9x15 Low Speed Wind Tunnel Improvements Update

Acoustics Branch Point-of-Contact: David Stephens

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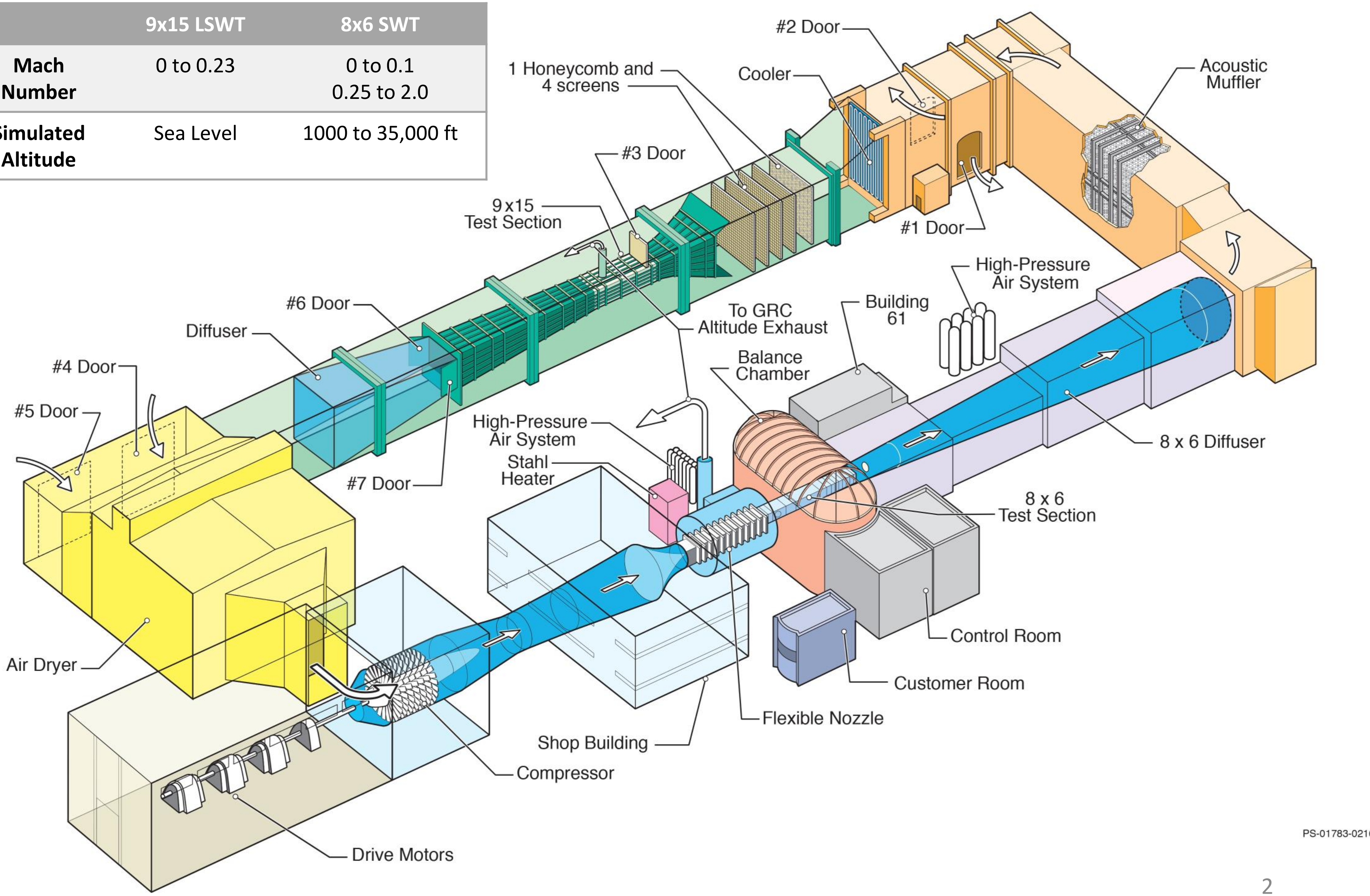
- NASA Advanced Air Transport Technology Project
- NASA Aeronautics Evaluation and Test Capabilities Project

Unique facility for testing propulsors

	9x15 LSWT	8x6 SWT
Mach Number	0 to 0.23	0 to 0.1 0.25 to 2.0
Simulated Altitude	Sea Level	1000 to 35,000 ft



Fan/Propulsor Testing in 9x15 Tunnel

- The GRC 9x15 Low Speed Wind Tunnel has been extensively used to study and acoustically characterize nearly all of the NASA/Industry propulsor concepts over the past 20 years.

- Except for maintenance, the acoustic treatment has remained essentially unchanged in 20+ years.

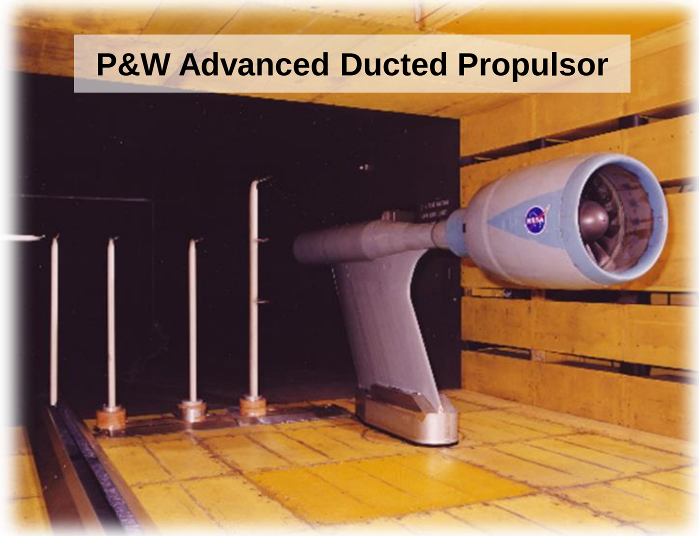
Honeywell Turbofan with Acoustic Liners

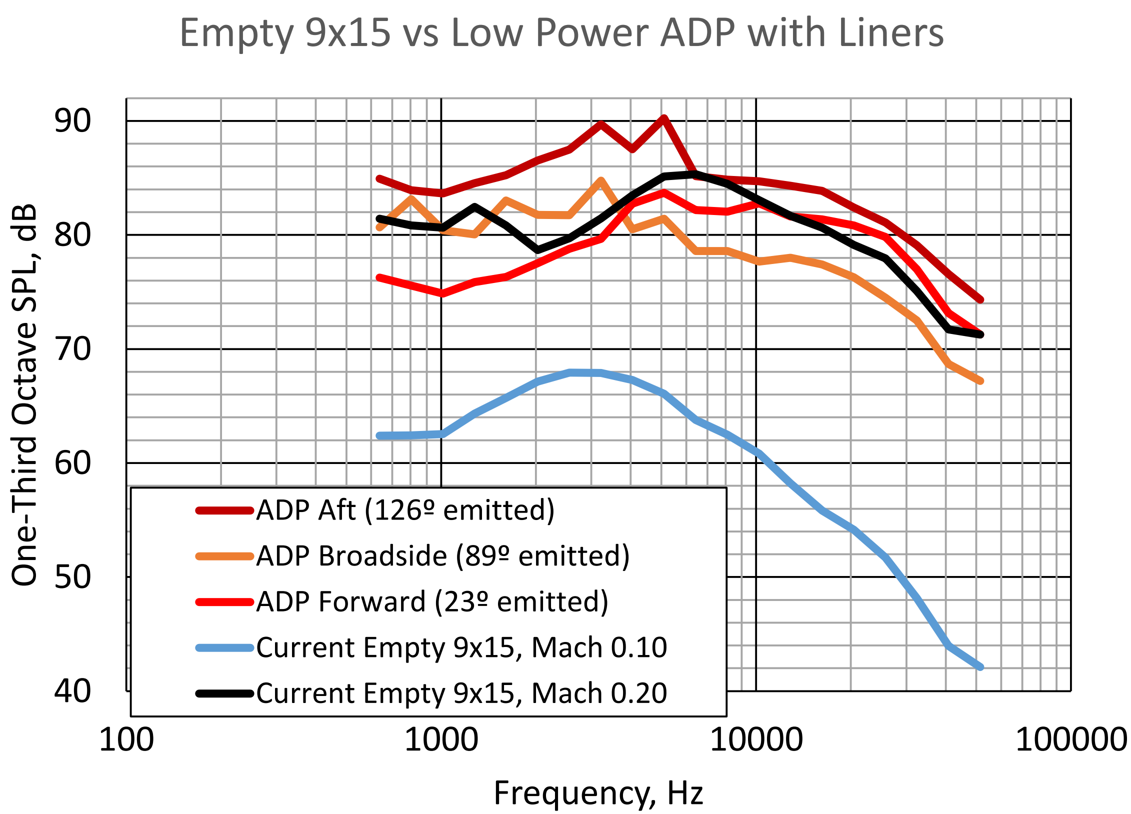
P&W Geared Turbofan


NASA/GE Open Rotor

Testing quiet fans requires a quiet wind tunnel

- Historically this has been done by testing a Mach 0.1, which is below true take-off and landing speeds.





- Future fans may be even quieter
  - Low tip speed
  - Low pressure ratio
  - Acoustic liners
- Open rotors and other concept fans require testing at higher tunnel speeds than Mach 0.1

Anticipated Schedule*

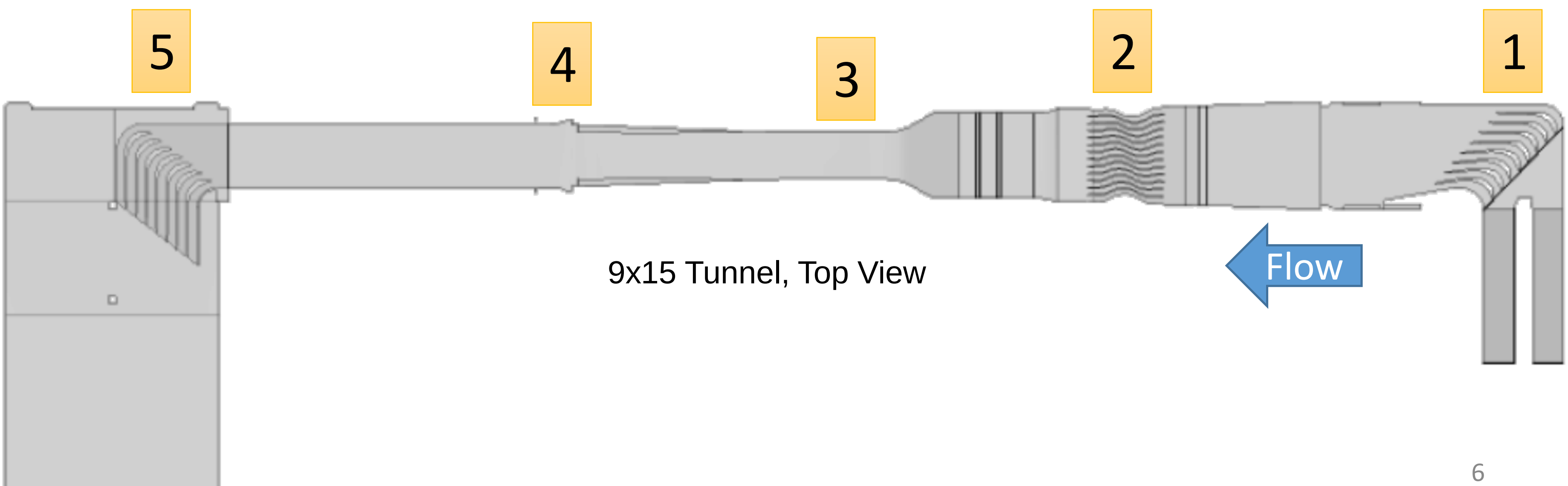
- May 2017 – 8x6 QueSST test ends, model removal
  - Site preparation work
  - Both 8x6 and 9x15 shut down
- June 2017 – Start of 9x15 acoustic improvement task
- May 2018 – Completion of acoustic improvement task
- June 2018 - Acceptance testing for both test sections
- September 2018 – Tunnel ready for testing

*schedule commitment pending

Planned Wind Tunnel Renovation

Complementary but discrete improvements

1. Add fairings and turning vanes to turn 2
2. Add acoustic baffles downstream of doors 1 & 2
3. Replace test section, new flow surface, remove slots
4. Reshape diffuser and add acoustic treatment
5. Add turning vanes to turn 3



9x15 Tunnel, Top View

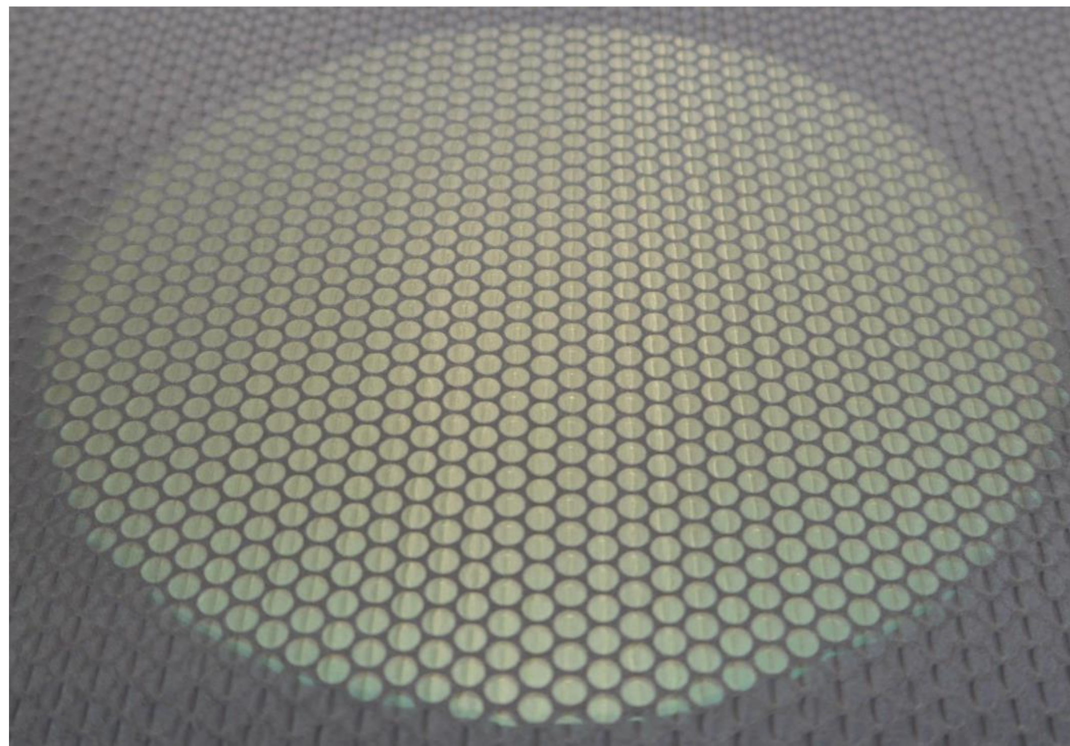
Diffusion Bonded Plates

Diffusion bonded plates (DBP) are produced by combining perforated sheet metal with fine wire cloth. These materials are joined in a vacuum furnace under heat and mechanical load in a process called diffusion bonding.

The function of the DBP is to allow passage of sound waves into bulk absorber material, while producing minimal self-noise under grazing flow.

DBP Details:

- 5/32” holes on 3/16” centers (63% open area) 16-gauge perforated sheet metal
- 200x600 Twilled Dutch Weave wire cloth
- 304 stainless steel cloth and plate
- Wire cloth “dimples” (depressions over perforations) approx. 0.005” deep
- Flow resistivity ~12 CGS Rayls

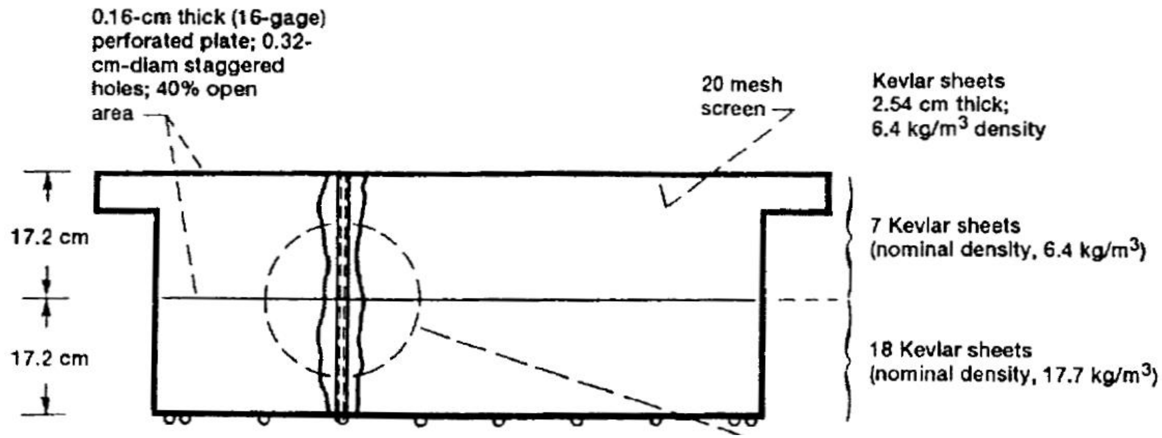


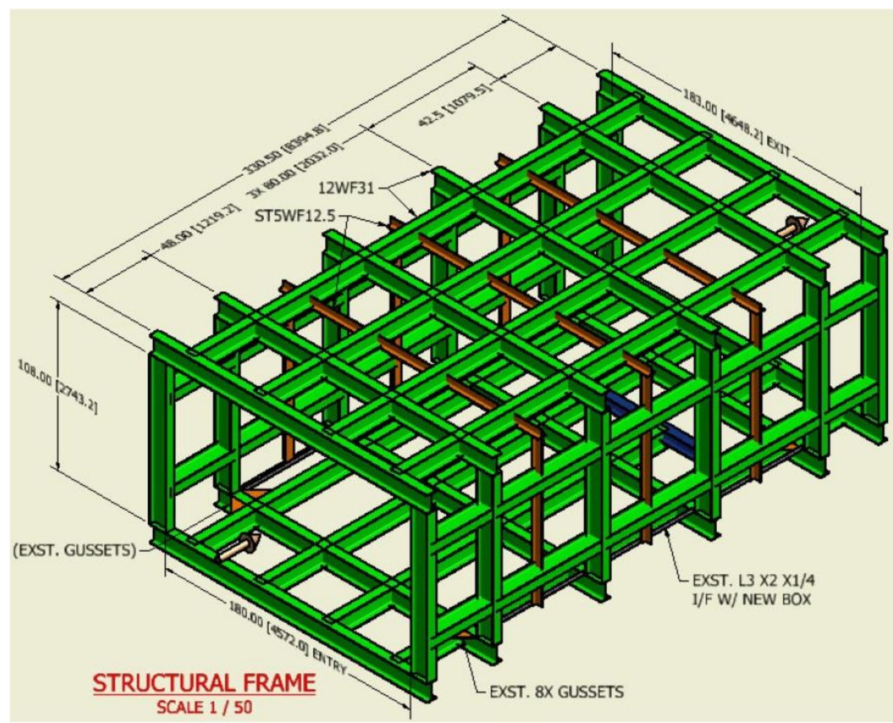
2016 Roughness Noise Test Objectives

1. Test pre-production panels from expected manufacturer. Determine acceptable level of dimpling.
2. Modify boundary layer and re-test several samples to verify conclusions and better quantify noise scaling.
3. Test panels with mechanical fasteners to determine noise impact.

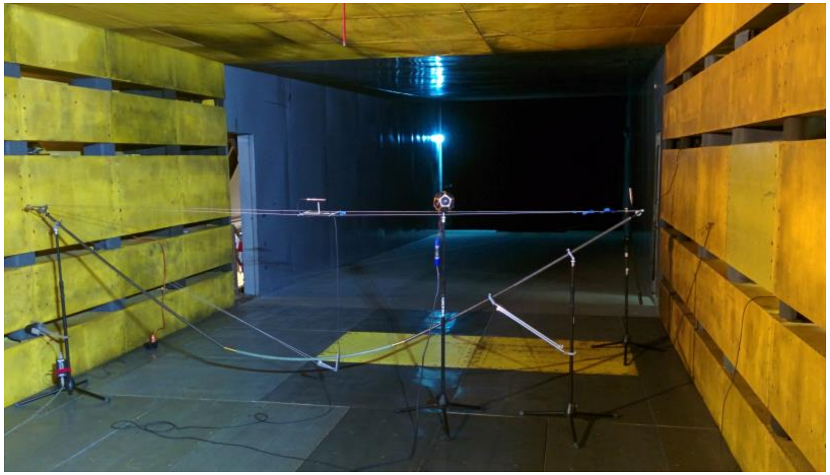
9x15 Test Section acoustic treatment is built as boxes

- The acoustic treatment was designed in 1986 to be 13.5” deep.
- As designed, this is an excellent sound absorber
- However, the acoustic treatment was fit around the beams that make up the test section, and over the beams the treatment is only 2” deep
- There are a LOT of beams

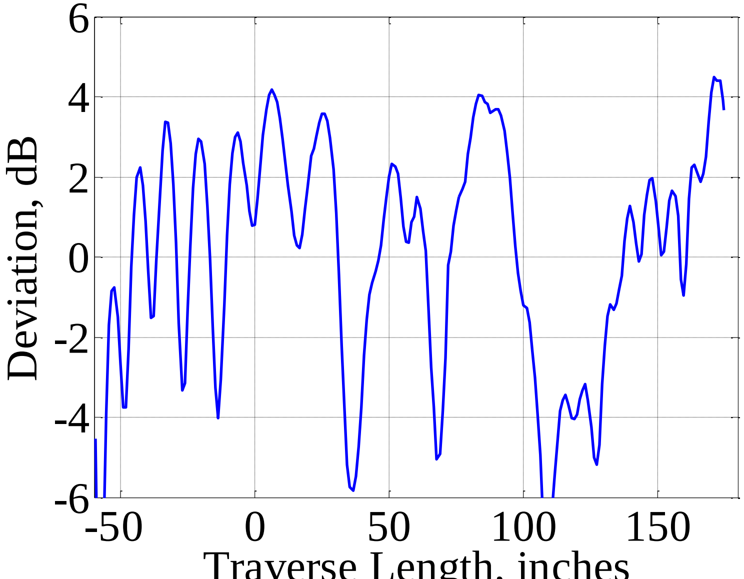




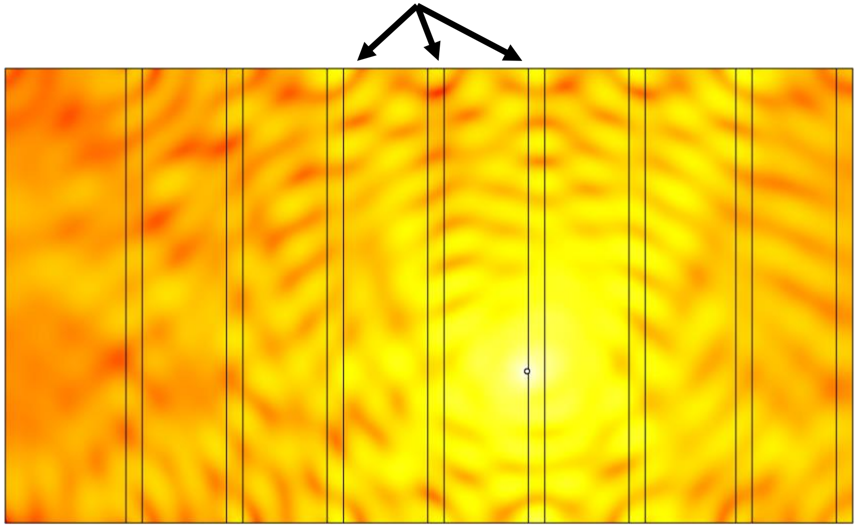
Testing and simulations have confirmed the effect



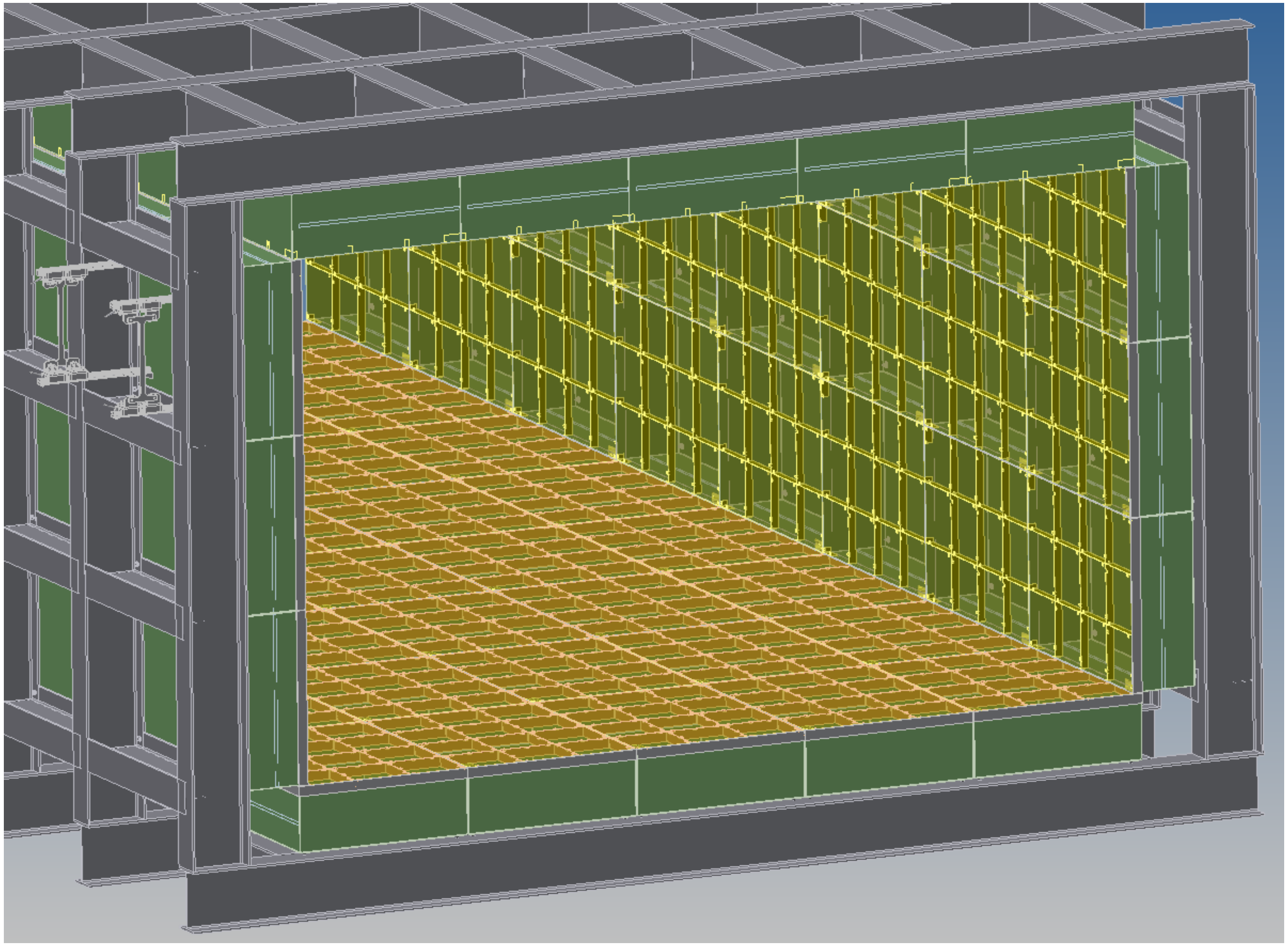
- Beams cause reflections, which cause uncertainty in tone level measurements
- Anechoic quality measured according to ISO 26101 in July 2016



Simulation of beams causing reflections

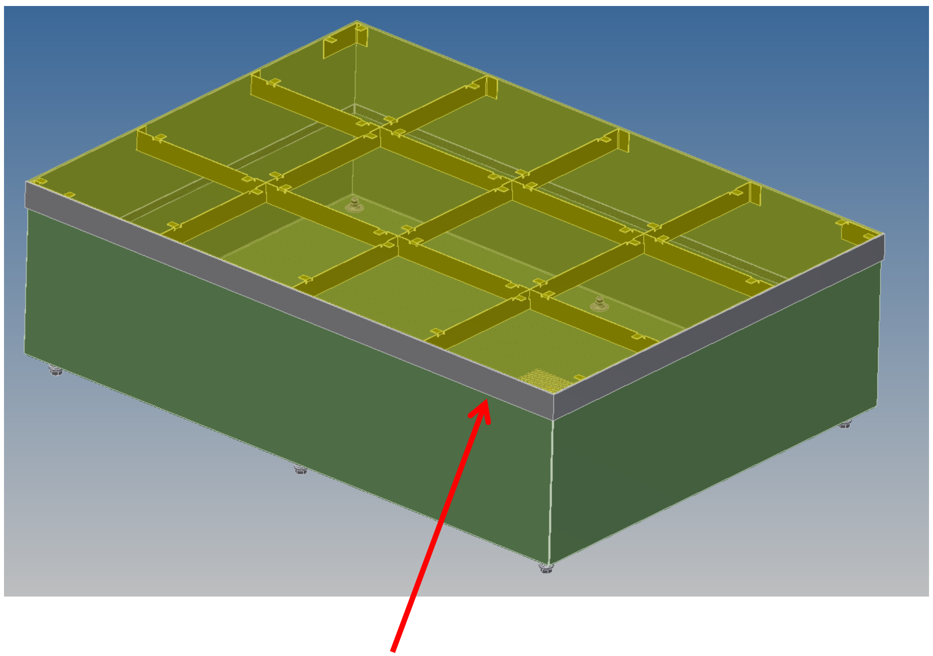


Redesigned Test Section, Beams Outside Acoustic Boxes



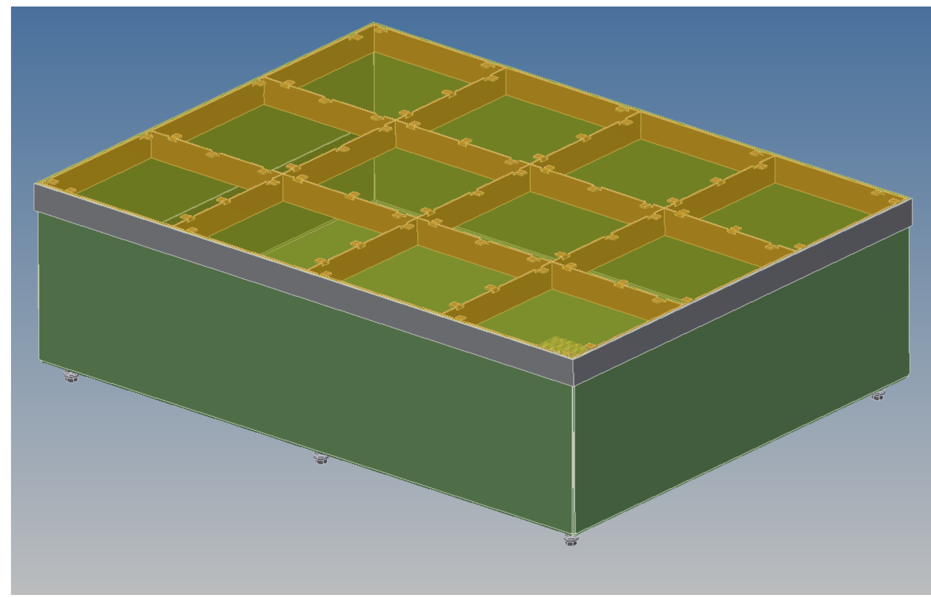
Acoustic Box Designs

Wall/Ceiling Boxes - 16GA Box, 20GA Panel



1/8” Thick EPDM rubber seal.

Floor Boxes - 12GA Box, 16GA Panel

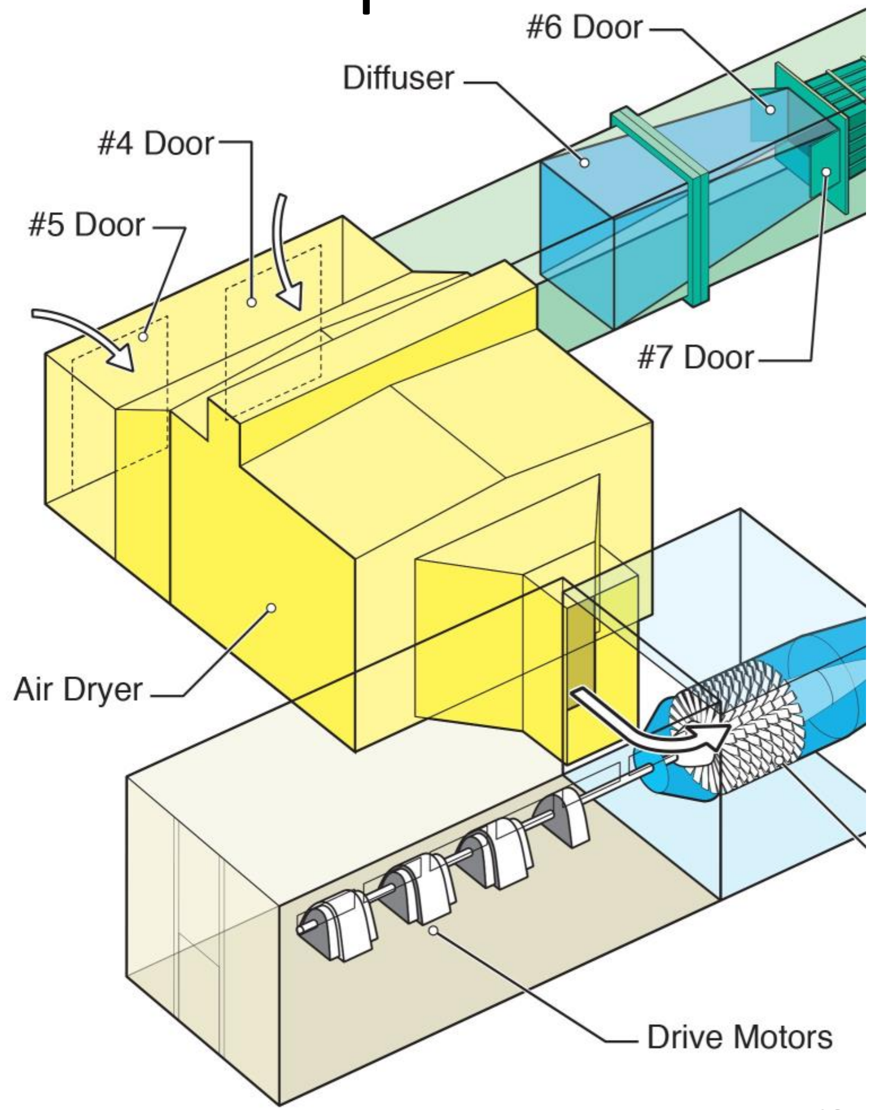


Retain 13” deep bulk absorber

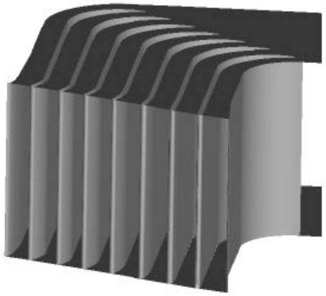
Turn 3 Studies for 8x6 Operation

- Air Dryer Performance
  - Can we avoid reducing run time for the 8x6 due to inefficient use of air dryer beds?

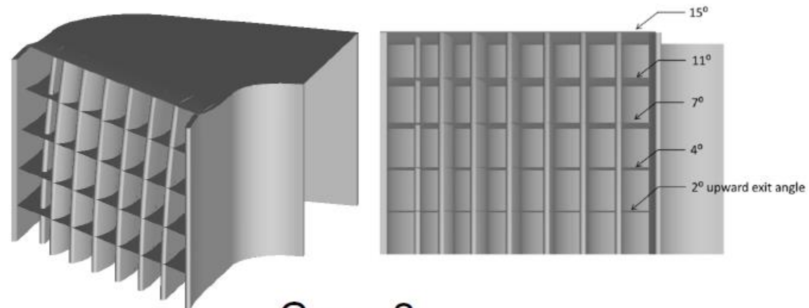
- Static Pressure in Compressor Plenum
  - Must keep static pressure on compressor and building within existing permitted range



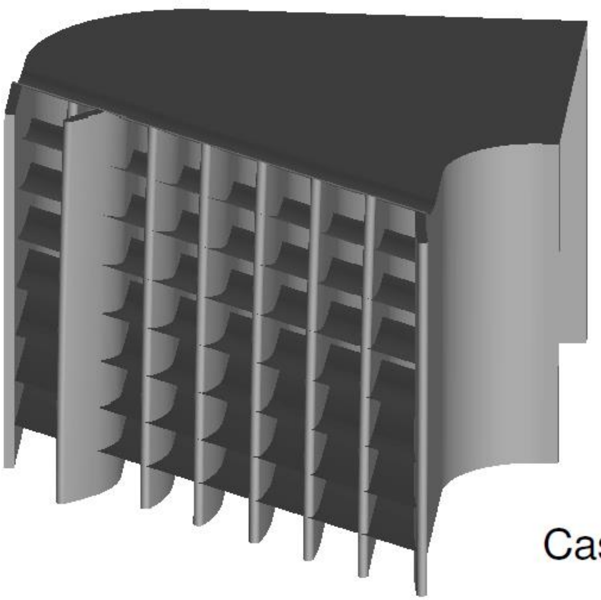
Development of Corner 3 Design

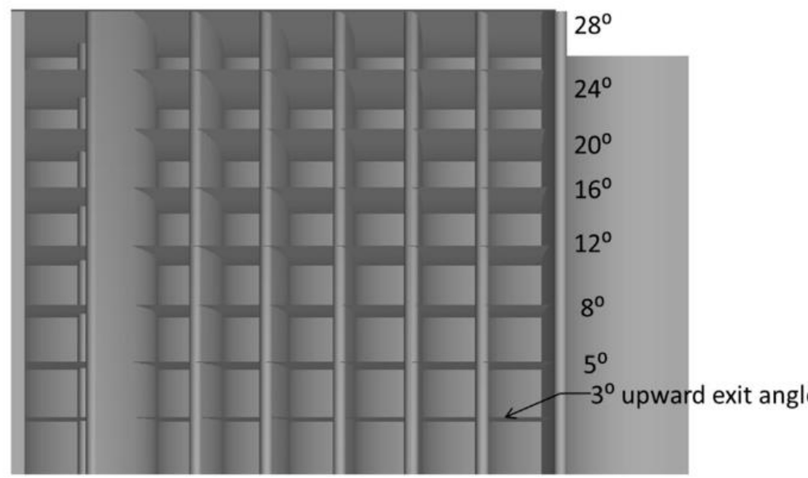


Case 2



Case 3

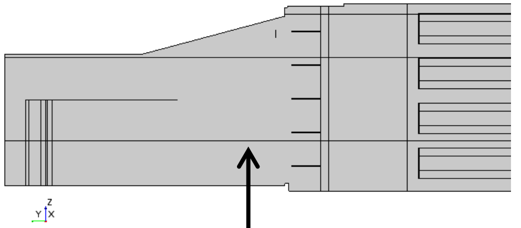




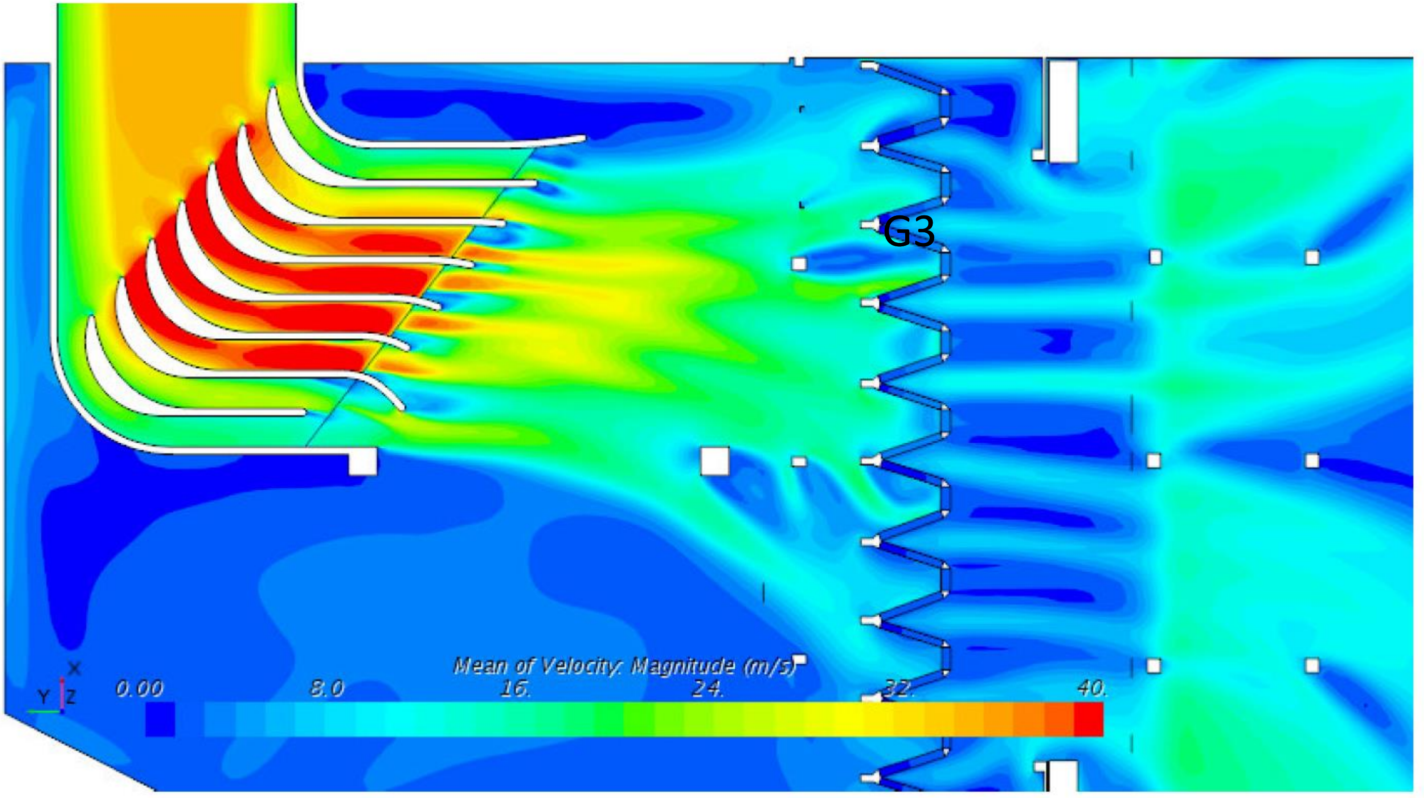
Case 4

Turn 3 Modifications for 8x6 Operability

- Smaller diffuser exit area presents challenge for supplying air dryer
- Simulation of diffuser, turning vanes, air dryer inlet filters and porous desiccant beds

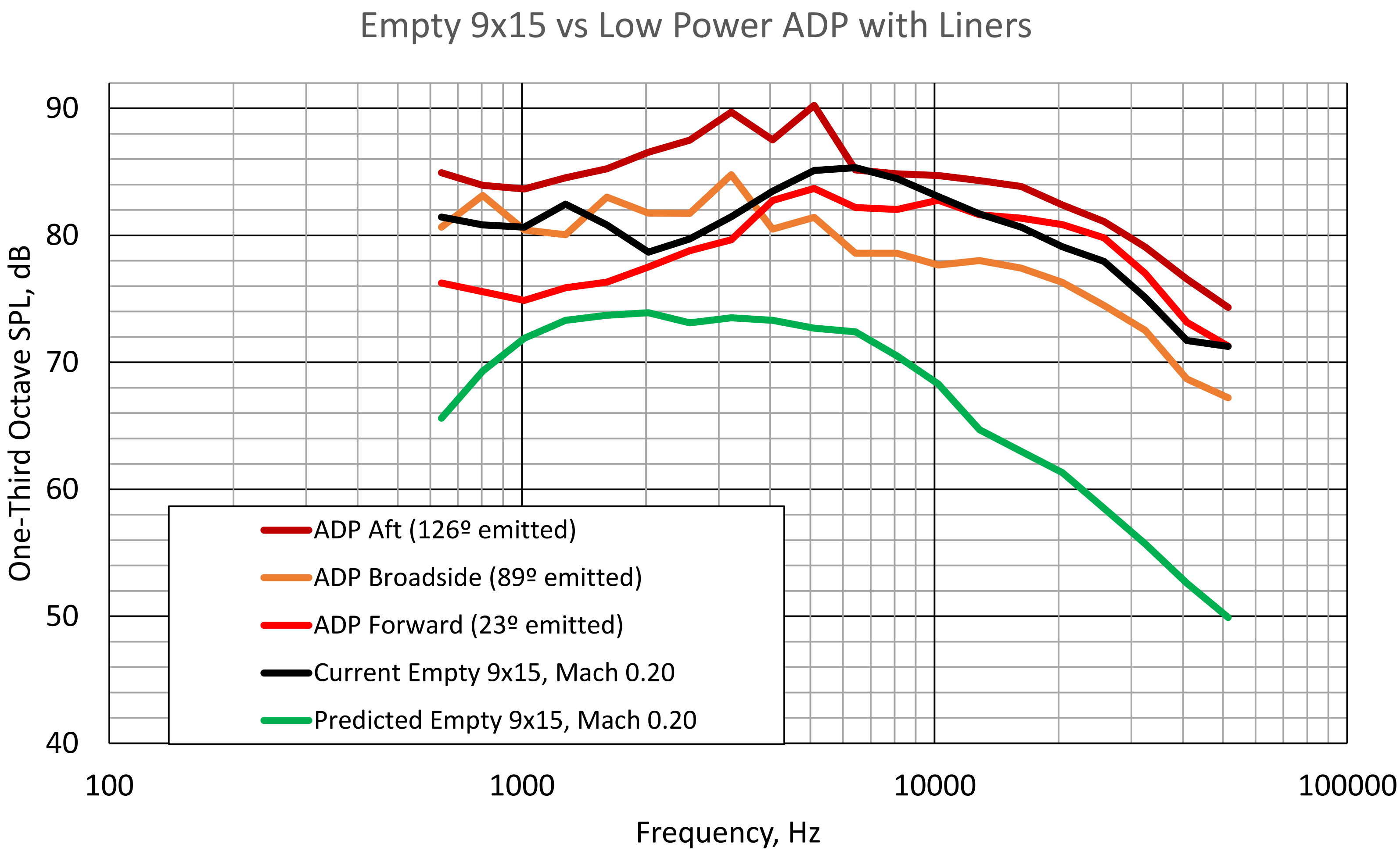


At half turning vane height



The flared geometry effectively fans out the corner 3 exit flow laterally.

Relative to P&W Advanced Ducted Propulsor (ADP) Model Fan Measurements



Summary

- Custom solution for turn 3 designed
  - Acoustic turning vanes for reducing background noise in the 9x15
  - Flared geometry to ensure 8x6 air dryer operability
- Roughness noise validation completed
  - Pre-construction panels, dimpling tests
  - Mechanical fasteners
- Deep acoustic boxes and new test section frame designed for improved anechoic quality
- Site work to begin in June

Executive Summary

The 9- by 15-Foot Low Speed Wind Tunnel (9x15 LSWT) at NASA Glenn Research Center was built in 1969 in the return leg of the 8- by 6-Foot Supersonic Wind Tunnel (8x6 SWT). The 8x6 SWT was completed in 1949 and acoustically treated to mitigate community noise issues in 1950. This treatment included the addition of a large muffler downstream of the 8x6 SWT test section and diffuser.

The 9x15 LSWT was designed for performance testing of V/STOL aircraft models, but with the addition of the current acoustic treatment in 1986 the tunnel been used principally for acoustic and performance testing of aircraft propulsion systems. The present document describes an anticipated acoustic upgrade to be completed in 2018.

8x6/9x15 Facility Manager : [David Stark]