Phased Array Methods Panel Session - Introduction

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6th Berlin Beamforming Conference
February 29th, 2016

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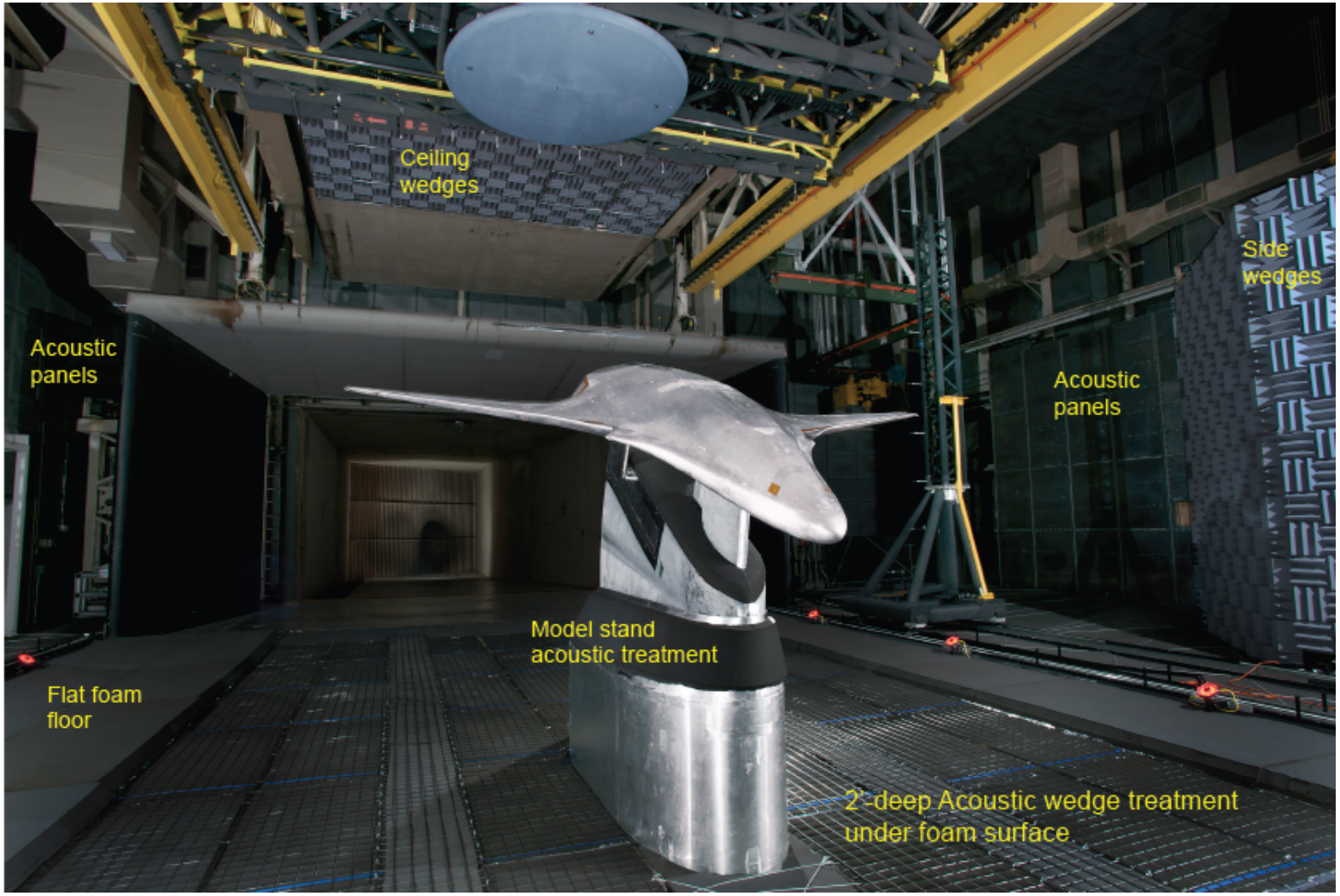
Example Test



HWB N2A-EXTE in NASA Langley's 14- by 22-Foot Subsonic Wind Tunnel (open test section configuration)

Available Routines (2014)

Conventional

Multiple steering vector formulations

Common/Recent

- CLEAN-SC
- DAMAS
- DAMAS2
- Functional
- SODIX (engine test stand)

Extended Literature

- (Robust) Capon
- CMF
- FFT-NNLS
- (Improved) Generalized Inverse
- Linear Programming
- LORE
- Observer-Based
- SEM(WAN)
- SONAH
- Wavenumber-Frequency

This is just from Aeroacoustics literature… barely scratched surface of IEEE, Radio Astronomy, Geoacoustics, Ocean Acoustics, etc…

List grows every year

Applicability/agreement dependent on source type, experiment details

Researcher asks: *which do I use?*

Year 1 Recap

- Community effort for analysis of array processing techniques - Kick-off held at AIAA Aviation 2014
- Representation
  - Government: NASA, DLR, JAXA, NLR, ONERA
  - Industry: Airbus, AVEC, Boeing, CFD Berlin, Optinav, Siemens
  - Academia: TU-Cottbus, FAU, FSU, ISVR, University of Adelaide, Va. Tech
- Discussion
  - Test cases
    - Well-defined data sets representative of problems of interest
    - Broad range of physical phenomena addressed
  - Data Format/Reporting
  - Timeline

Cases - Simulated

- Category Lead: Pieter Sijtsma
- B0 – isolated point source (system test) – Pieter Sijtsma/PSA3
- B1 – closed test section line source, poor SNR – Pieter Sijtsma/PSA3
- B7 – multiple incoherent monopoles, varying strength (no flow) – Sarradj et al./TU-Cottbus
- B8 – multiple monopoles in round open jet with expanding shear layer – Sarradj et al./TU-Cottbus

Cases - Experimental

- Category Lead: Chris Bahr
- DLR1 – Dornier-728 half-model in closed-wall wind tunnel – Daniel Ernst et al./DLR
- NASA2 – Leading & trailing edge noise from 2D airfoil model in open-jet wind tunnel – William Humphreys/NASA
- ONERA1 – Multi-speaker configuration (coherent & incoherent, varying phases) in open-jet wind tunnel – Vincent Fleury & Jean Bulté/ONERA

Initial Outcomes

- Meeting held at AIAA Aviation 2015
- Results
  - Significant variability between methods for low signal-to-noise conditions
  - Noticeable variability between methods when strong sources mask weak ones
- Additional discussion
  - Revise Year 1 cases based on experience
  - Incorporate ~3 more cases to cover different problem types
  - Need more time for turnaround of case processing

Phased Array Methods Panel Session - Year 2 Progress

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Outstanding Issues as of June 2015

- More analysis time required
- Data format – orientation of 3D arrays in HDF5 needs better validation check
- Cases – clarify intent of each case: designed to test steering vectors? Propagation models? Noise sensitivity?
- Cases need path to lessons-learned
- Auxiliary data for each case should support case intent: e.g. if a test of deconvolution method noise sensitivity, perhaps provide propagation/steering vectors, grid and integration bounds
- Select additional cases to address problem types currently absent (e.g. CAA, distributed coherence)

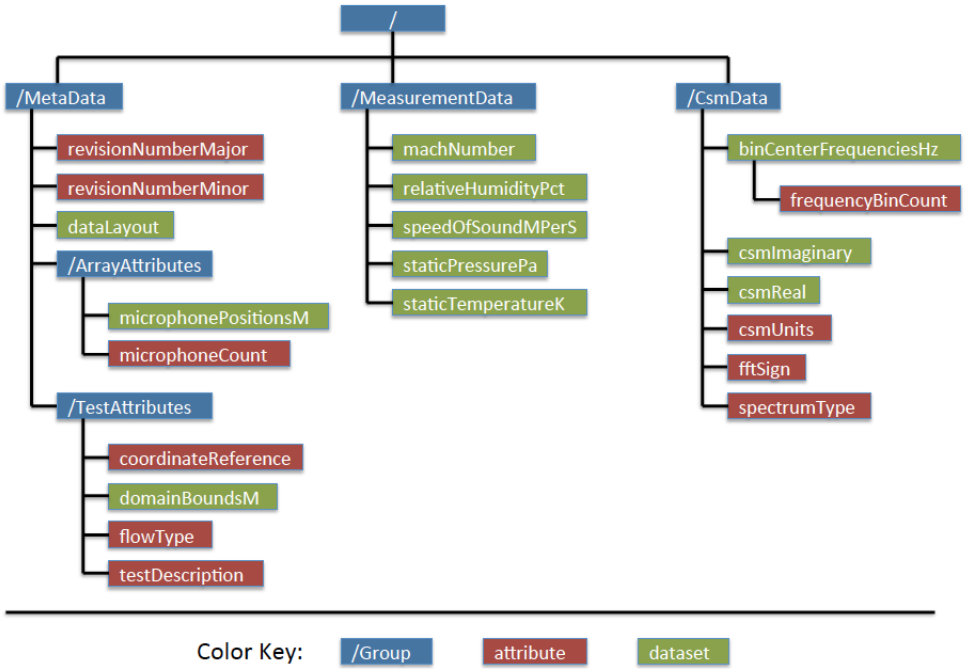
Analysis Time

- Addresses data release requirements of additional participants
- Allows interaction/iteration between case manager & participants to address questions arising from case
- Allows use of more expensive algorithms

Data Format

- Example 3D array built into format revision 2.3
  - dataLayout Size 2 x 3 x 4 (rows x columns x pages)
  - Entries of column-major ascending integers
- Should address any questions on given case's CSM orientation

Array Methods HDF5 Essential CSM File Layout



Case Intent

- Case managers revisiting & modifying for coming year
- Cases test:
  - Variability due to noise contamination
  - Discernment of weak sources near strong ones
  - Propagation calculation
- Some of the efforts shown today
- Consideration in preparation of Year 2 cases

Year 2 Cases

- ONERA – Landing gear CAA + Accompanying Experiment – validation of computation vs. experiment – Delayed to Year 3
- NASA LaRC – Jet Noise Experiment – distributed coherence
- Virginia Tech – Wall-Mounted Finite Airfoil Experiment – distributed incoherent source, complexity between NASA2 and DLR1 cases
- NASA/Virginia Tech expected release dates March 2016 – allows analysis for Year 2/Year 3 of effort
- ONERA preview at Aeroacoustics 2016

NASA LaRC Jet Noise (AIAA 2010-3780)

- P.o.C.: Chris Bahr (NASA LaRC)
- Two nozzle configurations, three flow conditions
  - Convergent, cold flow (no tunnel flow, tunnel Mach 0.1)
  - Dual flow, no chevrons, heated, tunnel Mach 0.1

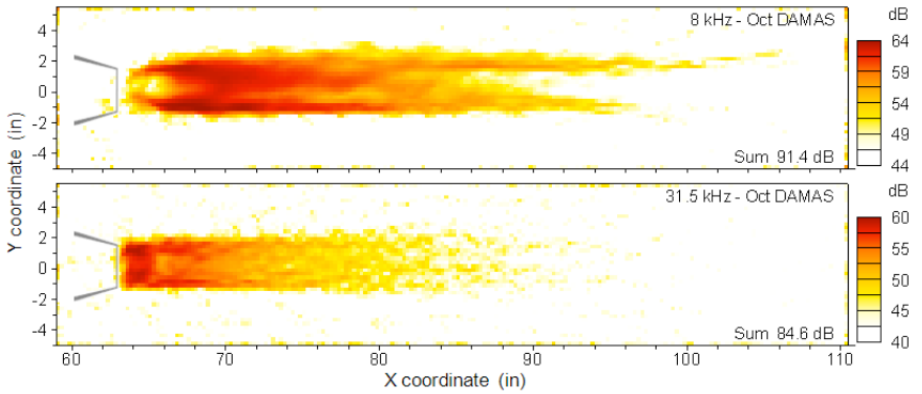


Figure 17. Single CV nozzle for subsonic cold jet at $M_J = 0.8$ and no-wind tunnel co-flow, $M_{WT} = 0$. Both 8 and 31.5 kHz octave presented.

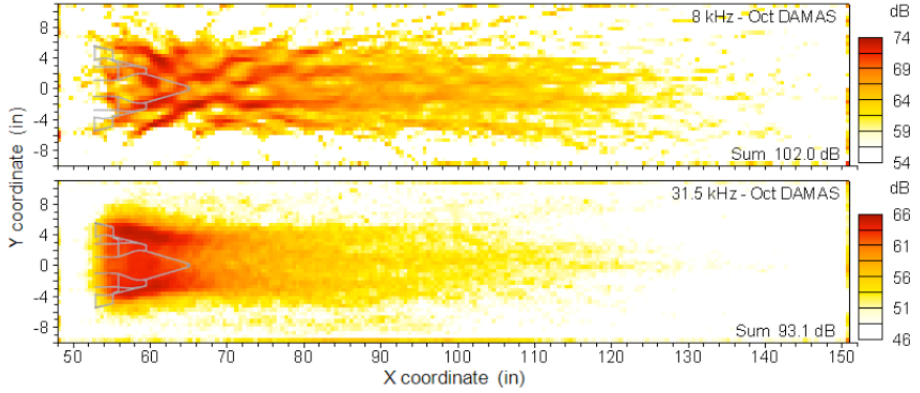
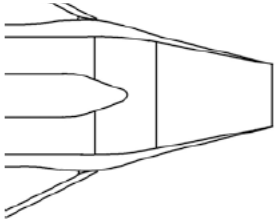
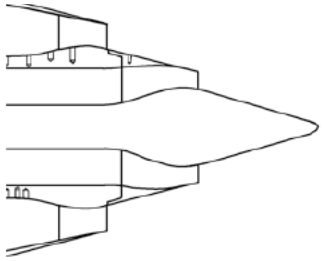


Figure 26. BPR5 dual-flow nozzle, no Chevrons, BASELINE (Chevron Study). Wind tunnel flow, $M_{WT} = 0.1$.



(a) Single CV; Conf. 30000



(d) BPR-5, Baseline Round; Conf. 50000

NASA LaRC Jet Noise (AIAA 2010-3780)

- Array at 90 degrees observer angle
- CSM conditioning data included

Figure 4. Point noise source mounted 2 inches downstream of the CV Nozzle, Conf. 30000

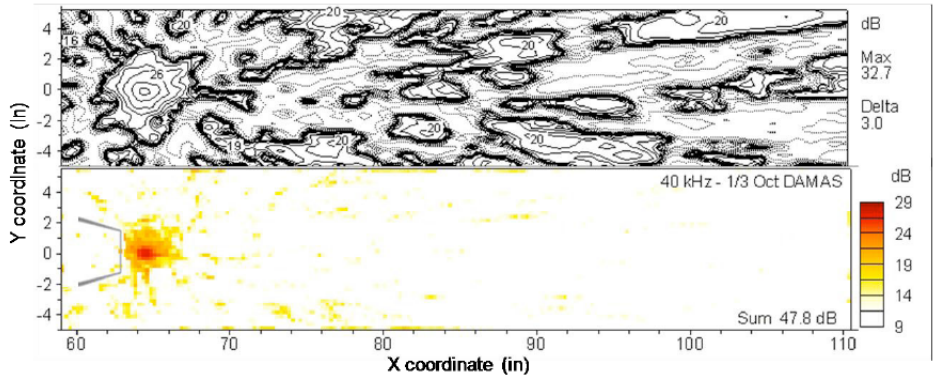


Figure 6. Results for a calibration PS at (X,Y) = (65", 0"). Wind tunnel flow at M_{WT} = 0.1. Jet flow is at zero velocity. 40 kHz 1/3-octave band is shown for 250-iteration DAMAS with no CSM Conditioning. Beamform (top) and DAMAS (bottom) is presented.

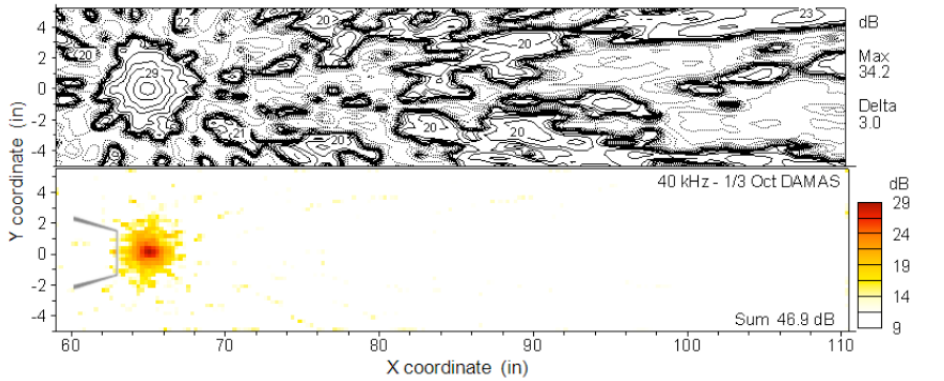
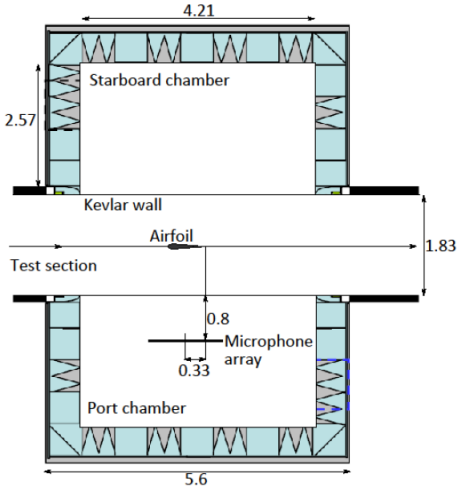


Figure 8. Results for the PS calibration case of Fig. 6, but for CSM Conditioning

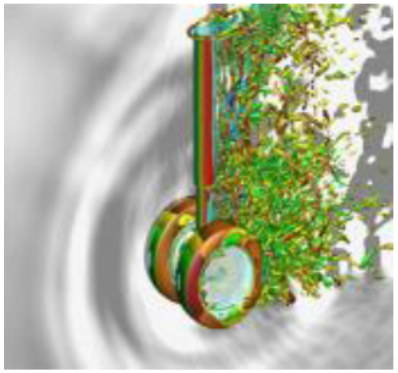
Wall-Mounted Finite Airfoil

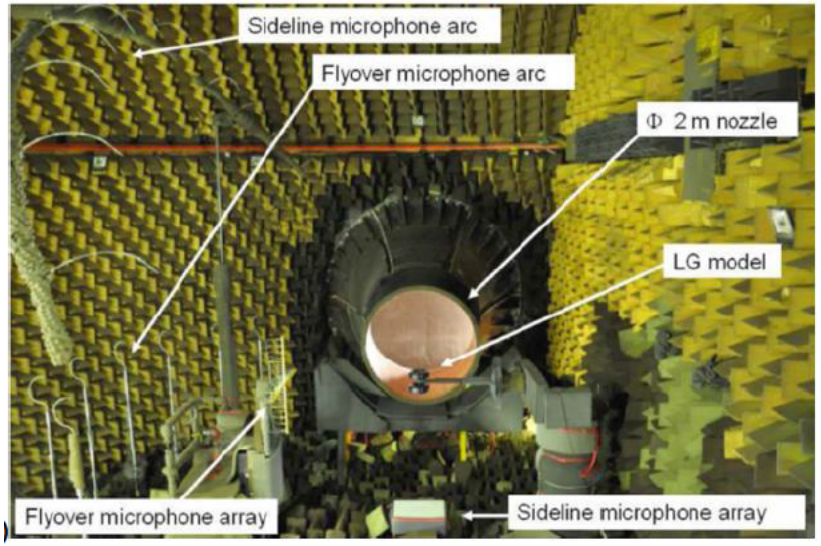
- P.o.C: Danielle Moreau (UNSW)
- NACA 0012 model mounted in Virginia Tech Stability Wind Tunnel
- Array out-of-flow: propagation through Kevlar walls
- Deliverables: 1/12th-octave band maps and integrated spectra



ONERA Landing Gear (CAA + Experiment)

- P.o.C.: Stéphane Redonnet & Jean Bulté
- See AIAA 2013-2068
- Coupled CFD/CAA simulation of simplified nose landing gear (LAGooN)
- Corresponding experimental data from ONERA's CEPRA 19





Next Meeting

- 22nd AIAA/CEAS Aeroacoustics Conference – 30 May – 1 June, Lyon, France (Wednesday afternoon session)
- Further opportunity for Year 1 submissions/ discussion/analysis
- Initial presentation/discussion of Year 2 cases and results

Open Discussion

Chris's Thoughts

- Still missing a couple of problem types of interest, e.g. transients such as runway flyover or wind turbine
  - Could be difficult to define reasonable metrics here
  - Already a large number of cases, significant time investment to participate in them all
  - Proprietary data issues
- Metric definition an iterative process
  - easier for similar cases (e.g. Va. Tech & DLR1)
  - How to define metrics for unexplored dataset features – distributed coherence estimates for jet noise?

Chris's Thoughts

- Data format for essential files looks mostly complete
  - May still want to have one party do final "clean-up pass" of HDF5 files (time consuming)
  - At least in MATLAB, chunk size of time series data leads to very slow data read, would perform better if done in data blocks of microphoneCount x blockSizePts
- No well-defined end-point for most cases – when should a case be considered complete?
- Year 3 – Time to consider summary papers of Year 1 cases?