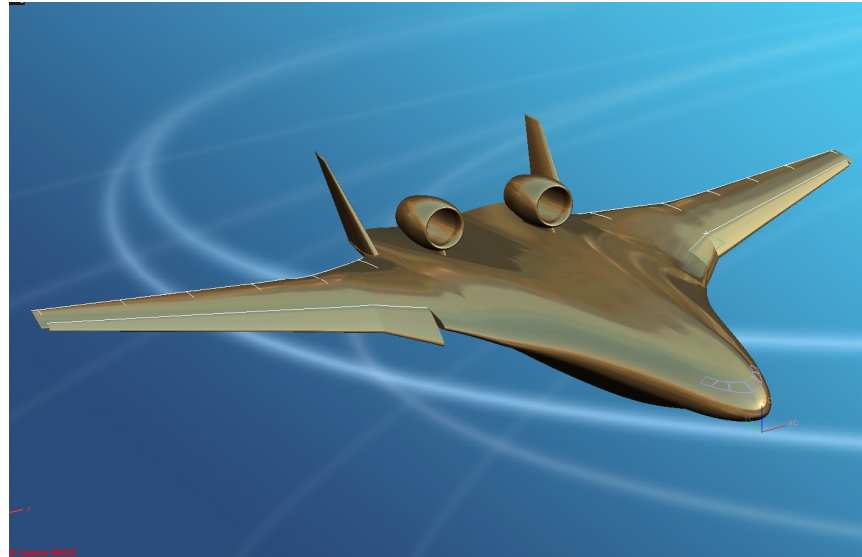
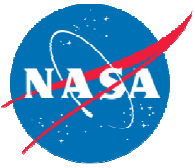
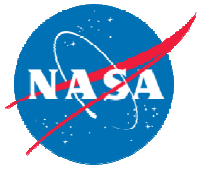




Hybrid Wing Body Acoustic Test in the 14 by 22 ft Subsonic Tunnel

Thomas Brooks

NASA Acoustics Technical Working Group Meeting
ODU Peninsula Higher Education Center, Hampton, VA
October 21 and 22, 2010



Test Preparation Contributors



Langley Research Center (Acoustic test P.I. : Thomas Brooks)



Glenn Research Center

NASA NRA team :



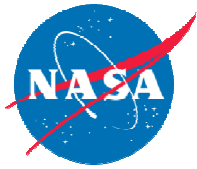
(P.I. : Ron Kawai)



MIT



UCI



Key HWB program effort aspects

Year '07-'10

NRA Partners:

Define HWB (Hybrid Wing Body) vehicle to meet noise, emissions, and performance goals – define evaluation metrics.

Fabricate modular HWB fuselage model for NASA wind tunnel. Do theoretical support and deliver prediction methods to NASA.

NASA:

Define windtunnel acoustic test to evaluate vehicle and establish benchmark noise data. Develop nacelles and jet engine simulators for test.

Develop new model-testing and instrumentation capabilities. Prepare for wind tunnel test. Prepare prediction capabilities for test.



N2B - Embedded engine model studied



N2A - Poded engine model to be tested

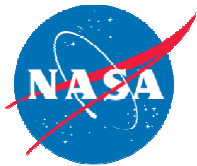
Year '11-'12

NRA Partners: (TBD)

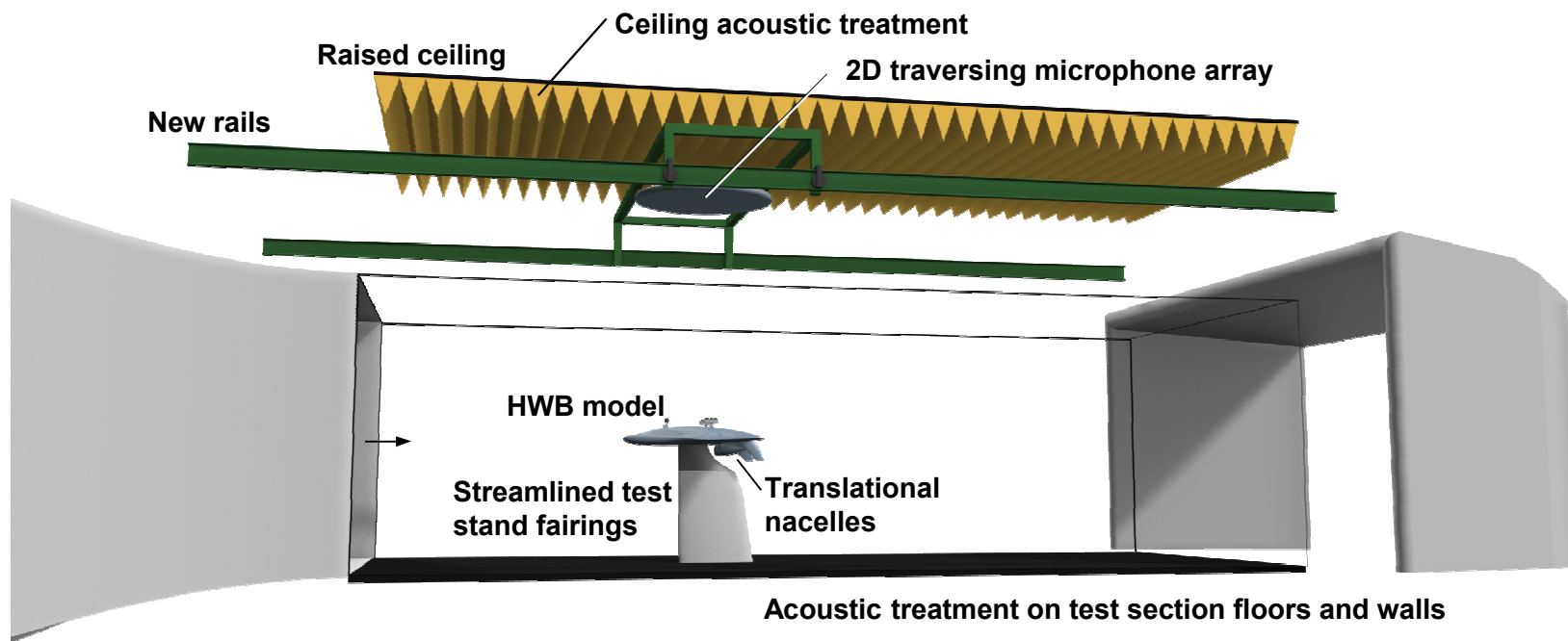
NASA:

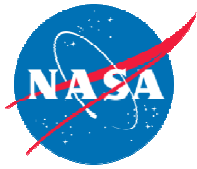
Conduct risk-reduction testing and pre-test preparation.

Conduct HWB Aerodynamic Test (7/11) and the Acoustic Test (1/12-4/12). Provide test data for prediction validation and full-size vehicle scaling.



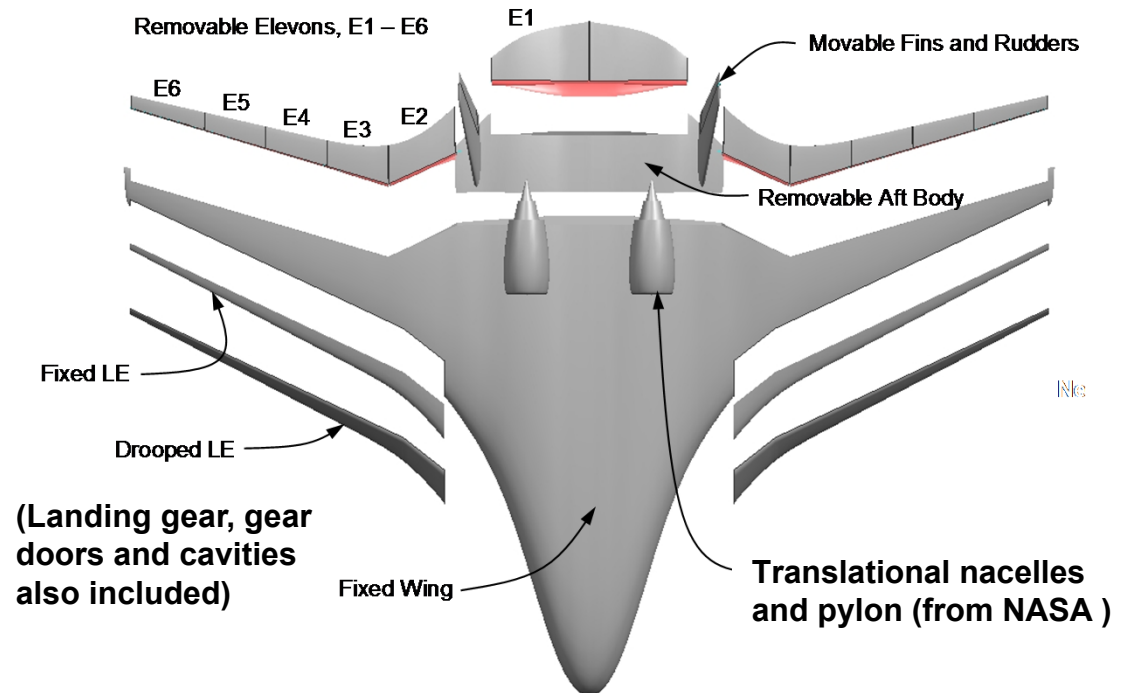
Acoustic Test Set-up Overview

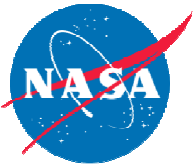




HWB Wind Tunnel Model for 14'x22' Test

- 5.8% of full scale (12.35 ft span). Allows measurements over the full scale equivalent range of 230 Hz to 4.1 kHz (4 to 70 kHz model scale).
- Modular with control surfaces deflected to match specific flight conditions.
- Mountable upright (aero testing) and inverted (acoustic testing).
- Fuselage details accurately scaled for airframe noise studies.
- Nacelle configurations (multiple positioning):
 - Flow-through,
 - Fan noise simulator,
 - Jet engine simulator.

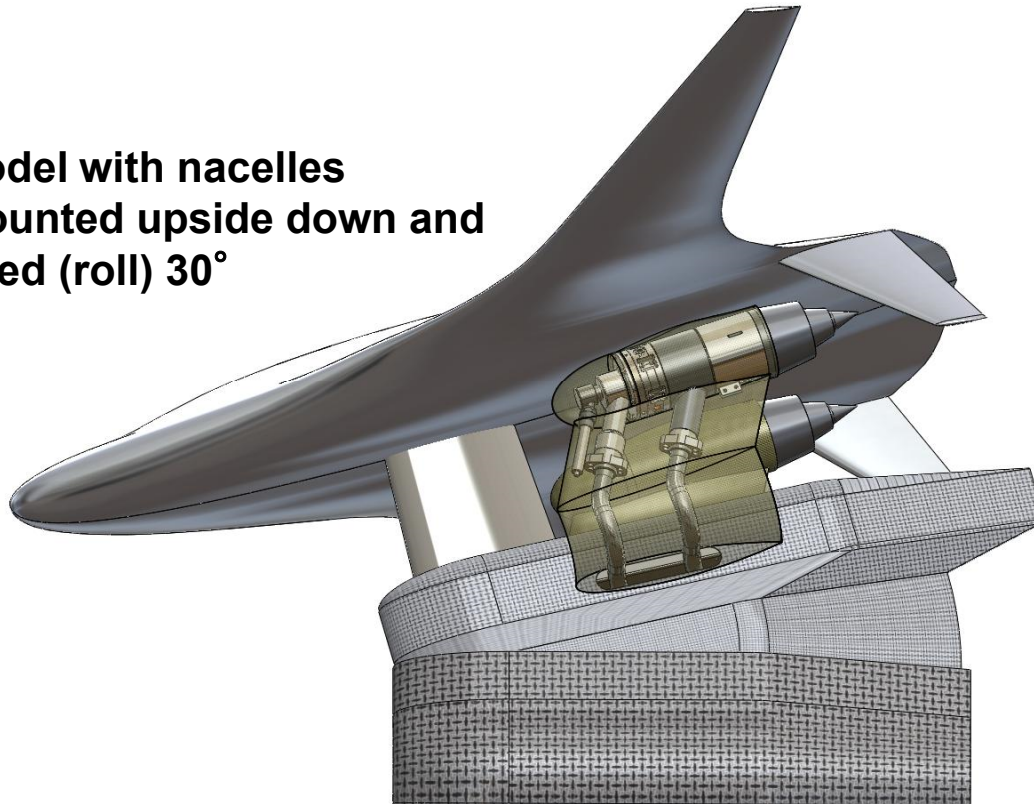


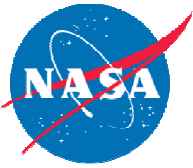


Jet Engine Simulators (JES)

- Two variable-position, dual stream, hot core, powered nacelles.
- Mid and rear portion of the simulators match the 5.8% HWB nacelles. The front-burner region and the supply-lines and mounts are curved and faired to minimize effect on flow field.
- Acoustic model support can orient model in pitch, independent of roll angle

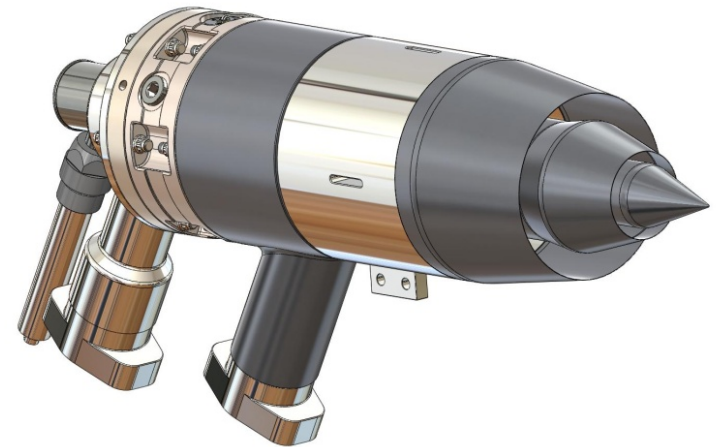
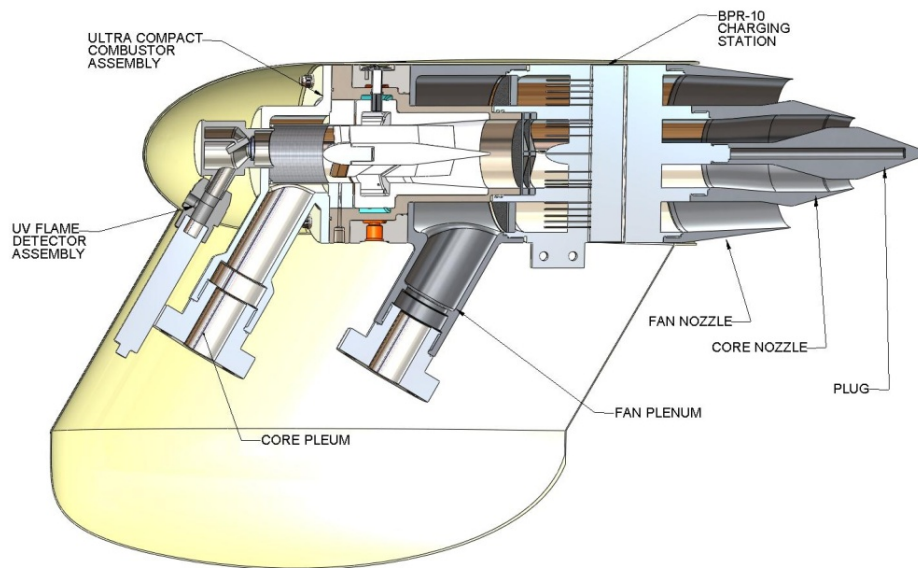
**Model with nacelles
mounted upside down and
tilted (roll) 30°**

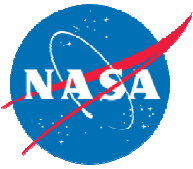




Jet Engine Simulators (JES)

- Fan and core nozzles to have several configurations including both circular and chevron configurations.
- Configured to match proper operating cycles for the Bypass Ratio (BPR) 10 engines specified for N2A.
- Support infrastructure to be designed to support a larger operational envelope for future programmatic needs.
- New 14x22 facility infrastructure requirements for the JES have been defined.

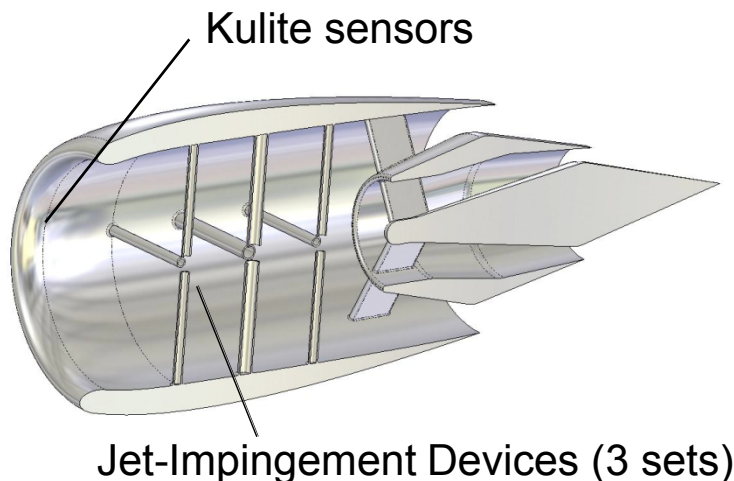




Fan Noise Simulator Nacelles

- High-intensity broadband noise generators will be used to determine fan noise shielding in HWB test.
- Nacelle inlets and exhausts are to be alternately capped to separately study inlet and exhaust noise shielding.
- Positioning range on fuselage is same as for the hot-jet powered nacelles.
- Modal/tone fan noise simulator, using electrostatic actuators is being developed at NASA GRC (Dan Sutliff)
 - Comparative shielding tests (at GRC) between the two nacelle types is to establish differences in broadband and tonal noise shielding. This will be applied to HWB test data

Broadband Noise Generator



“Turbomachinery” Tonal Noise Generator

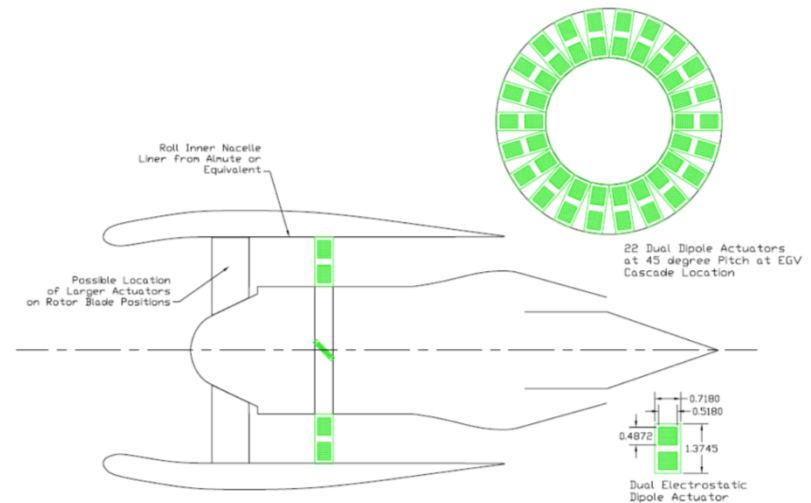
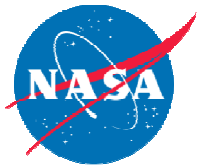
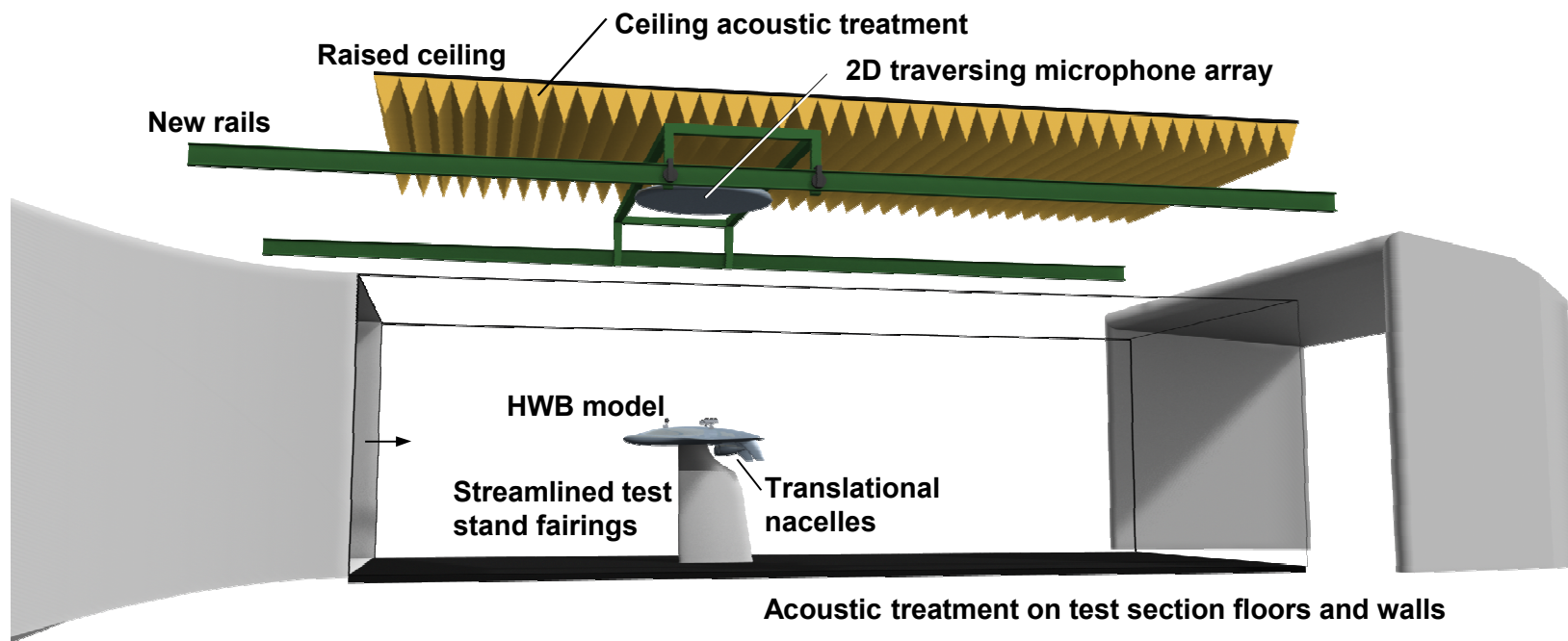
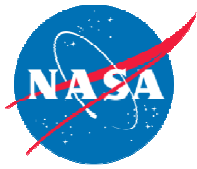


Figure 4. UCFANS installed in Model Scale BWB-Engine Nacelle

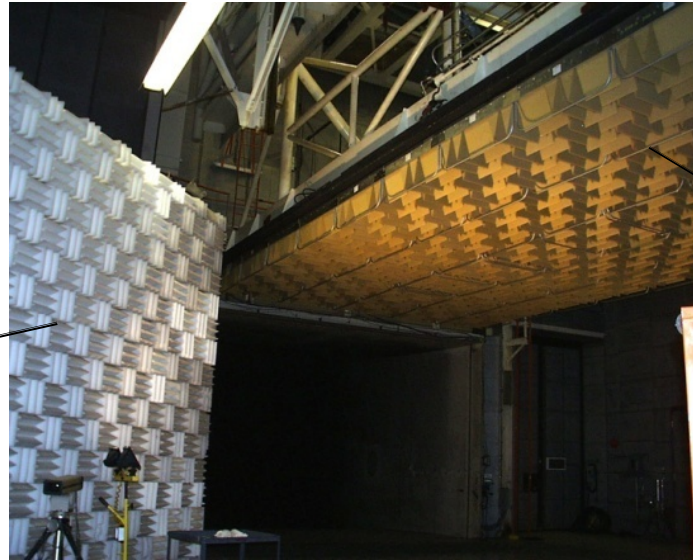


Acoustic Test Set-up Overview





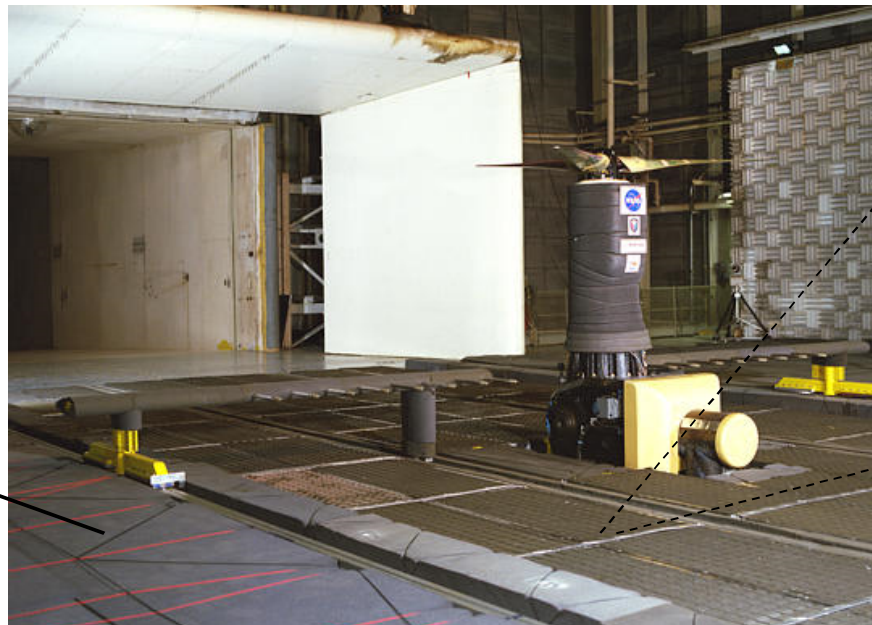
Acoustic Treatment in the 14'x22' Wind Tunnel Facility



wall treatment

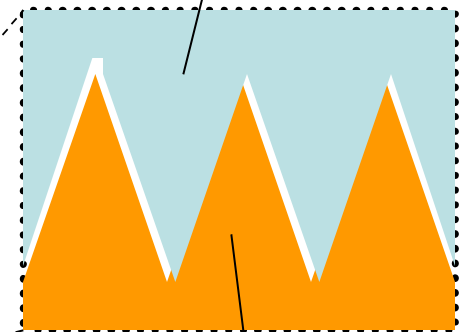
-past anechoic tests-

Ceiling treatment

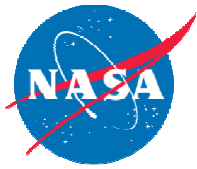


6" thick open cell foam

Low density foam

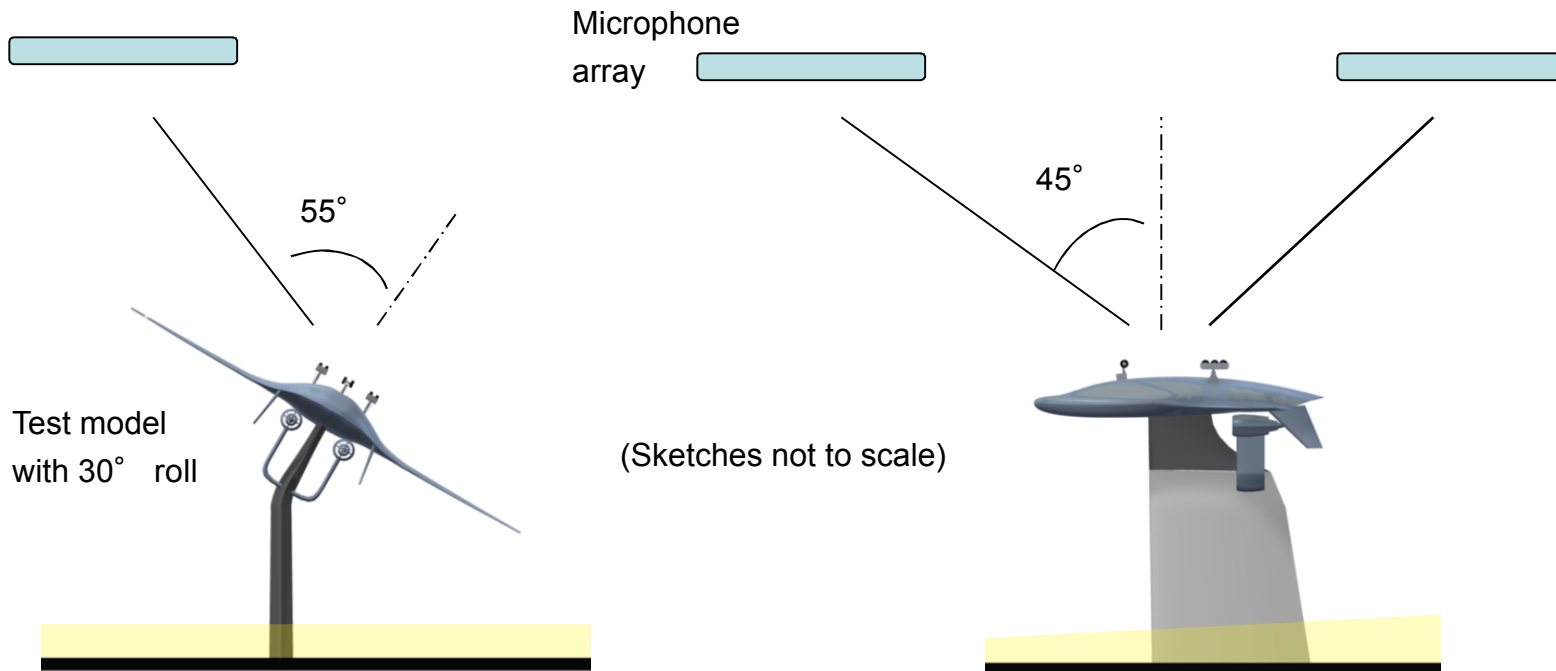


Acoustic wedges



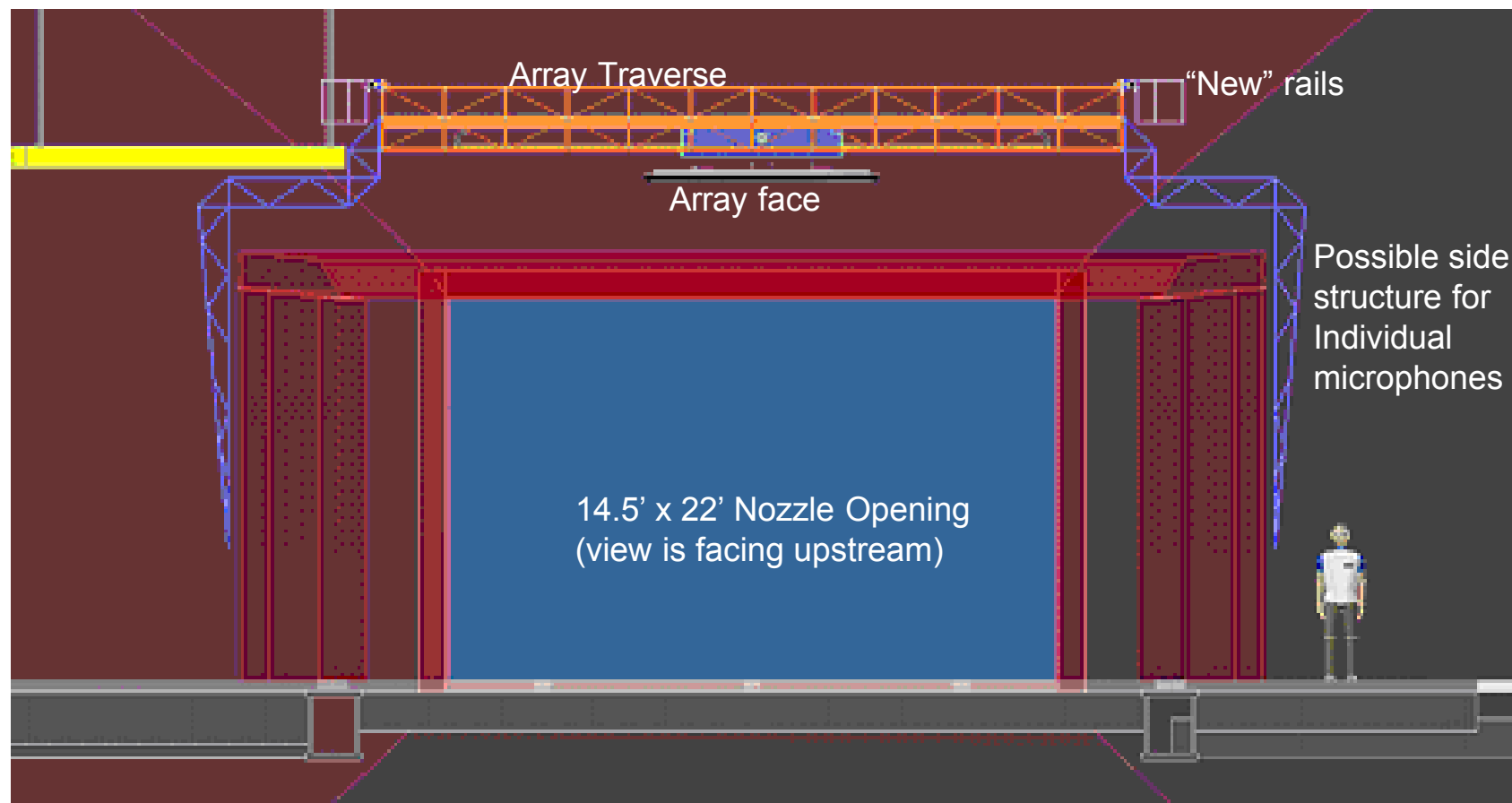
Phased Array Traverse System

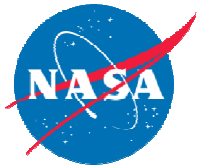
- Traverse positions array panel 13.5 ft above the model
 - forward-to-aft directivity angle range $90^\circ \pm 45^\circ$ (90° is above model).
 - Side-to-side directivity angle range $90^\circ \pm 55^\circ$ with HWB fuselage roll.



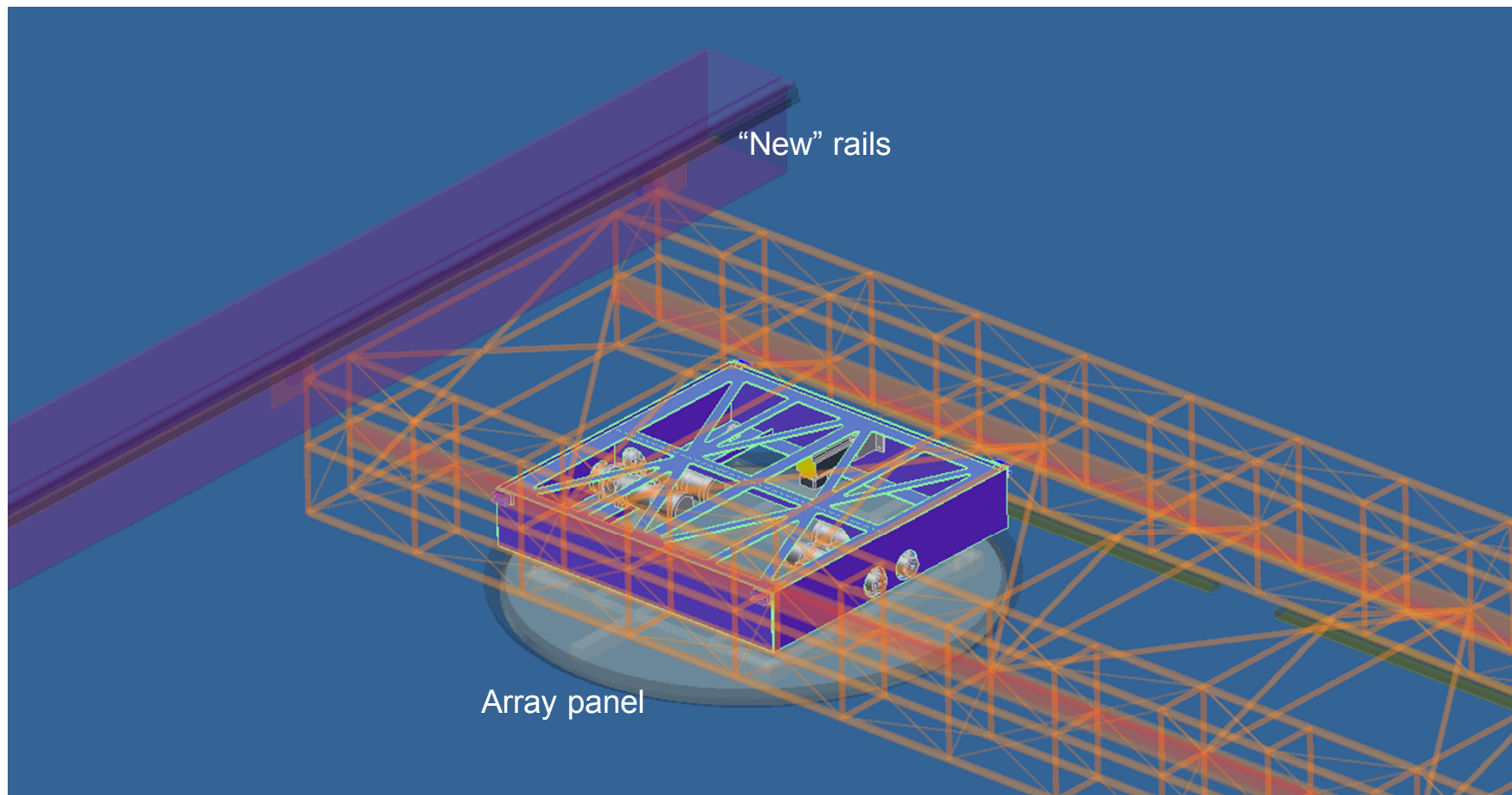


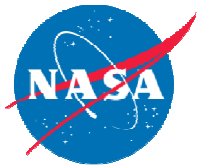
A “Current” Crane Rail Mounted Design for the Array



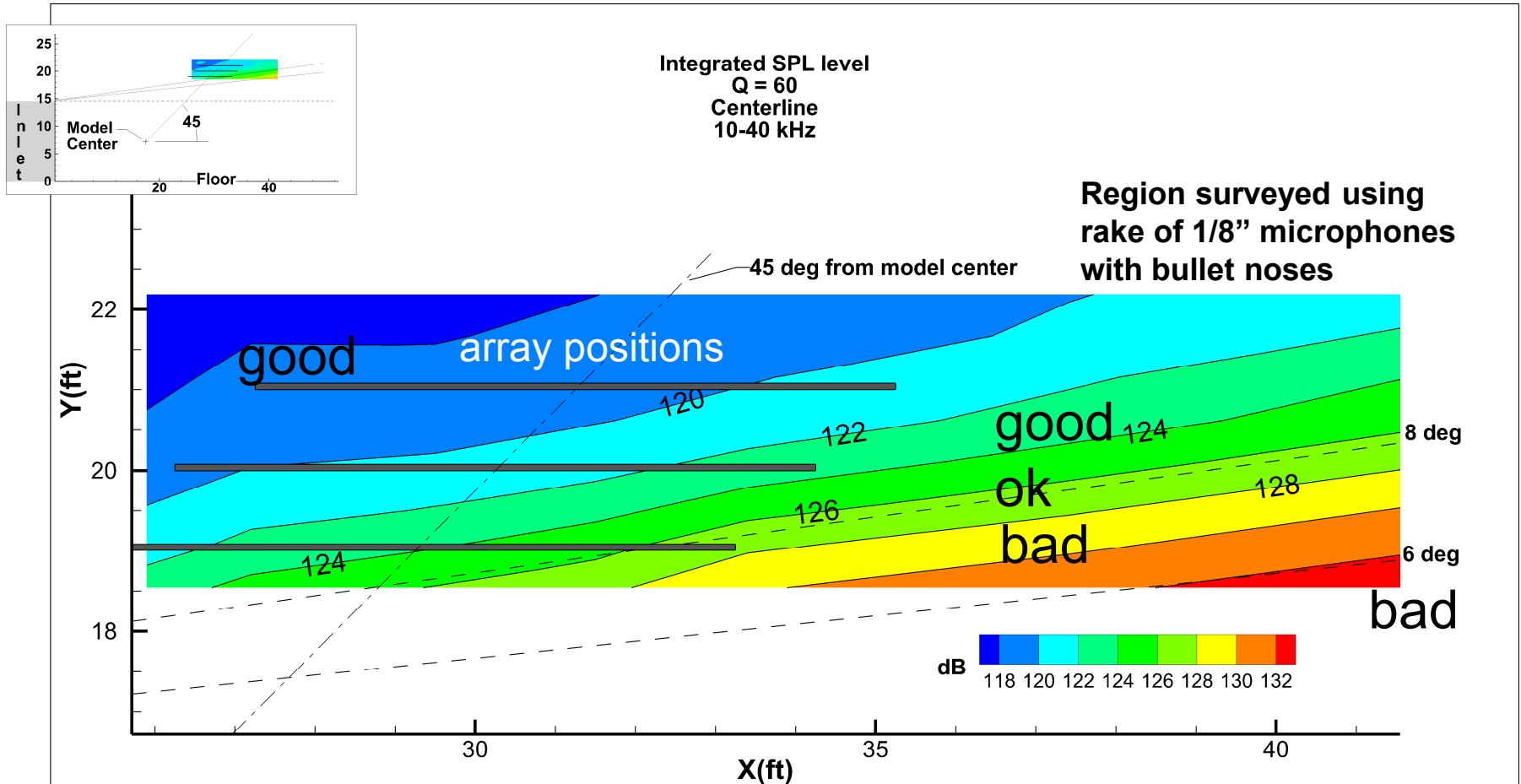


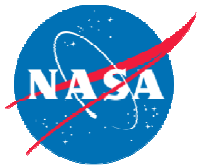
Carriage of Array Panel Design





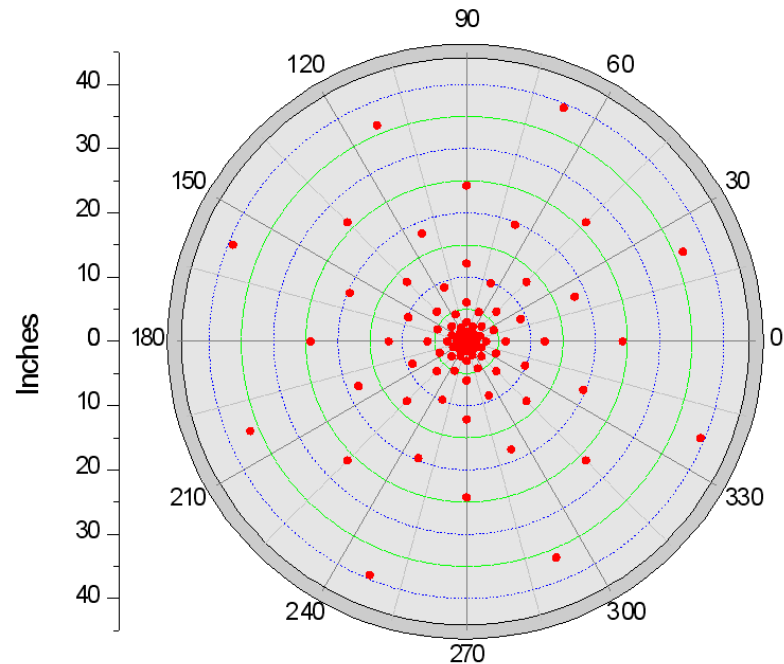
Tunnel, array positions, shearlayer turbulence survey region

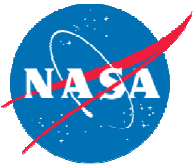




Phased Microphone Array

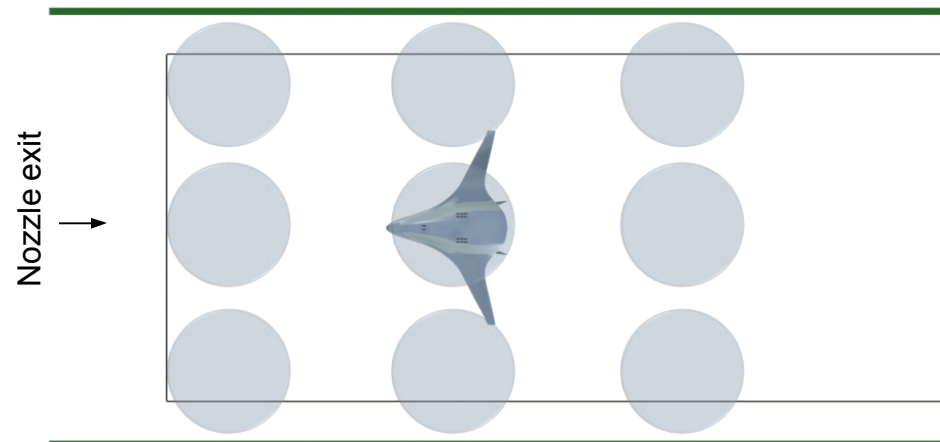
- Ninety seven 1/4-inch microphones flush-mounted to a lightweight, 8 ft diameter, rigid circular panel.
- Frequency range – approximately 1.5 to 80 kHz.
- Mounted accelerometers and inclinometers for monitoring tilt and vibration of panel.
- Embedded sources on HWB test model to fine-tune array beamforming steering vectors.



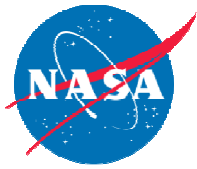


Data Acquisition

- Semi-automated operation in test:
 - nominally 9-12 stations with up to four 15-sec acquisitions at each array station.
 - about 5 min to record and save data at each station and to relocate traverse
 - about $\frac{3}{4}$ hr of tunnel time for sets of 9 stations.
 - over 3 hr of tunnel time for sets of 36 stations.
- Data acquisition system to record all signals simultaneously.
- Data to be processed as it is acquired to generate initial noise spectra.
- Data to be forwarded to processing cluster for more detailed analysis.



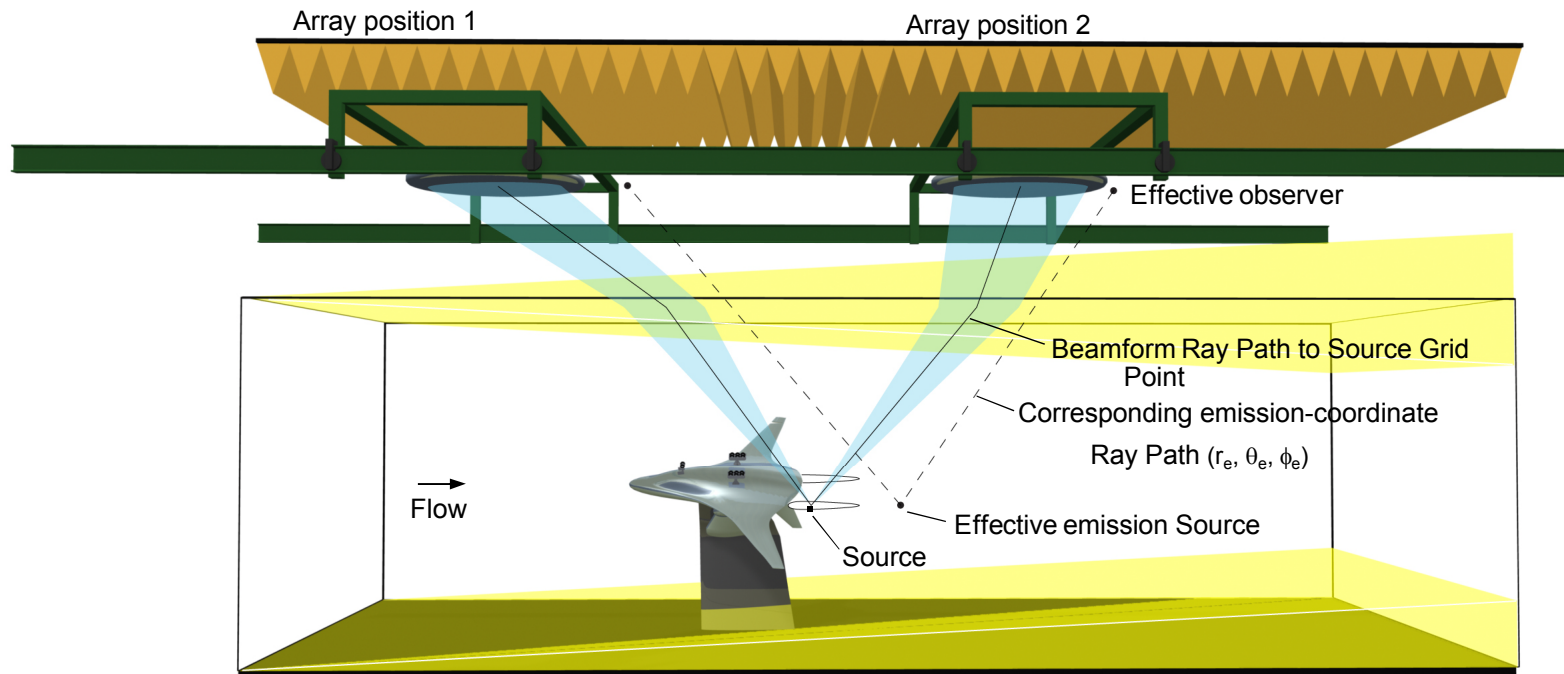
Top view with 9 array stations

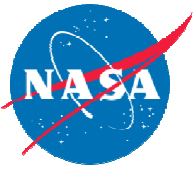


Acoustic Phased Array Data - Processing

At each array position and for each model configuration:

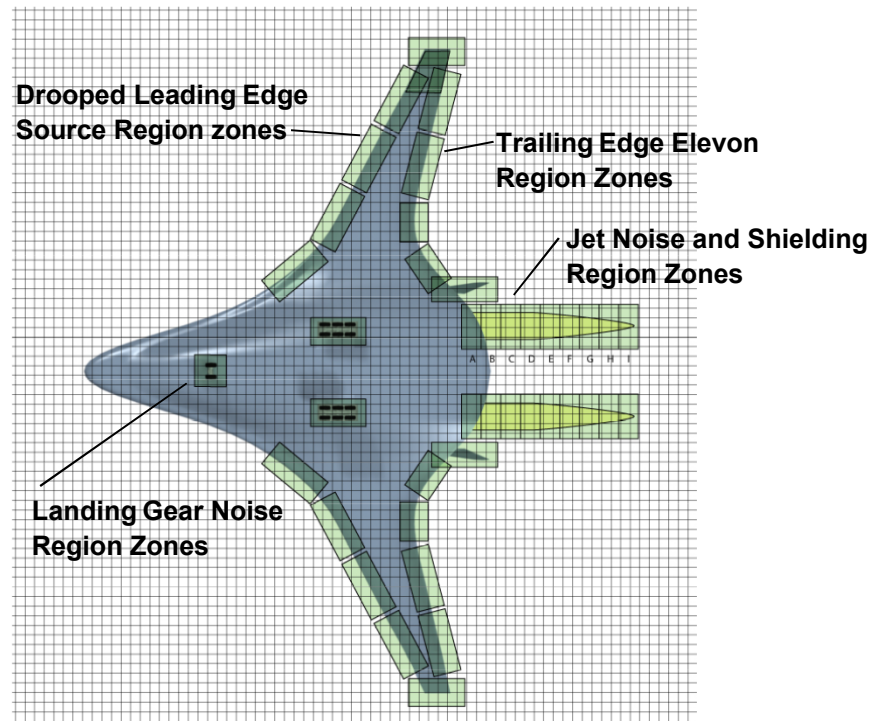
- Beamform processing:
 - create Cross-Spectral Matrix (CSM) between all microphones
 - perform beamforming to each grid point over prescribed model regions
 - extract source/observer emission coordinates (r_e , θ_e , ϕ_e)

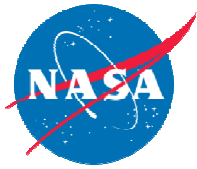




DAMAS Application to HWB Test

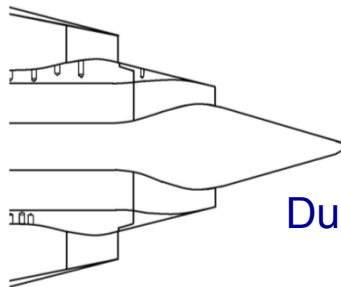
- DAMAS processing
 - Perform DAMAS analysis for each beamform map grid point over the model for each frequency
 - Form DAMAS noise source maps for each frequency
 - For defined spatial region (zones) over DAMAS maps, determine noise spectra, level, directivity as function of (r_e, θ_e, ϕ_e)





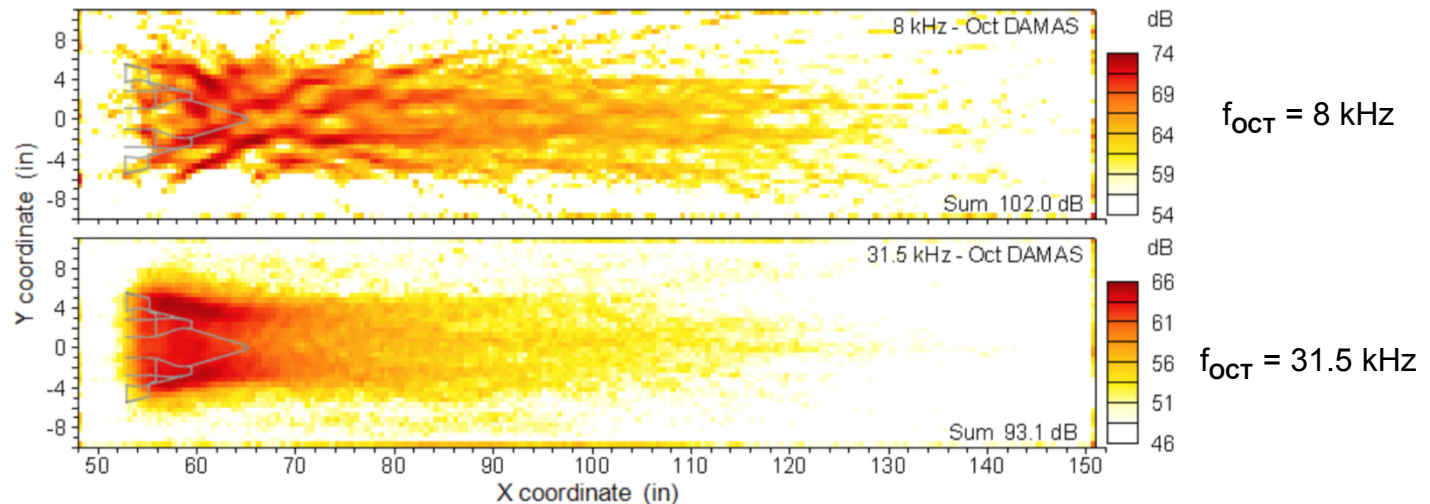
Example: DAMAS application to Similar Jet Noise Case

Array positioned in the Low Speed Aeroacoustics Windtunnel (LSAWT) Jet Noise Laboratory



Dual flow BPR-5

Hot $M=0.8$ core flow, tunnel flow $M_{WT} = 0.1$





HWB test data use for prediction comparison and scaling

- Individual microphone measurements useful to a limited extent for prediction comparison for Jet noise and Fan noise
- DAMAS processing required for
 - Noise maps of components of **wind tunnel model** for comparison to prediction
 - Full HWB model noise by combining maps of component noise
 - Noise mapping for **full-scale** HWB flyovers by scaling to prescribed heights and angles for noise metric definition.
 - This requires matching (r_e, θ_e, ϕ_e) values in the DAMAS data base and use of predicted fan-turbomachinery noise spectra

