ANCF at UND
Commissioning Test Highlights
GRC AAPL vs UND White Field

Acoustics Technical Working Group Meeting

Langley Research Center

10-April-2019

Dan Sutliff / NASA GRC Acoustics Branch

National Aeronautics and Space Administration
Aeronautics Research Mission Directorate
Advanced Air Vehicles Program
Advanced Air Transportation Technology Project
Aircraft Noise Reduction Technical Challenge

HISTORY

- née **ACTIVE** Noise Control Fan
- Originally built as part of the AST/QAT engine noise reduction programs in ~ 1992
- Initial Operation in 1994 / **1995**
- Highly flexible, fundamental test bed
- Multiple configurations, including rotor alone
- 4-foot diameter ducted fan - 75 HP electric motor
- Low speed: Ω=1886 rpm, V_{tip} ~400 ft/sec, M_{duct} ~ 0.14
- Built to evaluate *active* noise control technologies and develop a duct mode database
- In early 2000's upgraded to 200 HP motor:
  Ω=2500 rpm, V_{tip} ~525 ft/sec, M_{duct} ~ 0.2

Renamed to
Advanced Noise Control Fan
when research emphasis changed.

NASA/SP-2019-643 AIAA-2019-####

"The Advanced Noise Control Fan:
A 20 Year Retrospective of Contributions to
Aeroacoustics Research"

1995	2000	2005	2010	2015
Active Noise Control	Unique Fan Noise Reduction Techniques			Novel Liner develop
		Array development / Rotating Rake enhancement		

HISTORY

Problem:

- 1994 – 2013: Low-TRL significant and prolific collaborative research performed on ANCF enabled the advancement of multiple noise technologies. (NRAs/SBIRs/AARC/STTR/SRF,etc).
- 2014 – 2016: Funding structure is limited – more emphasis on broadband. Innovative approaches were needed to maintain the capabilities of the ANCF rig for advancing low-TRL fan acoustic research.

Solution:

- Develop a formal relationship with a university to provide relevant research and STEM opportunities in the area of fan acoustics.
- Partner university will operate the (ANCF) at their location.

Activity:

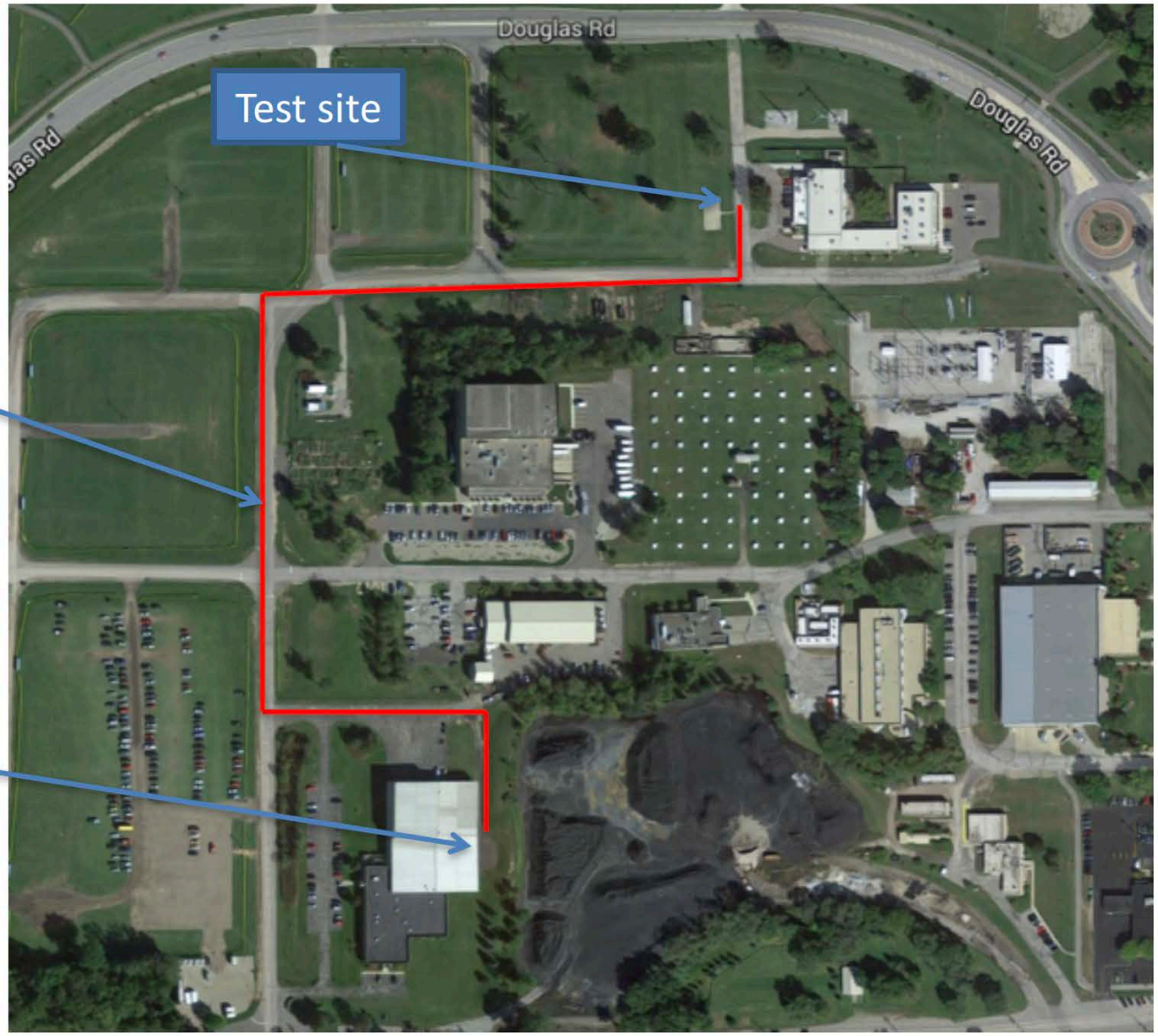
- SAA developed and signed in 2016
- ANCF & 75 crates/tubs/boxes of supporting equipment transferred to ND in summer of ‘16.
- 1st test at ND in Feb 2017 – linear array of ground mics (Knowledge transfer).
- Commissioning Test in September 2018 (Pole mics and wedges borrowed from AAPL as well as circular array of ground mics at multiple radii).

DISASSEMBLY

JUST A LITTLE SWEEPING UP…

AMP STORAGE/BUILD-UP AREA

DAILY MOVEMENT to/from TEST SITE



Courtesy: Google Maps

Courtesy: Scott Morris & Scott Bilka / UND

EXITING AMP

DAILY MOVEMENT to/from TEST SITE

AMP Building -> White Field Lab Test Area

COMPARISIONS

GRC AAPL

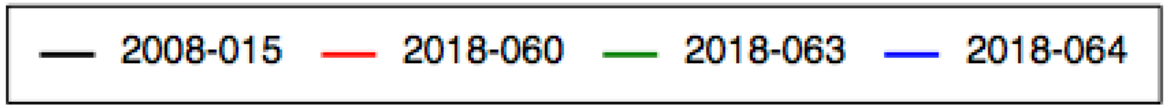
- Data acquired in 2008
- Rig CL @ 10’
- Indoor facility (mostly)
- Wall in close proximity
- Fixed location of rig
- Very low back ground noise
- Pole mounted microphones @ duct CL

UND White Field

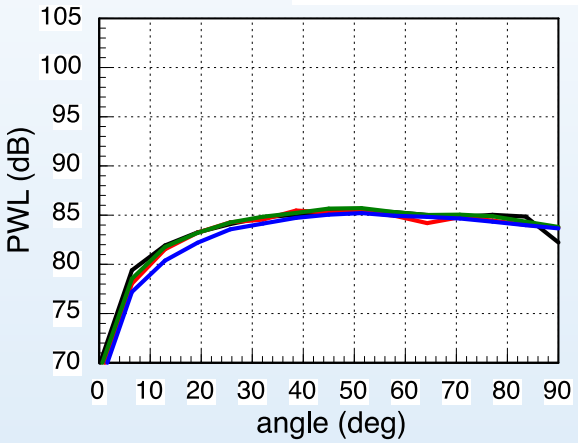
- Data acquired in 2018
- Rig CL @ 8’
- Outdoor facility
- Nothing in front
- Rig moved from storage daily
- Wind & traffic background noise
- Pole mounted microphones @ duct CL

  *ground mics re-sited daily

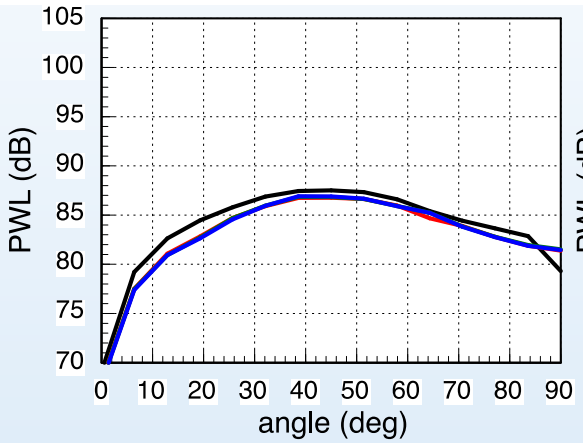
DIRECTIVITY



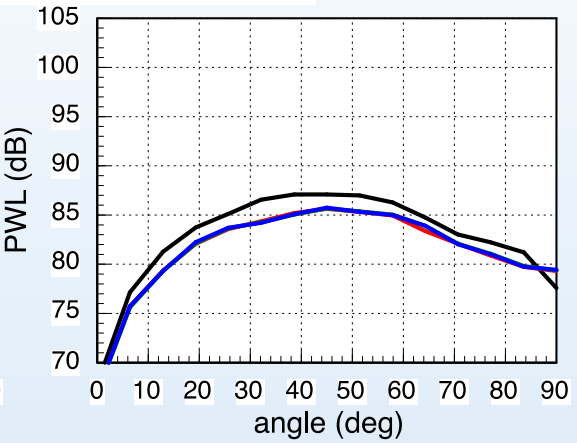
BB PWL Directivity



(a) 1st Harmonic Band

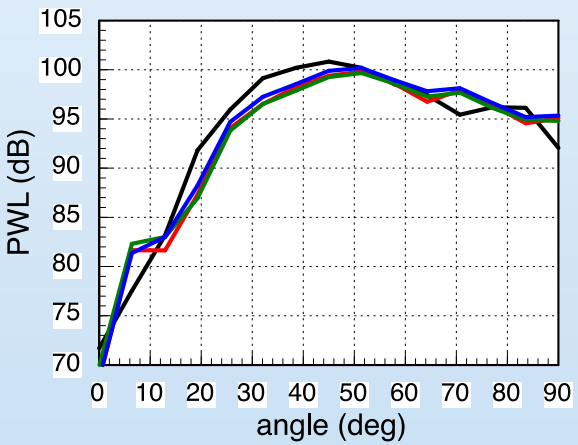


(b) 2nd Harmonic Band

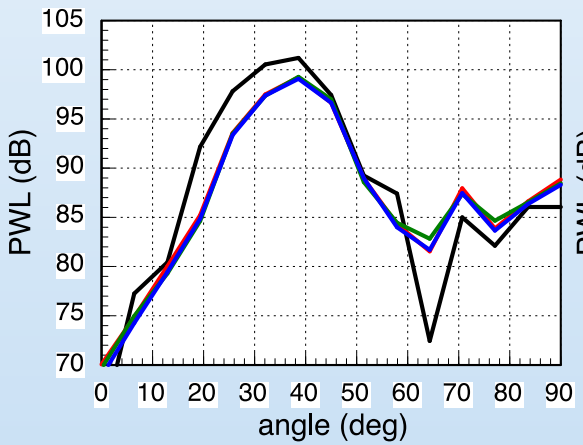


(c) 3rd Harmonic Band

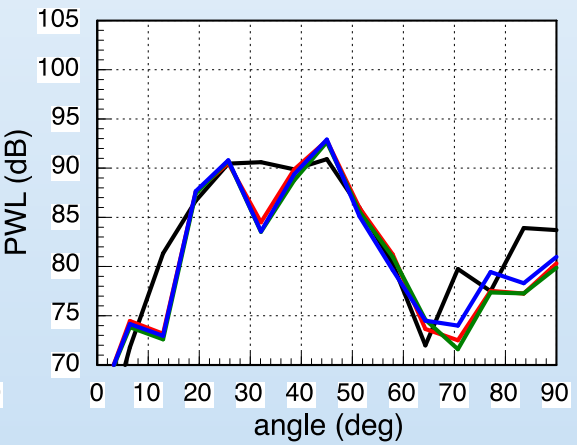
Tone PWL Directivity



(a) 1st Harmonic

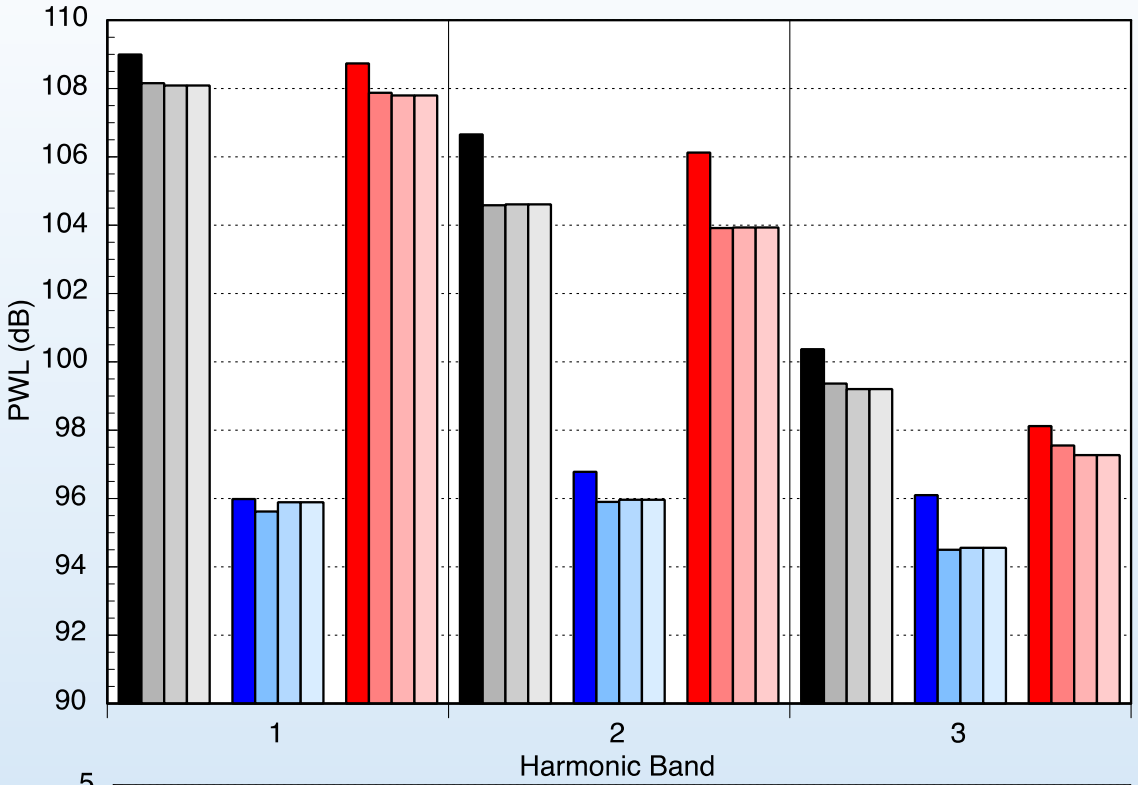


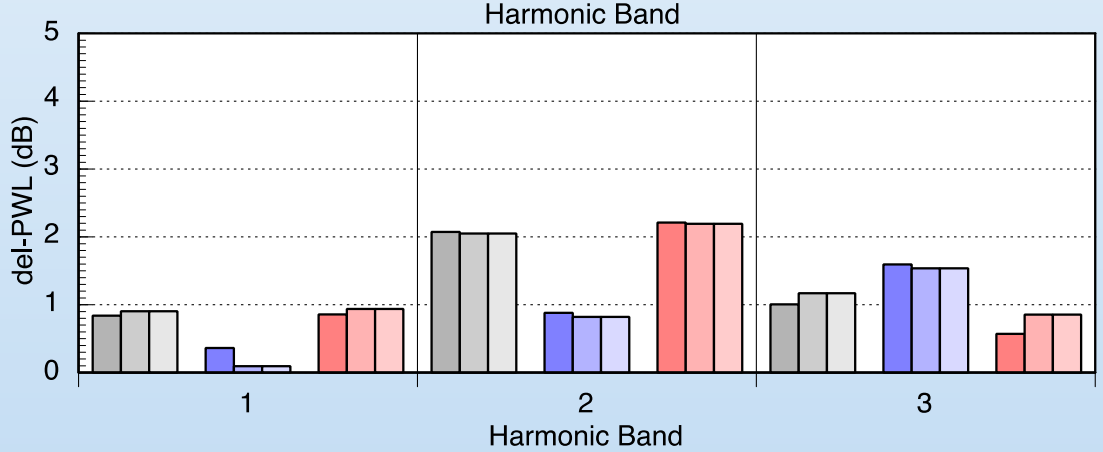
(b) 2nd Harmonic



(c) 3rd Harmonic

PWL





Overall PWL

2008 AAPL 2018 UND

BB PWL

2008 AAPL 2018 UND

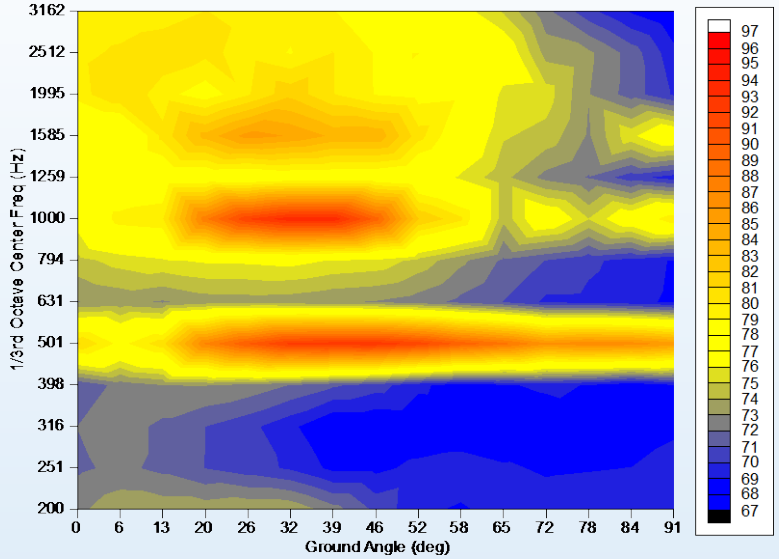
Tonal PWL

2008 AAPL 2018 UND

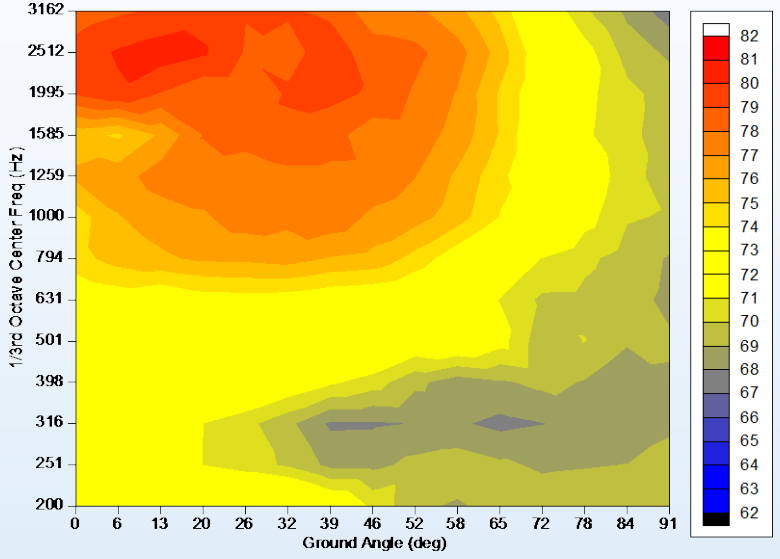
1/3rd OCTAVE SPECTRA

POLE MIC STANDS

@AAPL

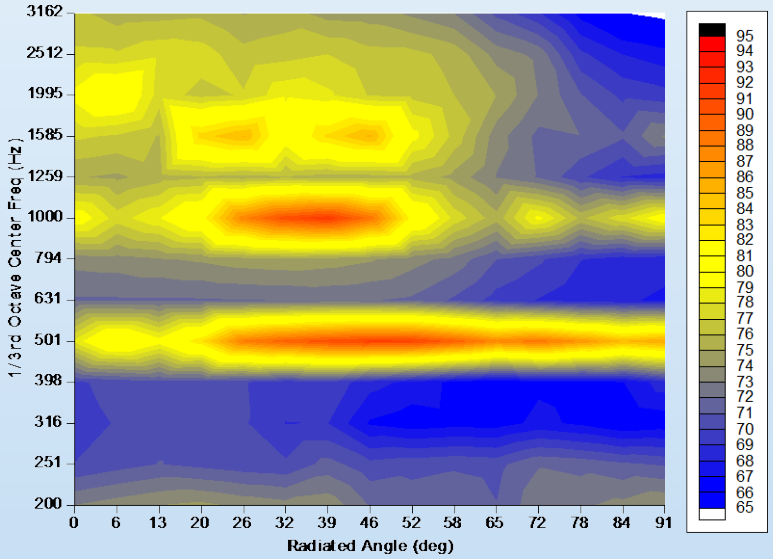


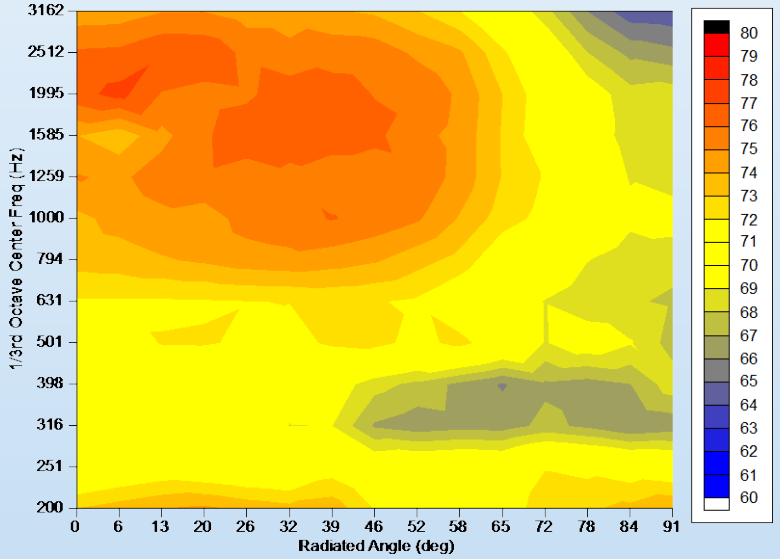
(a) Full



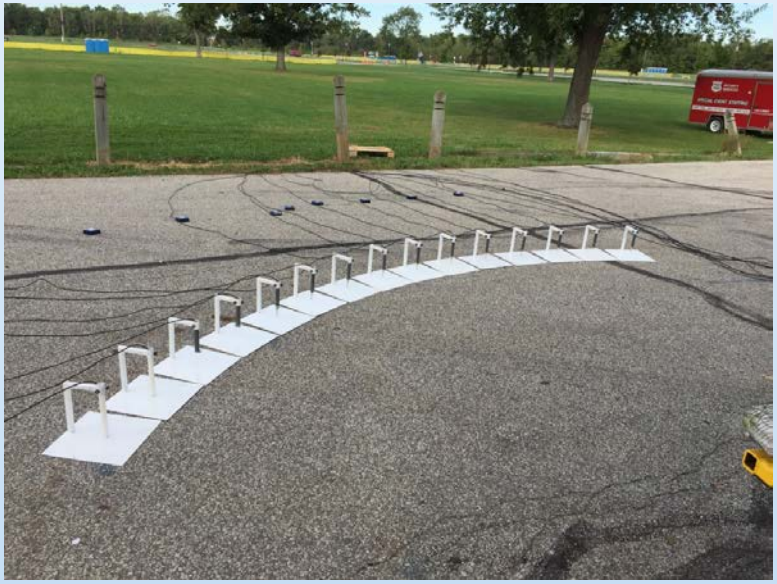
(b) Broadband

@ND





GROUND MICROPHONES



For practical operational reasons:

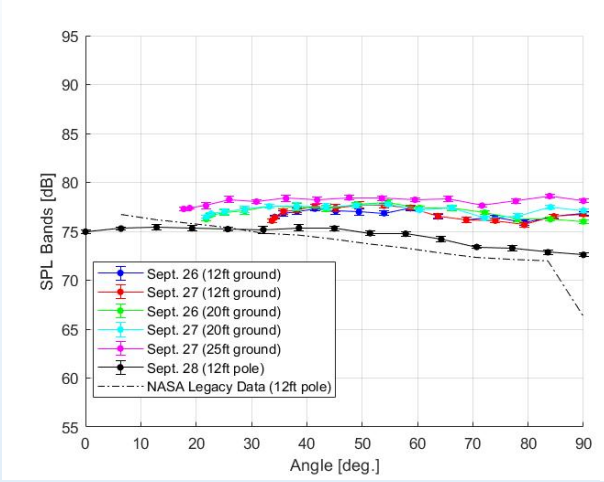
- UND will be using ground plane microphones.
- Unable to place in geometric farfield.

Azimuthal effects arise in this case in terms of direct comparisons – however that is an opportunity.

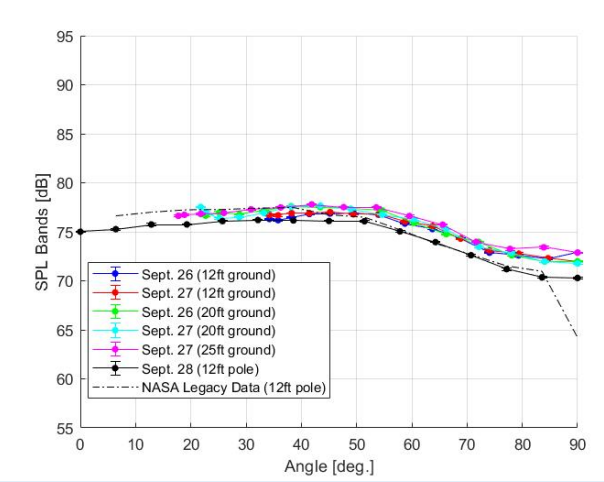
NAME	POLE ANGLES 12 ft	GROUND ANGLES 12ft.	GROUND ANGLES 20ft.	GROUND ANGLES 25ft.
FF mic 1	0.0°	33.7°	21.8°	17.7°
FF mic 2	6.4°	34.2°	22.7°	18.8°
FF mic 3	12.9°	35.8°	25.1°	21.8°
FF mic 4	19.3°	38.2°	28.8°	25.9°
FF mic 5	25.7°	41.4°	33.2°	30.8°
FF mic 6	32.1°	45.2°	38.2°	36.3°
FF mic 7	38.6°	49.4°	43.5°	41.8°
FF mic 8	45.0°	53.9°	48.9°	47.7°
FF mic 9	51.4°	58.7°	54.6°	53.6°
FF mic 10	57.9°	63.7°	60.4°	59.6°
FF mic 11	64.3°	68.8°	66.2°	65.6°
FF mic 12	70.7°	74.0°	72.1°	71.7°
FF mic 13	77.1°	79.3°	78.1°	77.8°
FF mic 14	83.6°	84.7°	84.0°	83.9°
FF mic 15	90.0°	90.0°	90.0°	90.0°

GROUND MIC DIRECTIVITY

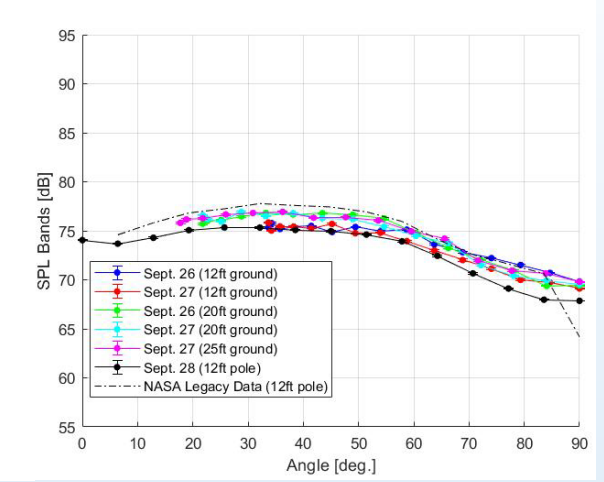
BB SPL Directivity



(a) 1st Harmonic Band

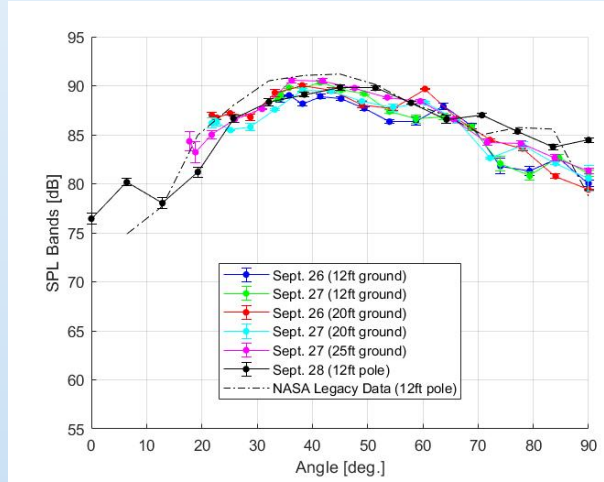


(b) 2nd Harmonic Band

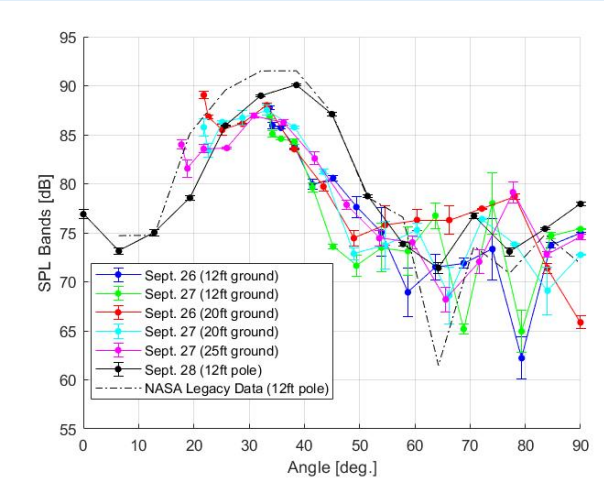


(c) 3rd Harmonic Band

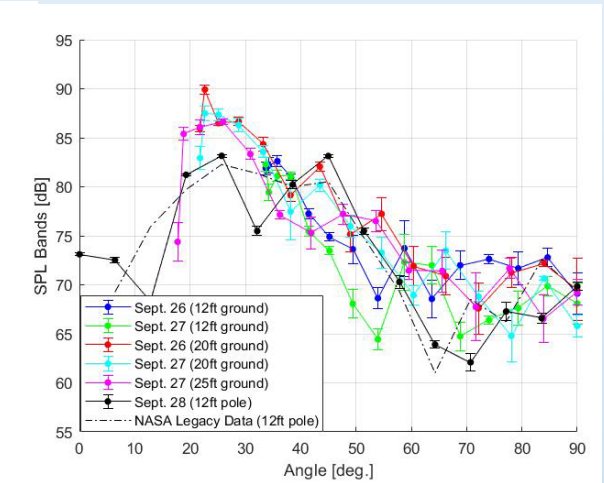
Tone SPL Directivity



(a) 1st Harmonic



(b) 2nd Harmonic



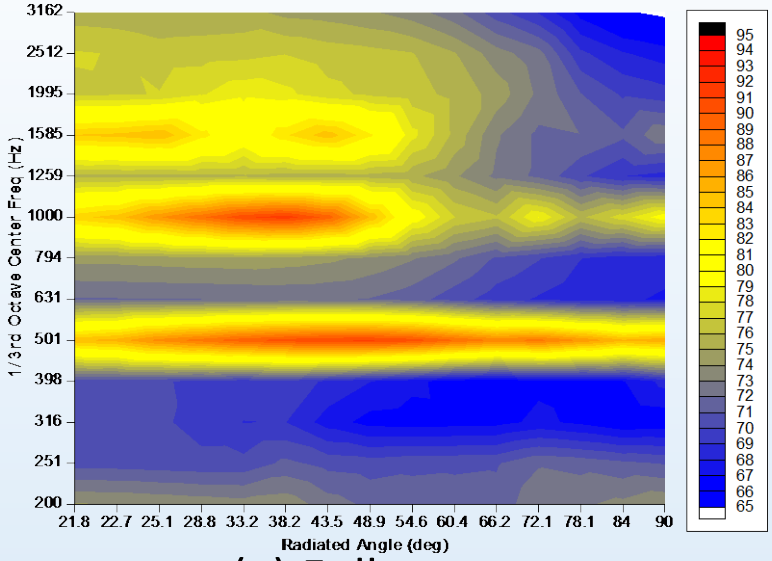
(c) 3rd Harmonic

Courtesy: Kelvin Figueroa-Ibrahim / UND

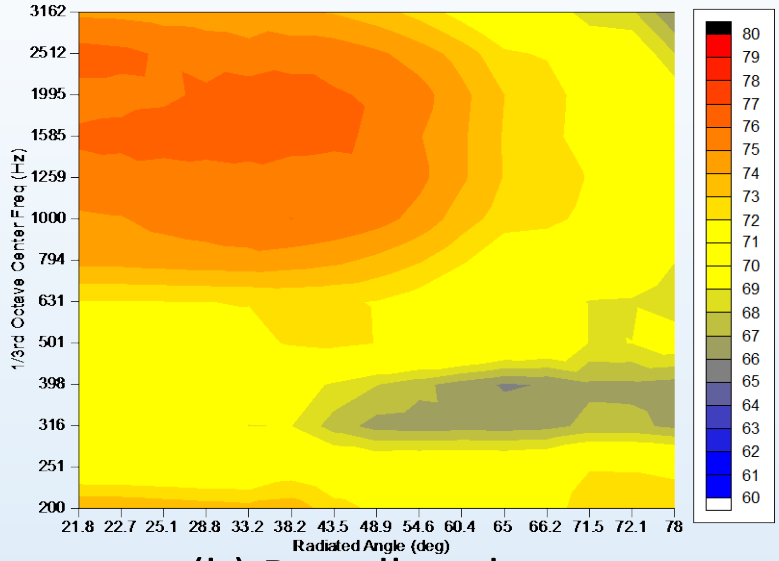
1/3rd OCTAVE SPECTRA

@ UND

POLE

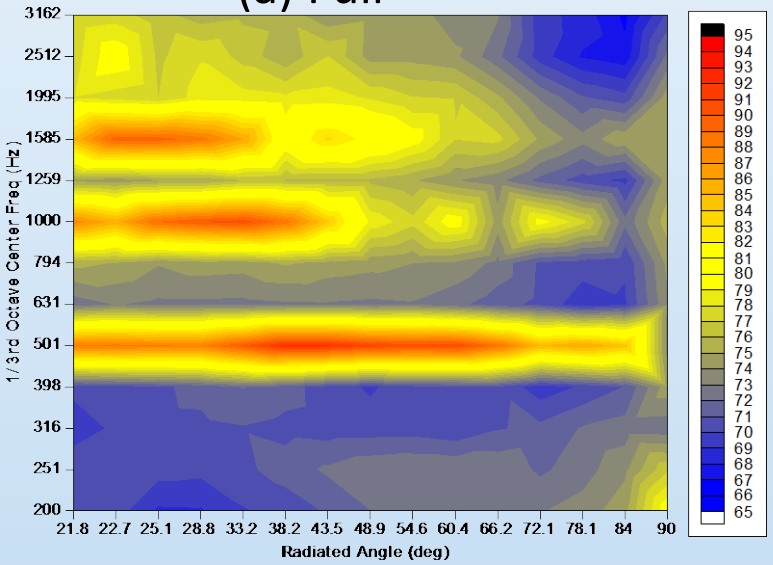


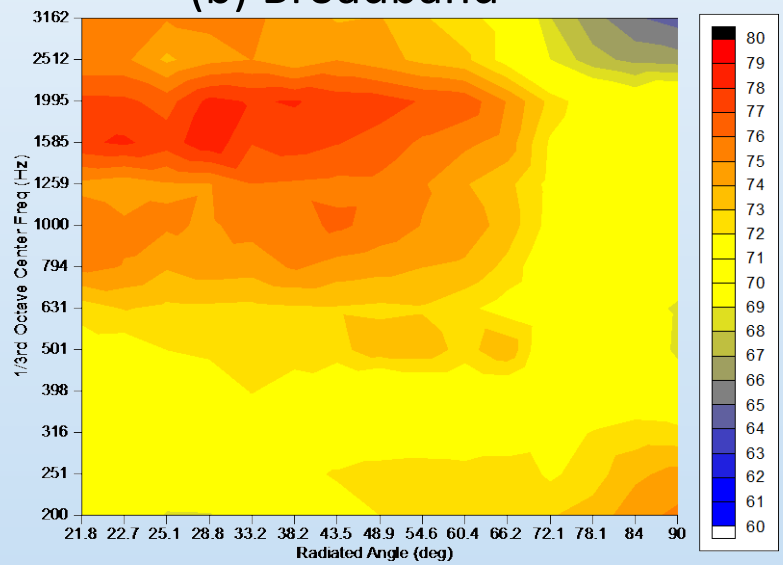
(a) Full



(b) Broadband

GROUND





OBSERVATION

- Successful Handover of ANCF to UND
  - Usage by external customers / AATT
- Farfield Acoustic Levels Remarkably Similar
  - Slightly higher levels at AAPL(2008) compared to UND

  (Probably inverse of increase noted when ANCF was moved from center of AAPL to 'enclosed' FF arena - wall in front creating extra turbulence)
- Pole vs Ground Microphone measurements
  - variations due to distance (i.e. closer than typical)
  - potential for exploration of alternate methodologies
- Outdoor Testing Challenges – Learning Environment

The End of the Beginning

Thanks to UND Team

- Scott Morris
- Tamuto Takakra
- Michael Bilka
- Rusty Collins
- Mark Ross
- Kelvin Figueroa-Ibrahim
- White Field Lab Team

Thanks to GRC Team:

John Lucero, Mark Jacko, Lenny Smith, Bruce Groeing, Ed Myslewick
T-FOME crew at AAPL

SPONSORED BY:
National Aeronautics and Space Administration
Aeronautics Research Mission Directorate
Advanced Air Vehicles Program
Advanced Air Transportation Technology Project
Aircraft Noise Reduction Technical Challenge