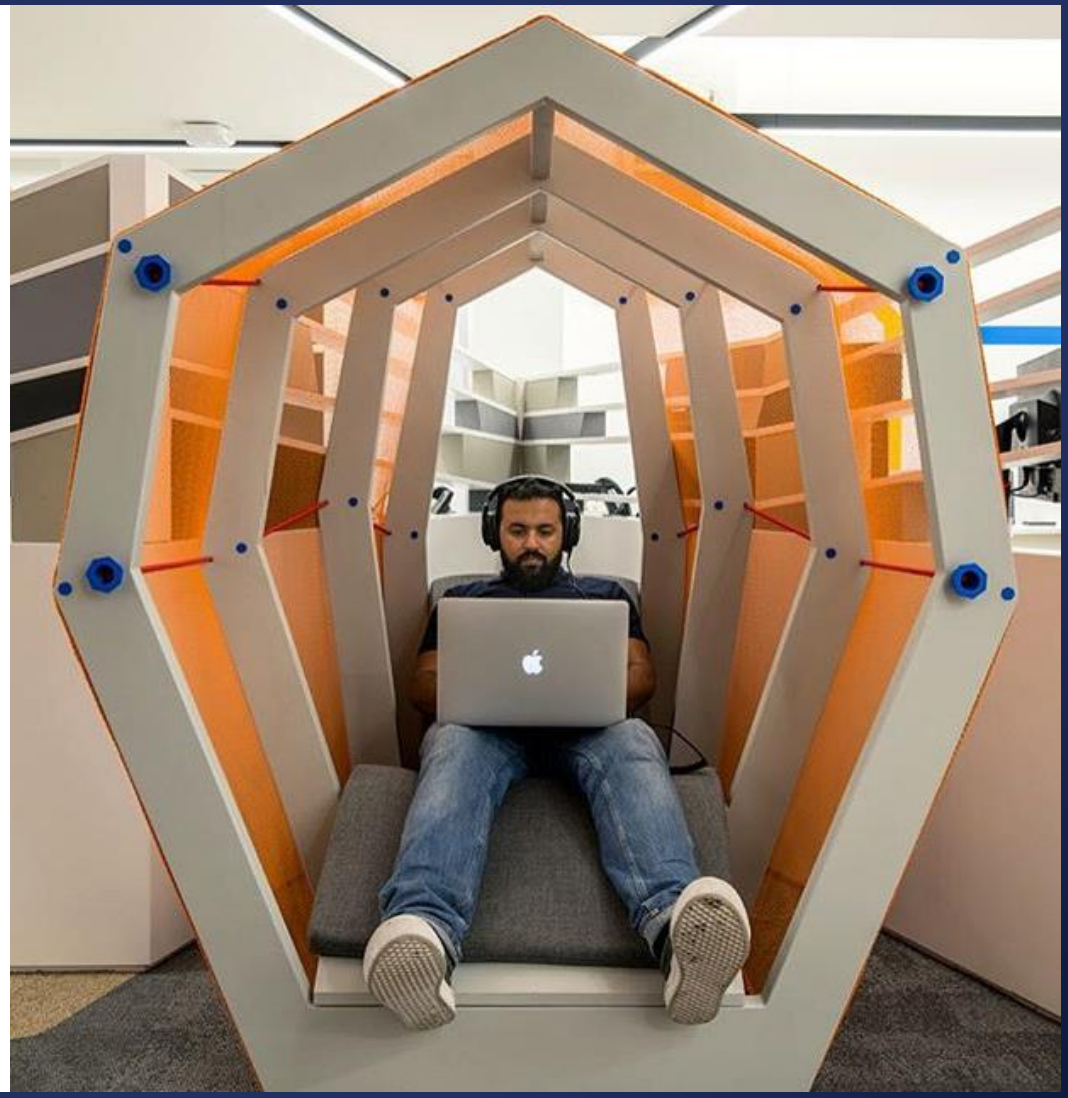


The Washington Post

Google got it wrong. The open-office trend is destroying the workplace.

Chicago Tribune

The open office plan is a disaster



FUTURE OF AVIATION

Advancing Aerial Mobility
through Technology, Sustainability,
and On-Demand Flight


HELMFON

The Isolator

By HUGO GERNSBACK

MEMBER AMERICAN PHYSICAL SOCIETY

The author at work in his private study aided by the Isolator. Outside noises being eliminated, the worker can concentrate with ease upon the subject at hand.

Boston Logan International Airport

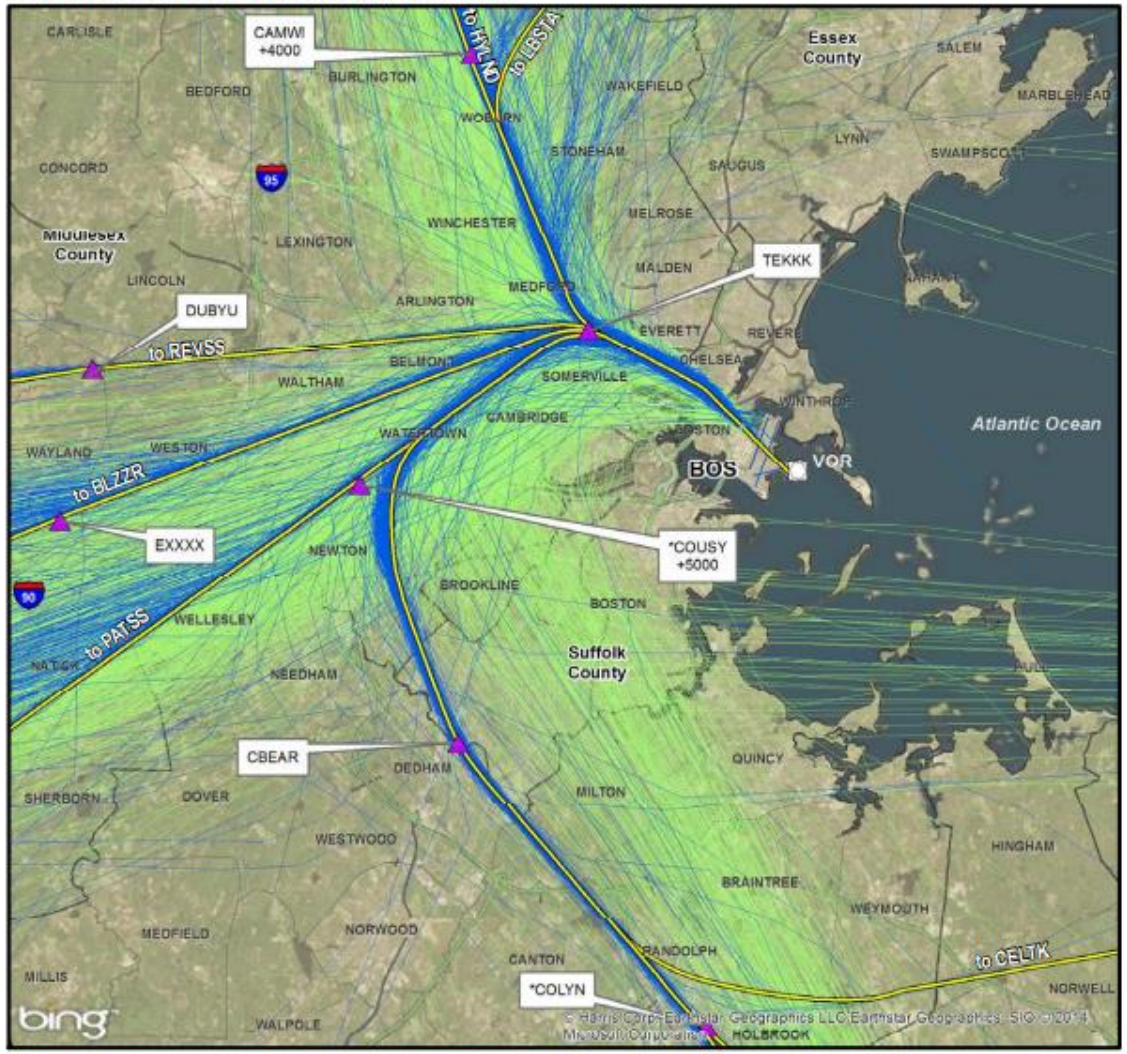


Figure 6
Runway 33L Flight Track Dispersion Comparison

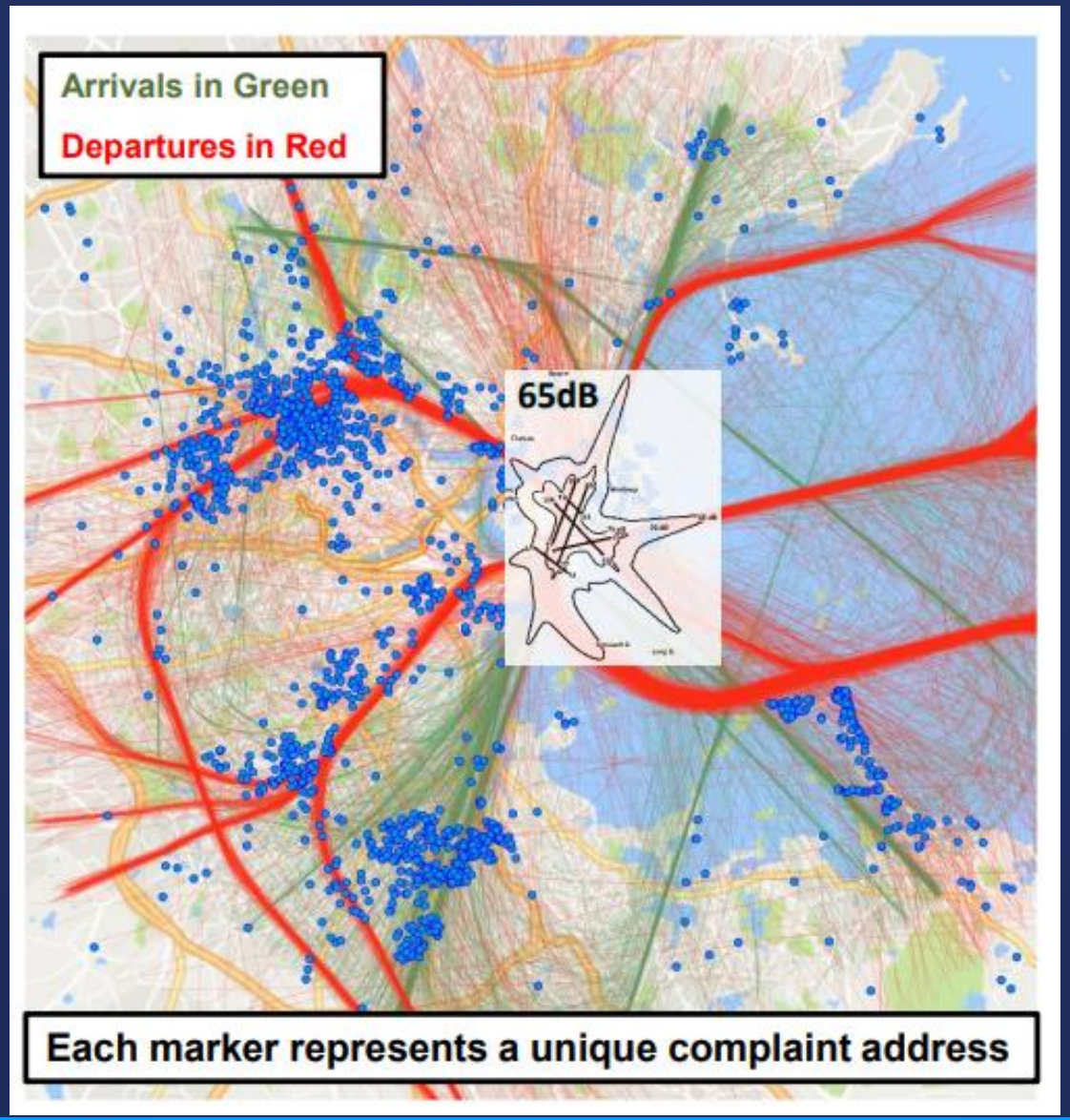
LEGEND

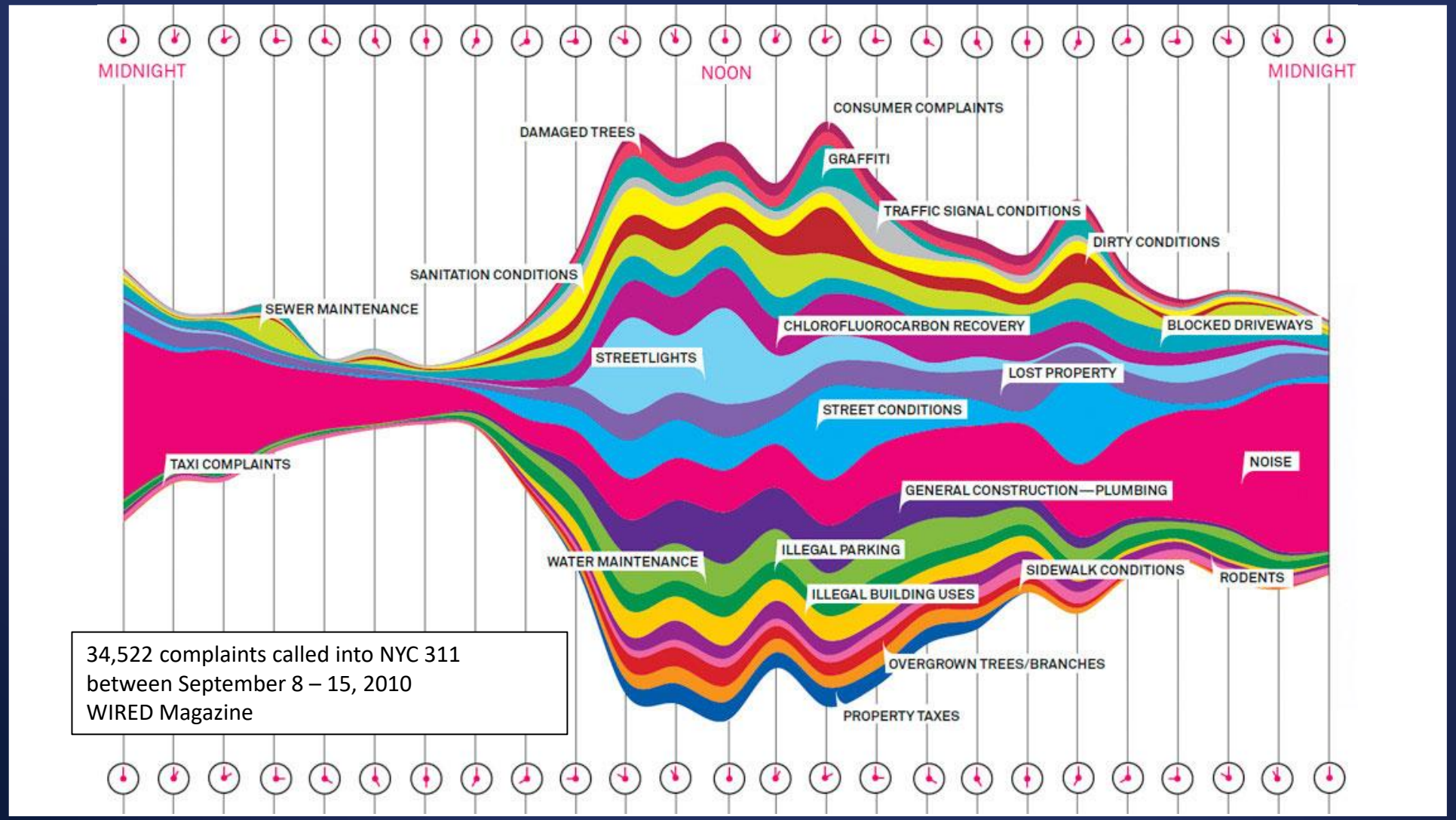
- Runway 33L RNAV SID Noise Model Departure Flight Tracks (Expected Flyability Track)
- Post Implementation RNAV Runway 33L Departures
- Pre Implementation Runway 33L Departures
- Waypoint
- Study Area
- Community within Study Area
- County Boundary
- BOS VOR/DME
- Interstate
- Highway

Note: Procedure applies to RNAV-capable Jet aircraft. Turboprop and non-RNAV capable aircraft use LOGAN SIX Conventional SID.

Boston Logan International Airport Runway 33L RNAV SID

Source:
Radar Data: RNAV: Two representative days per month, June through December 2012
Non RNAV: Two representative days per month between November 2012 and March 2013
RNAV TARGETS (FAA PBN Integration Office)
Office of Geographic Information (MassGIS), ESRI
*The COLYN and COUSY waypoints switched names in the final procedure design for the Runway 33L RNAV SID

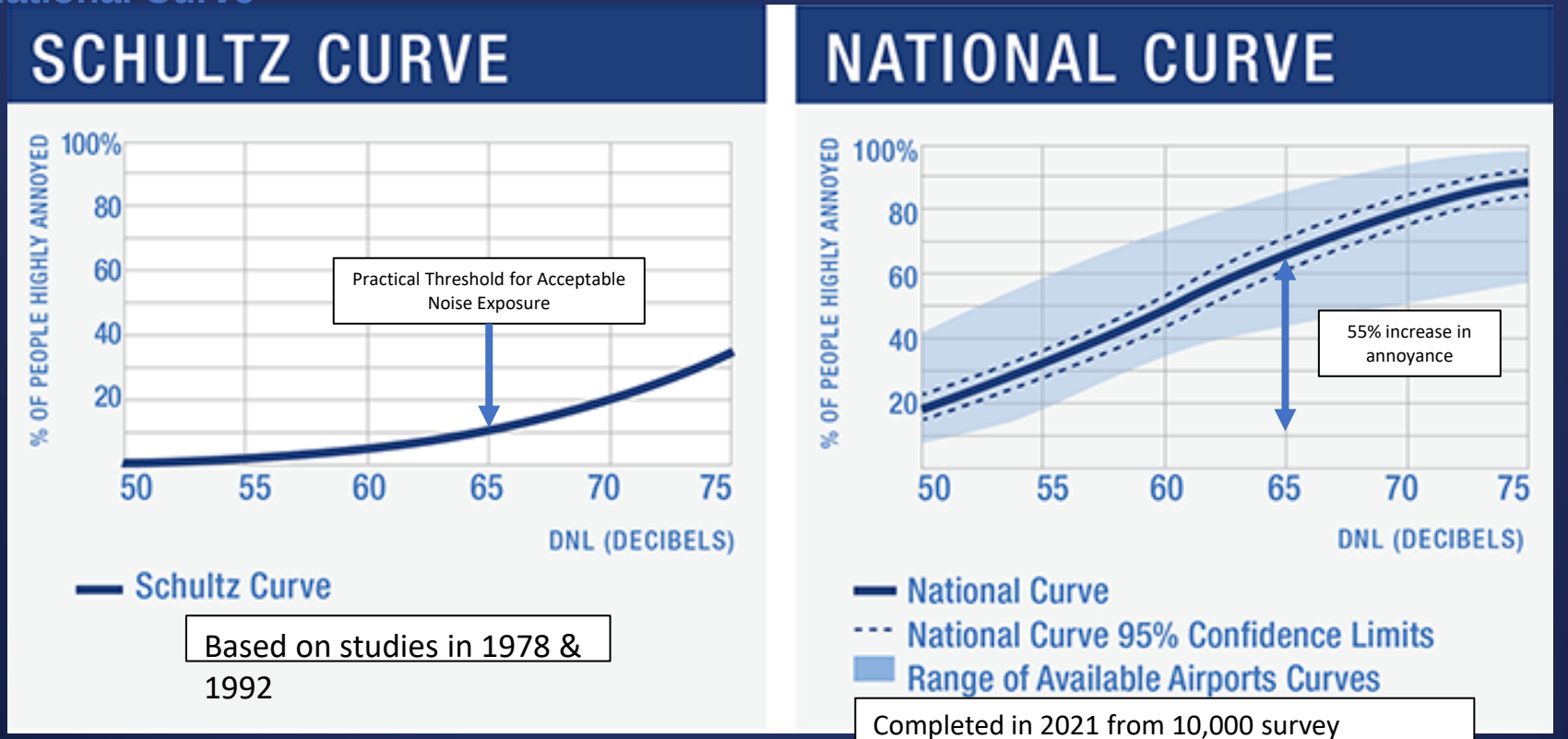

Arrivals in Green
Departures in Red
65dB
Each marker represents a unique complaint address



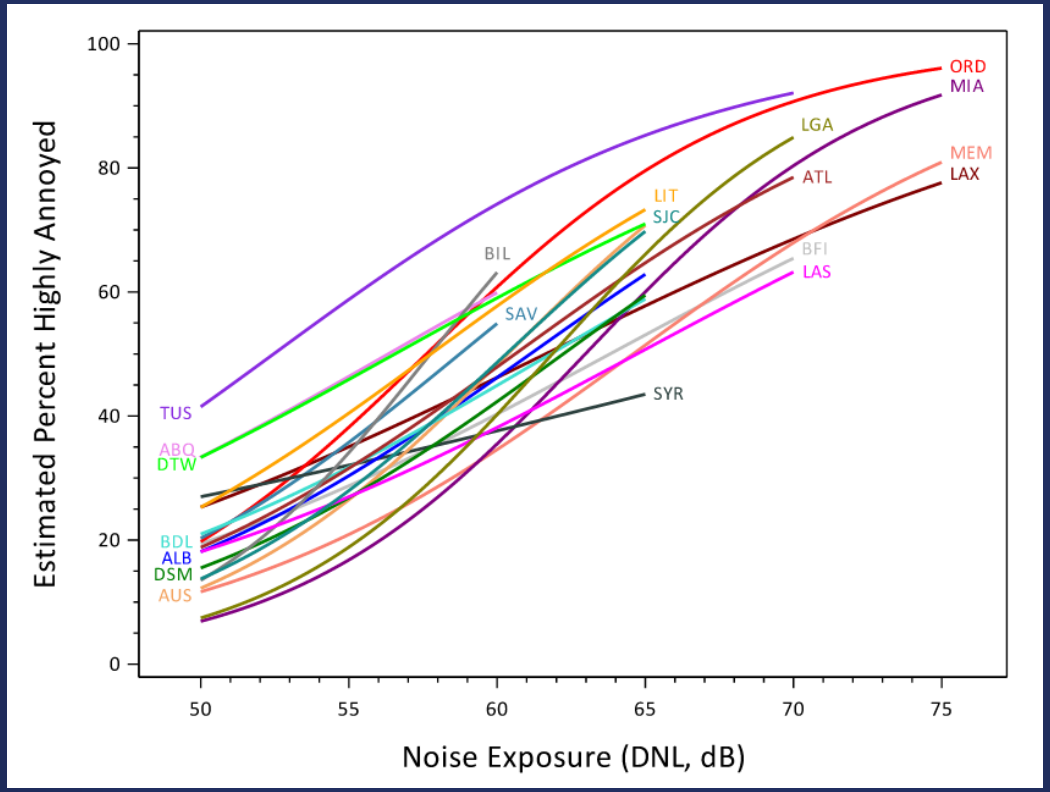
34,522 complaints called into NYC 311
between September 8 – 15, 2010
WIRED Magazine

FAA Neighborhood Environmental Survey

Schultz to National Curve



FAA Neighborhood Environmental Survey



What we see in the press…

*"When you experience a Volocopter for the first time, **you'll be astounded by how quiet it is**. Because all 18 rotors acoustically operate within a narrow frequency range, to the human ear they sound only twice as loud as one single rotor. For comparison: A Volocopter 2X within a 75-metre distance is as quiet as the smallest helicopter within 500 metres distance."*

*"The S-A1 will be **much quieter than conventional helicopters** with smaller and multiple rotors rotating at much slower speeds than the main rotor of a typical helicopter"*

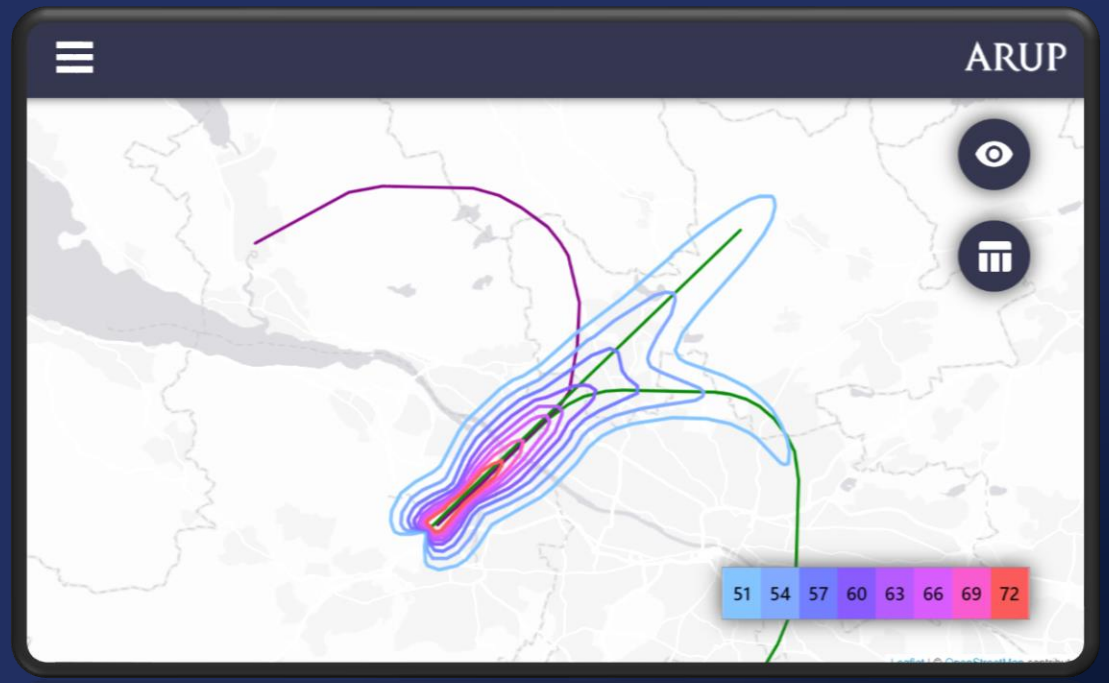
What we see in the press…

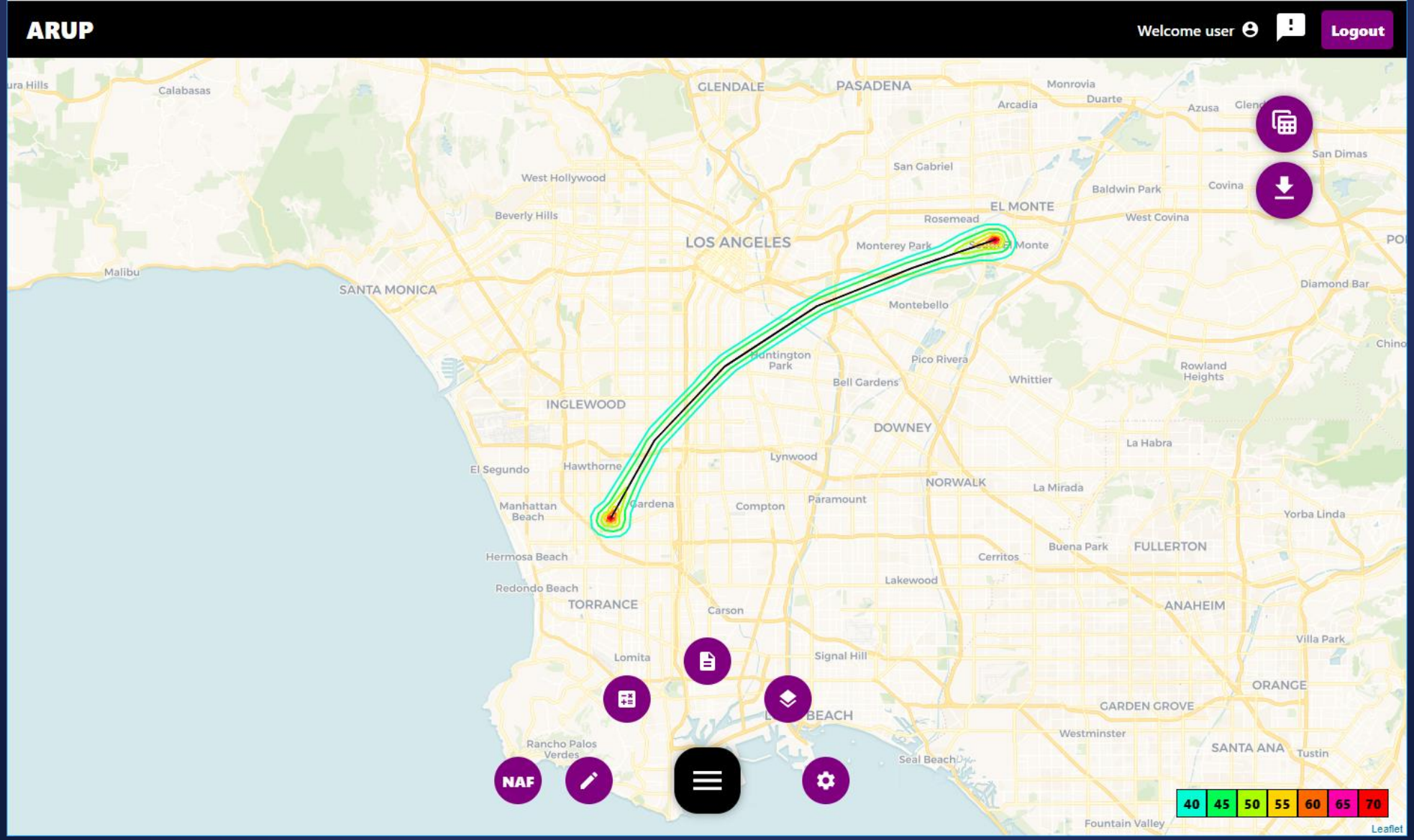
*"At only 45 dba, Archer aircraft are **designed to be virtually inaudible** while flying overhead."*

*"We've (Harmony Aeronautics) developed a propulsor that is **8x quieter** and 50% more efficient than a drone (multi-rotor) design. The patent-pending technology is already **15 dB quieter than emerging EU noise standards** and has dual-use potential in civilian and military markets."*

UAM Optioneering Tool

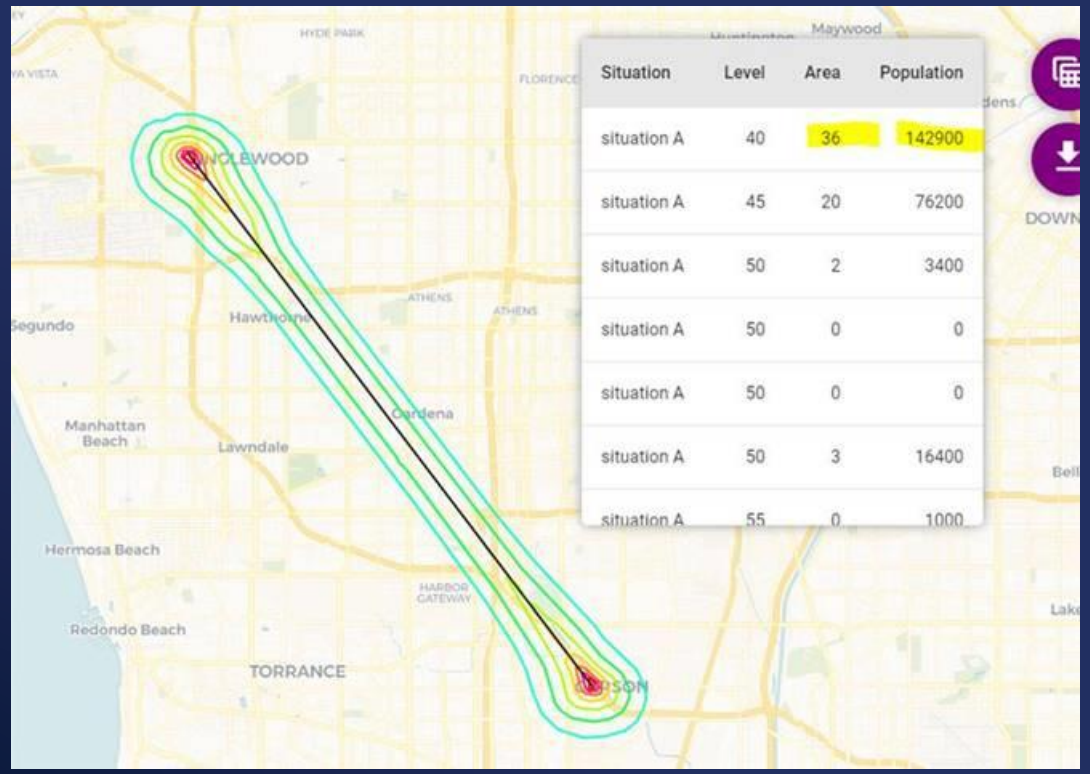
- An interactive tool for comparing different UAM airspace design options



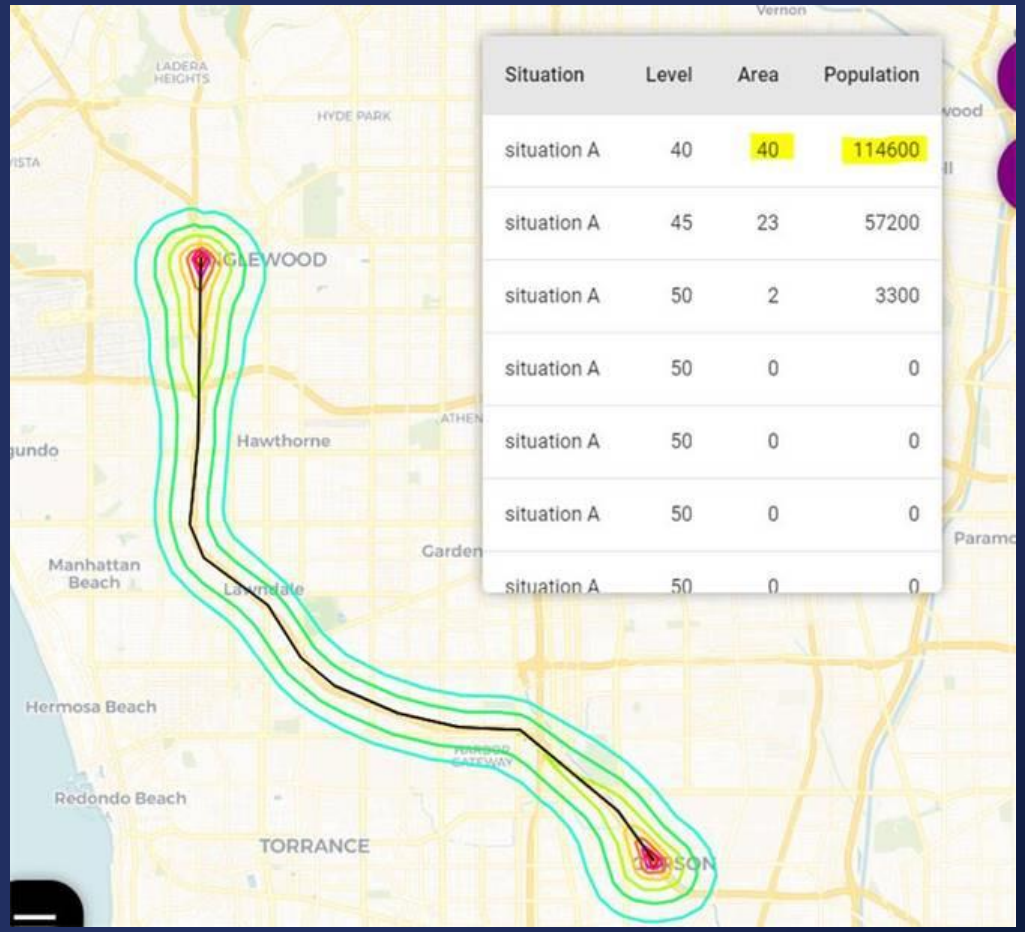


FUTURE OF AVIATION

Advancing Aerial Mobility through Technology, Sustainability, and On-Demand Flight



Situation	Level	Area	Population
situation A	40	36	142900
situation A	45	20	76200
situation A	50	2	3400
situation A	50	0	0
situation A	50	0	0
situation A	50	3	16400
situation A	55	0	1000



Situation	Level	Area	Population
situation A	40	40	114600
situation A	45	23	57200
situation A	50	2	3300
situation A	50	0	0
situation A	50	0	0
situation A	50	0	0
situation A	50	0	0

FUTURE OF **AVIATION**

Advancing Aerial Mobility
through Technology, Sustainability,
and On-Demand Flight

Auralization – Hearing is Believing

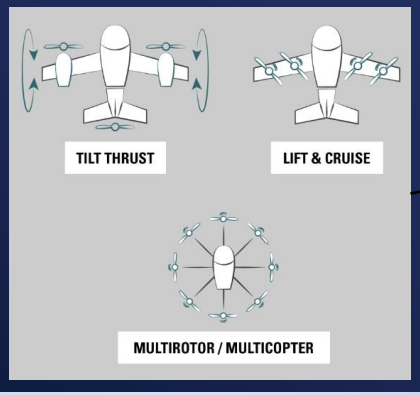
Urban Vehicle Class

Frequency

Policy Map

Auralization Process

3D Field Recordings of Vehicles / Concept Vehicle Parameters



Vehicle Variables / Operational Variables

3D Recordings of Existing Environments

ARUP

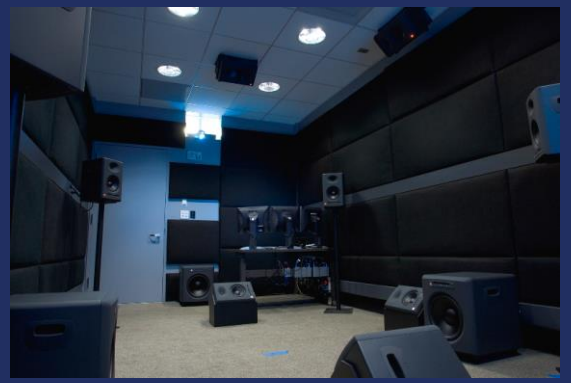
NASA

Arup SoundLab + NASA Auralization Framework Software

Arup SoundLab Auralizations








- 14 SoundLabs and 3 Immersion Labs around the world
- Purpose built listening facilities that enable us to listen to how spaces and environments sound before they are built
- Calibrated to acoustic and AV standards so demos can be shared across facilities with ease

Process for a UAM Policy Framework

A15E-10

Frequency
- **10 -** Landing / Takeoff Events per hour
- **XX** - Prohibited
- **NULL** - Unlimited

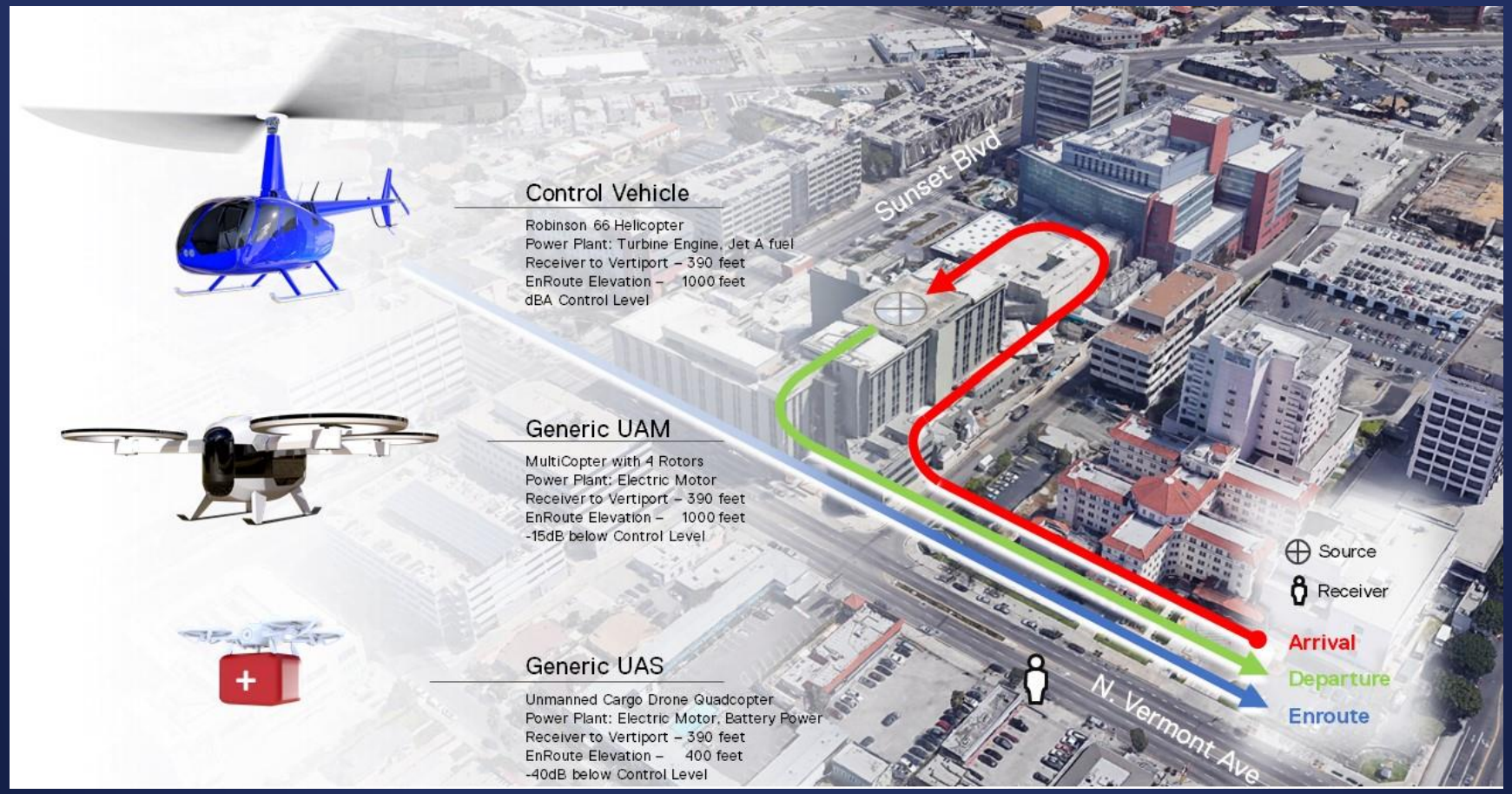
Energy Class
- **E** - Electric
- **P** - Petroleum

Vehicle Weight Class (mass / 100)
- **05** - 500-599 lbs
- **25** - 2500-2599 lbs

Urban Vehicle Class (A-F)
- **A** - Quietest, most acceptable aircraft (Modern Car)
- **F** - Most Offensive, least quiet vehicle (2-blade helicopter w open tail-rotor)

Scenario Development

LADOT AAM / UAM Auralizations



LADOT – Auralization Delivery

Contact Information:

Brendan Reed A.A.E.
BReed@san.org

Timothy Middleton C.M.
TMiddleton@hmmh.com

Colleen Reiche, Ph.D.
Colleen.Reiche@parthenon.ey.com

Paul Wheeler
Paul.Wheeler@wsp.com

Ryan Biziorek
Ryan.Biziorek@arup.com