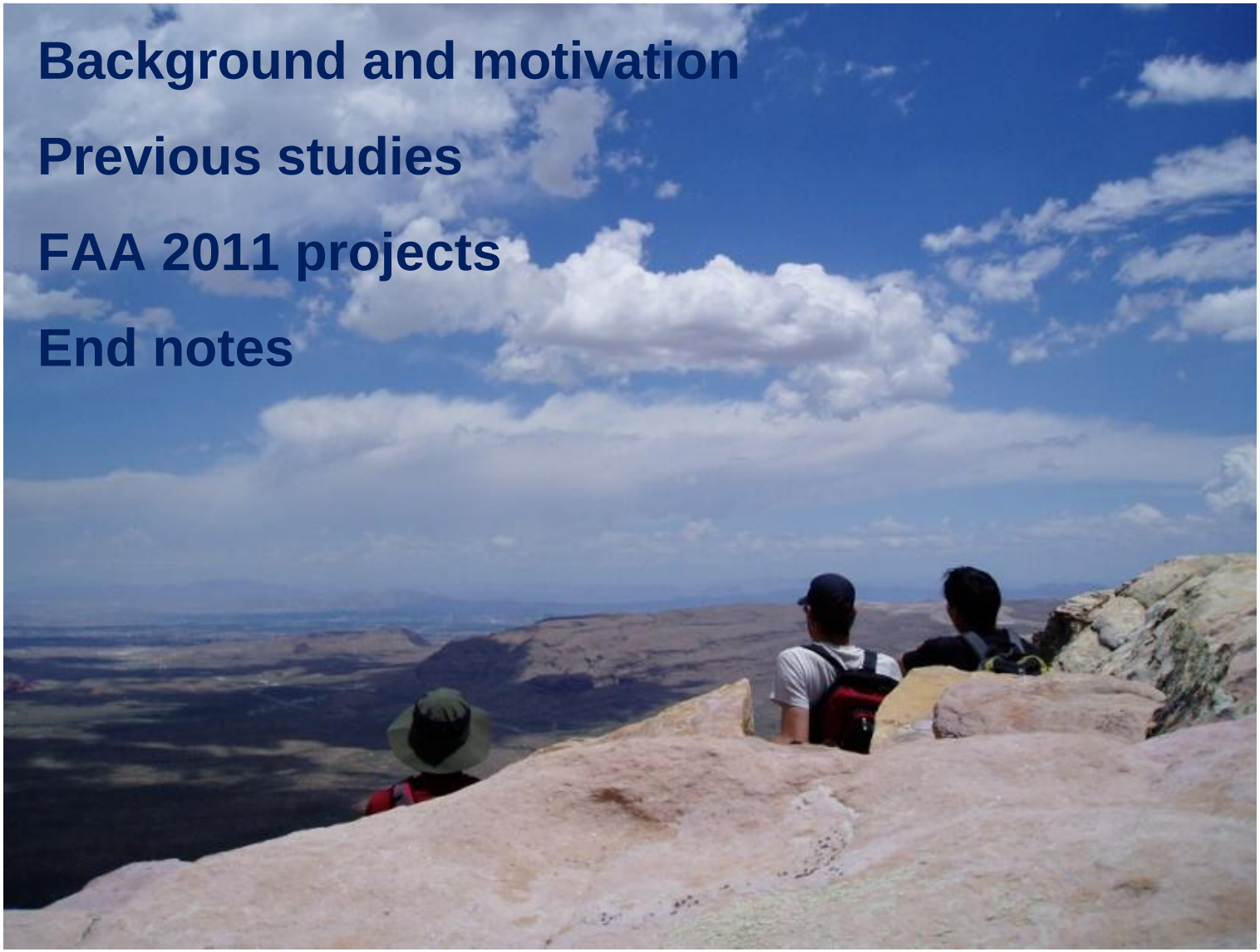
FAA's En Route Noise Modeling Research

Presented to: Aviation Noise Research Workshop
By: Hua (Bill) He, Ph.D.
FAA, Office of Environment and Energy
Date: April 20, 2011

Outline

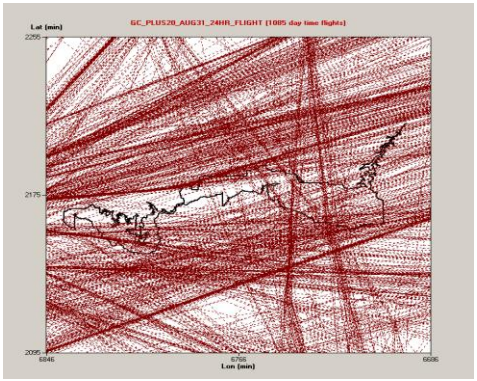

Background and motivation
Previous studies
FAA 2011 projects
End notes

Background and motivation

Much of the aircraft noise modeling effort has traditionally been focused on areas in the vicinity of airports (terminal area). But en route flight noise may impact broad areas, and may become important when considering:

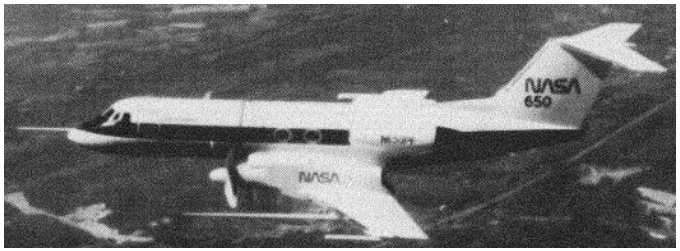
- Development of unconventional propulsion systems with unique noise source characteristics (level, spectra, directivity, etc.), i.e. open rotor

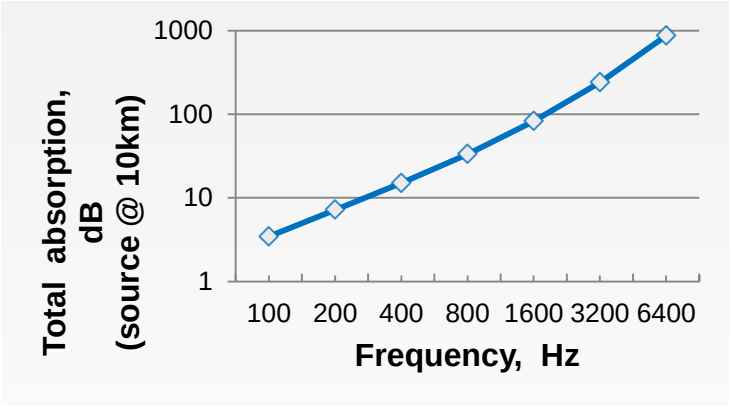
- Noise exposure in wilderness and other sensitive areas, even for aircraft with conventional propulsion systems



Previous studies – 80s

- i.e. from 1987 & 1989 NASA/FAA flight & ground measurement of the Propfan Turboprop Assessment (PTA) aircraft, and related analysis





Source noise characterization very important, but complicated due to multiple couplings among design variables across all system levels

Variations in noise measured on the ground: day-to-day variation is large; weather data measured concurrently can explain only part of the variation

Certain noise components may never propagate to the ground receiver

Atm. Absorption should address change in pressure and wide range of humidity.

Previous Studies – Grand Canyon modal validation study and modal comparison

Conducted 1999-2005, completed with FICAN Report: "Assessment of Tools for Modeling Aircraft Noise in the National Parks"

- Noise monitor and observer logging data collected from air tour flights, and also from high altitude flights
- Attempts made to scale existing models to predict noise from high altitude over-flights
- Substantial uncertainty observed when predicting audibility from high altitude over-flights

Likely source of uncertainty:

Noise source characterization
(level, spectra, directivity)

Noise propagation and attenuation

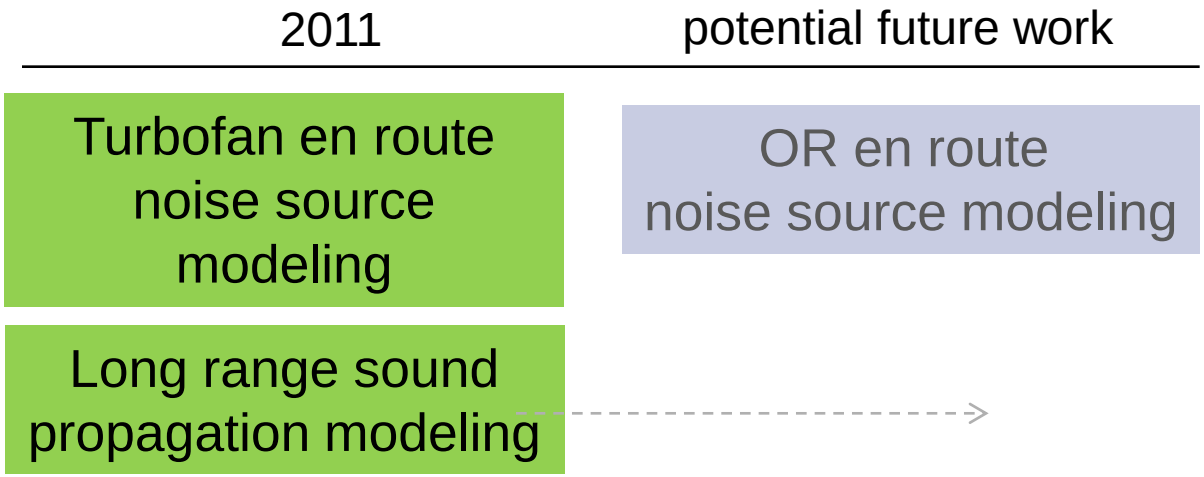
Ambient sound environment

Detectability threshold of the observer

FICAN: Federal Interagency Committee on Aviation Noise

FAA 2011 en route noise modeling research* overview

* via COE/PARTNER program - Project 2
http://web.mit.edu/aeroastro/partner/index.html



Two research tasks just started in 2011 (green boxes): turbofan en route noise source modeling and long range sound propagation modeling

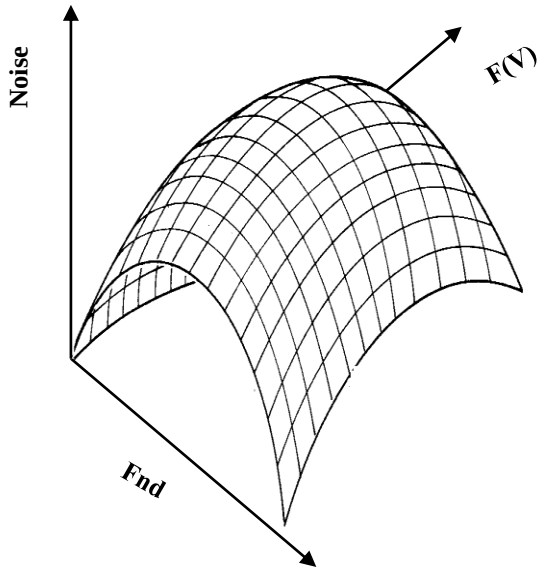
Propagation piece may interface with various noise source models (turbofan open rotor, …)

When OR source model is available, the long range sound propagation modeling can be leveraged

Turbofan aircraft en route noise source characterization

GaTech/Booz Allen team:

- Predict noise characteristics via a jet noise modeling module in ANOPP
- Integrate with existing performance modeling in AEDT/BADA.



Areas of focus:

- far field noise component
- low frequency component
- thrust-noise relationship
- validation

ANOPP: Aircraft NOise Prediction Program (NASA)
AEDT: Aviation Environmental Design Tool (FAA)
BADA: Base of Aircraft Data (EUROCONTROL)
EDS: Environmental Design Space (FAA)

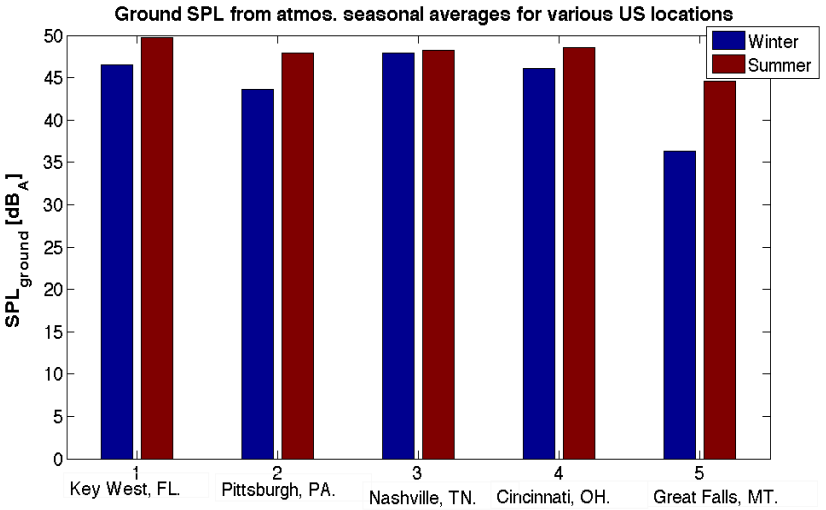
Long range propagation modeling

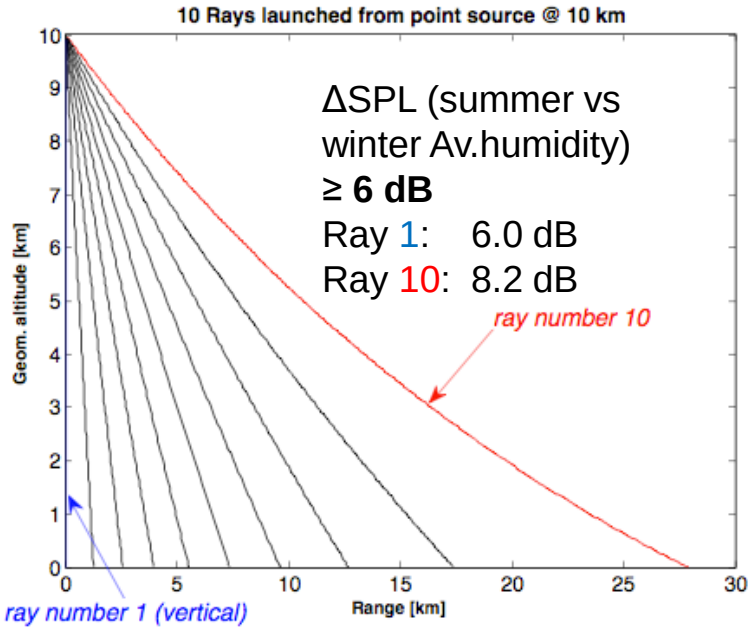
Atmospheric absorption following ANSI S1.26 is predicted by PennState (PSU) team
- humidity plays an important role.

PSU also developed a ray-tracing model, and will assess other models (i.e. Nord2000) for long range sound propagation

Areas of focus:

- atmospheric absorption
- sound speed profiles
- point source to “line” source
- computational time
- model validation





Nord2000: info can be found at
http://www.madebydelta.com/delta/Business_units/TC/Services+by+technology/Acoustics/Low+frequency+noise/Nord2000+reports+from+DELTA.page

SPL: sound pressure level

Summary

En route noise modeling capability needs to be developed as an extension of the current community noise modeling

- to estimate noise exposure from aircraft powered by both conventional and unconventional propulsion systems
- to facilitate joint noise, emission and fuel burn modeling for complete runway-to-runway analysis, for both conventional and unconventional propulsion systems

The current year research started with two tasks: modeling turbofan en route noise source and long range sound propagation

Research to focus on understanding critical elements and uncertainties, and making full use of previously collected field measurement data for model validation

En route noise research may be extended to open rotor if source modeling becomes available

References

1. William L. Willshire, Jr., et al., “PTA En route Noise Measurements”, pp 13-30, FAA/NASA En route Noise Symposium, Proceedings of a symposium held at NASA Langley Research Center, Hampton, Virginia, September 12-13, 1989.
2. Louis C. Sutherland and John Wesler, “Sound Propagation Elements in Evaluation of En route Noise of Advanced Turbofan Aircraft”, pp167-174, FAA/NASA En route Noise Symposium, Proceedings of a symposium held at NASA Langley Research Center, Hampton, Virginia, September 12-13, 1989.
3. K. Attenborough & Al., “Benchmark cases for outdoor sound propagation models”, J. Acoust. Soc. Am., Vol. 97, No. 1, 173-191 (January 1995).
4. K. Poulain, V. Sparrow, K. Brentner, and L. Sutherland, “Application of atmospheric absorption models for aircraft en route noise,” Proc. Noise-Con 2010, C. Burroughs and G. Maling, Eds., (Institute of Noise Control Engineering of the USA, Washington, DC, 2010), Baltimore, 19-21 April 2010.
5. Fleming, et al. “Assessment of Tools for Modeling Aircraft Noise in the National Parks,” FICAN Report, 2005.
6. Linde and Meijer, “Measurement of Noise from Aeroplanes Travelling at 3500-11000 M,” 1986
7. Weir, “The Prediction of En Route Noise Levels for a DC-9 Aircraft,” AIAA 88-268
8. Norum, et al. “Supersonic Jet Exhaust Noise at High Subsonic Flight Speed,” NASA TP-2004-212686
9. Woodward, et al. “Measured Far-Field Flight Noise of a Counterrotation Turboprop at Cruise Conditions,” NASA-TM 101383.
10. H. He, E. Boeker, “Overview of Aircraft En Route Noise Prediction Using an Integrated Model”, Baltimore, Maryland, NOISE-CON 2010.

Other related initiatives

SAE A21 SAE ARP 5534

- Added atmospheric pressure term
- Can address wide range of humidity
- Based on ANSI S1.26, but generates 1/3 octave band data

EU programs

BANOERAC

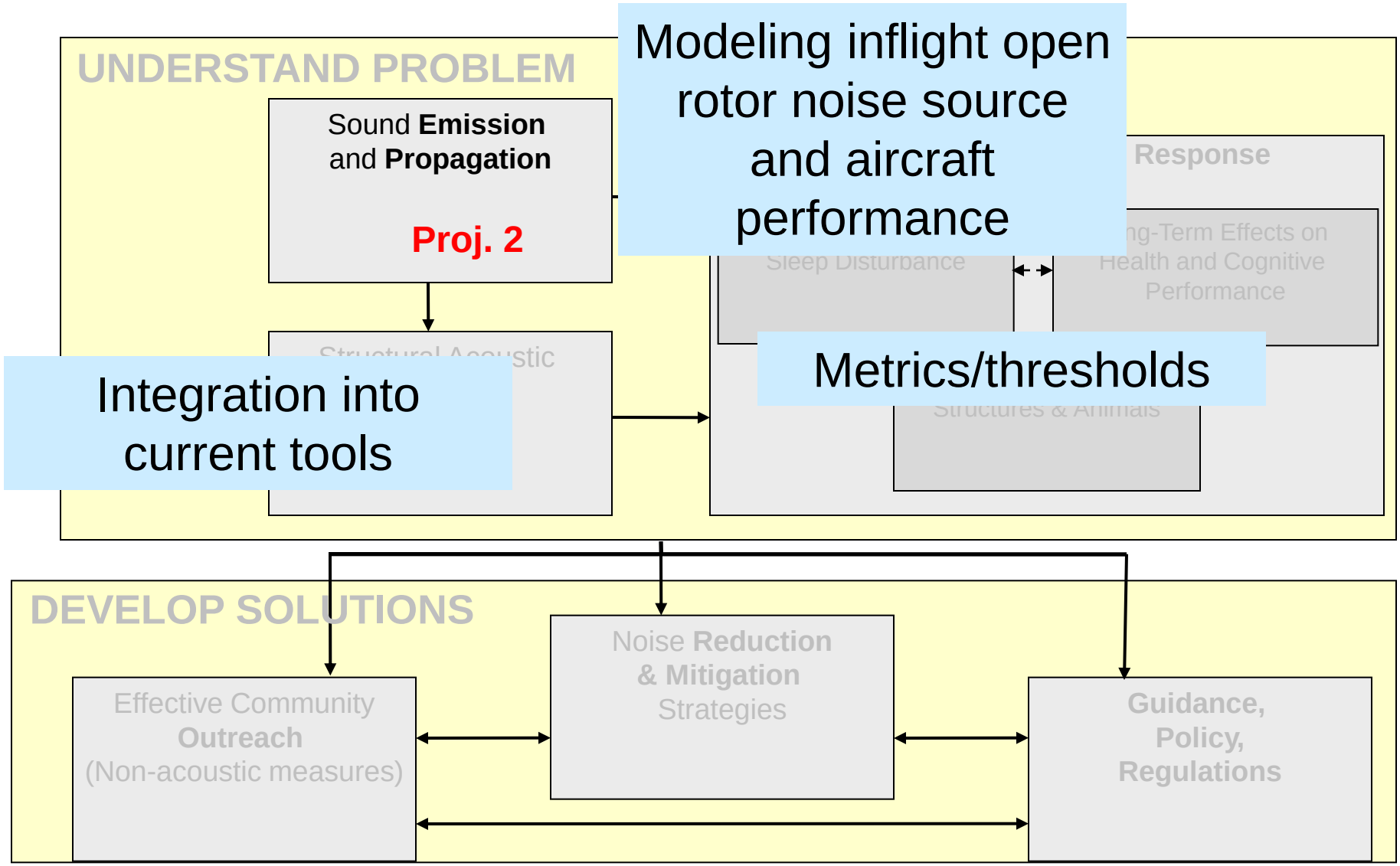
Background noise level and noise levels from en-route aircraft

http://www.easa.europa.eu/ws_prod/r/doc/research/Banoerac%20final%20report.pdf

NINHA (Oct.2010-Nov.2013)

Noise Impact of Noise from High-altitude Aircraft

Technical gaps and likely future research



Contact information

Bill He
FAA Office of Environment & Energy
http://www.faa.gov/about/office_org/headquarters_offices/apl/research/science_integrated_modeling/
hua.he@faa.gov
202-267-3565