AATT Propulsion Technologies: Advanced Liner Concept Development

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Fall 2024 Acoustics Technical Working Group

October 8, 2024

NASA Glenn, Cleveland OH

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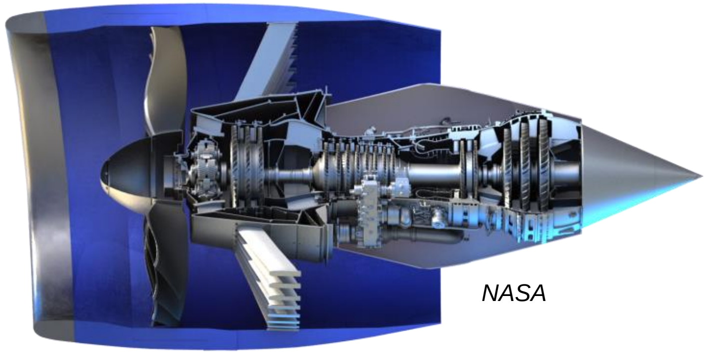
Funding support provided by the Propulsion Technologies subproject of the Advanced Air Transport Technologies (AATT) Project as part of NASA’s Advanced Air Vehicles Program

AATT Propulsion Technologies Technical Challenge

***TC Goal*: Predict, model, and assess** the ability for next-generation propulsors to meet market-driven goals for noise (4 dB reduction) and efficiency (3-5% fuel burn reduction) with integration effects, relative to 2021 best-in-class propulsors, and reduce risk to a new single-aisle aircraft in the 2030s.

- **Liner Concepts and Applications**
  - Low Pressure Ratio (LPR) Fan - *Podded*
    - Optimized liners for inlet and aft bypass
    - Bifurcation liners
  - Unducted Single Fan (USF) – *Open Fan*
    - Optimized external core nacelle liner
    - Treated OGVs
    - External airframe liners
- **Evaluation**
  - Liner Technology Facility (TRL 1-4)
  - **Static Engine Test (TRL 6)**
  - Virtual 9x15 tests (Performance Assessment)

Podded



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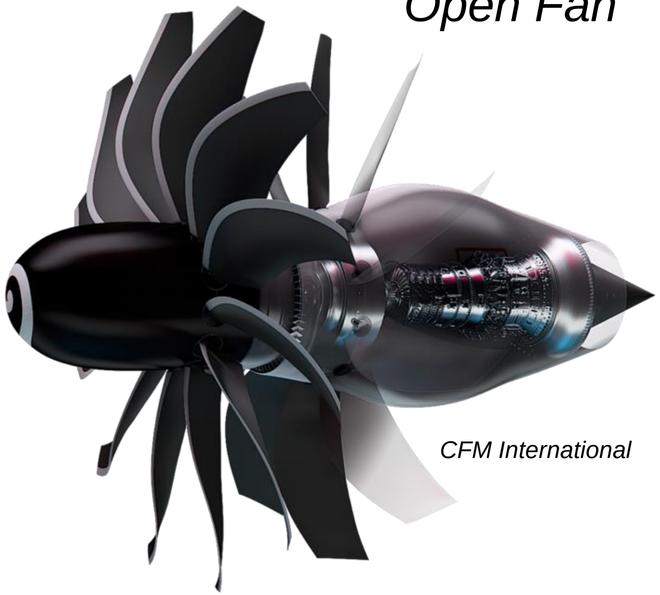
Open Fan



CFM International

Partnership with Honeywell Aerospace for a static engine test to evaluate advanced liner designs for the aft bypass duct

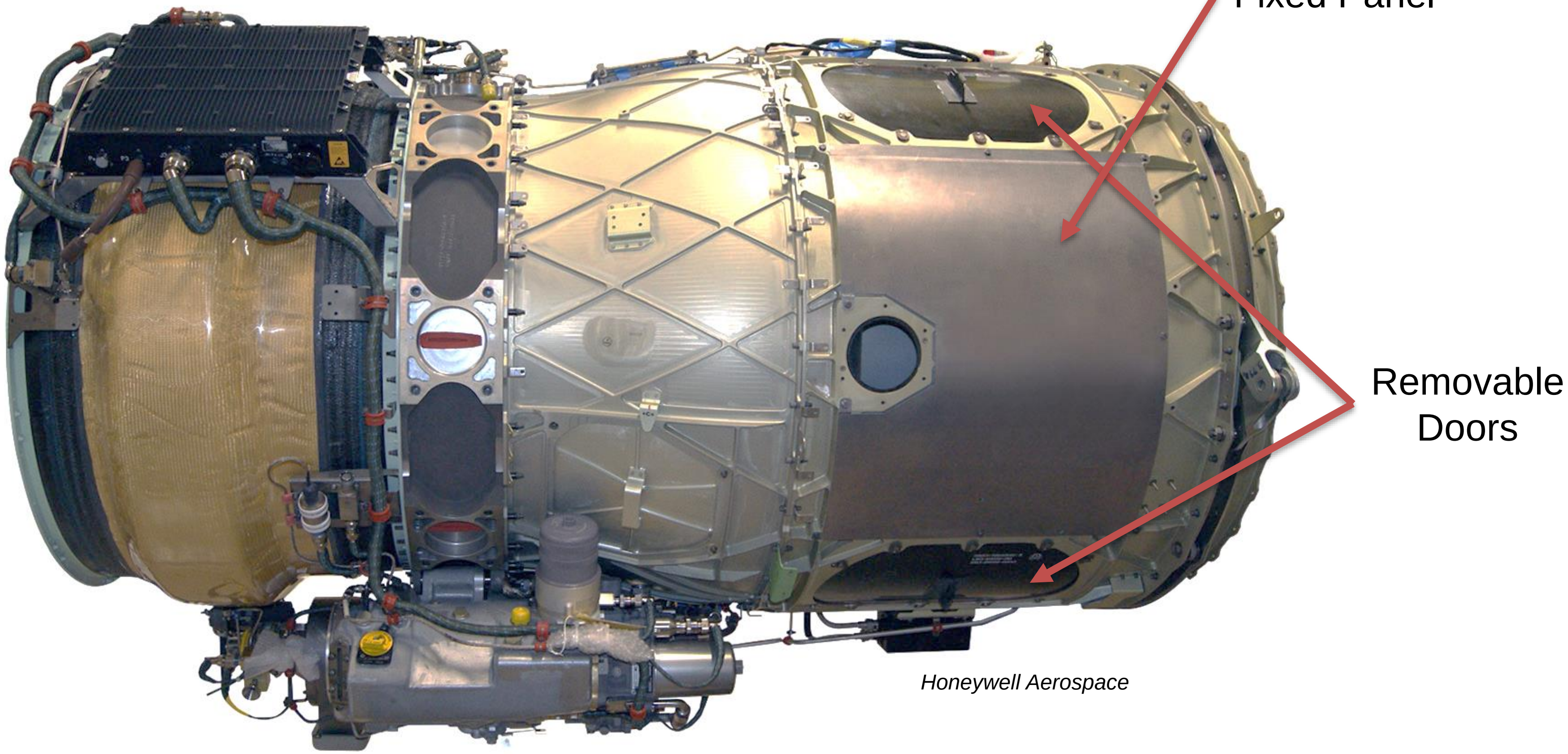
Honeywell Test Engine – AS907-3 (HTF7000-3)

<u>Key parameters</u>

- 6500-7500 lbf thrust
- BPR - 4.4
- 34.2 in. dia. fan
- 22 fan blades
- 51 fan stators

<u>Usage</u>

- Medium-size biz jets
- ~2000 units produced



Honeywell Aerospace

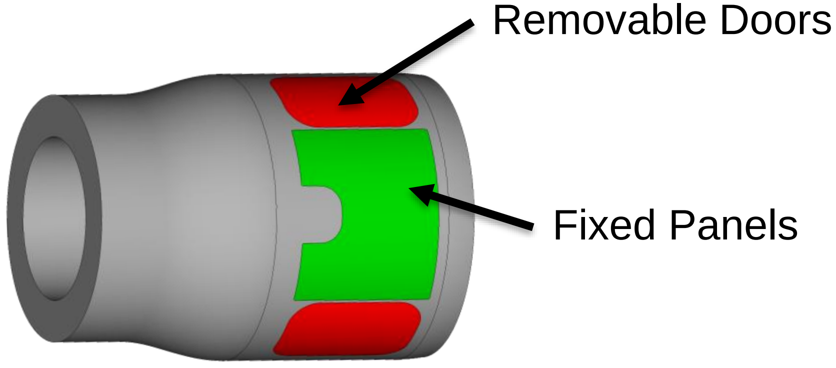
Honeywell Aerospace

Opportunity to test advanced liner concepts at TRL 6 in the aft bypass duct and validate liner design toolchain

Acoustic Liner Design Method

Indirect Approach

- **Step 1**: Optimize liner acoustic impedance to achieve maximum attenuation over range of frequencies and flow conditions
- **Step 2**: Optimize liner parameters to match target impedance from Step 1 (if possible)
- **Step 3**: Evaluate and iterate designs in the ***Liner Technology Facility***



Engine Aft Bypass Duct

CDUCT-LaRC (CDL)

- Parabolic approximation to the Convected Helmholtz Equation
- Acoustic source: All cut-on modes
  - 11 trials: random amplitude/phase
  - combined *coherently*

ACTRAN TM

- Convected Helmholtz Equation
- Acoustic source: All cut-on modes
  - propagated individually with equal energy
  - combined *incoherently*

ZKTL

- Transmission line approach
- Transmission matrix for each liner design element
- Predict liner impedance from liner geometry

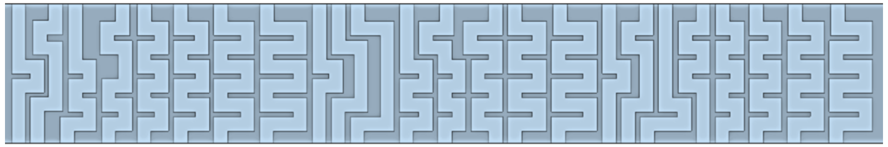
Liner Design Concepts

<u>Narrow Channel (NC)</u>

- Array of square cross-section channels
  - cross-section: 0.045 in. x 0.045 in.
  - minimum partition thickness: 0.015 in.
- Replicate unit cell to fill available volume
- Variable depth → broadband performance
- Bent chambers → reduced core thickness
- Resistance from wall scrubbing losses (no facesheet)
- Built additively using Ultracur3D RG 3280 resin

NC-24

0.45 in.

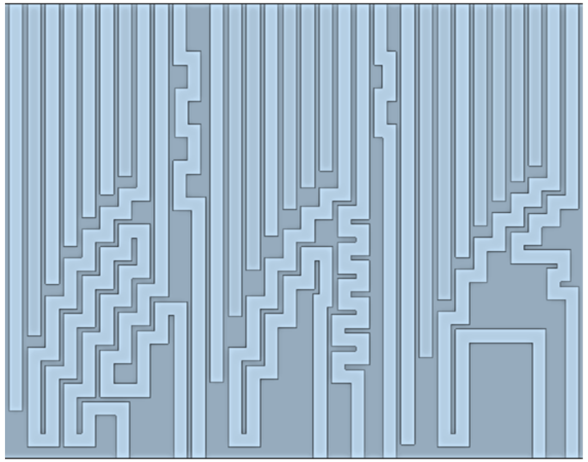


24-ch unit cell

Fixed Panel Liner

NC-30

1.5 in.



30-ch unit cell

Removable Door Liner

Flow

Liner Design Concepts

Optimized Hexcel Acousti-Cap

- Tunable for extended frequency range
- Proven technology ready for flight
- Lightweight construction
- Performance: 2DOF ~ 3DOF/MDOF
- Applied only to the removable door panels

Key parameters

Facesheet POA: 16%

Facesheet thickness: 0.0476 in.

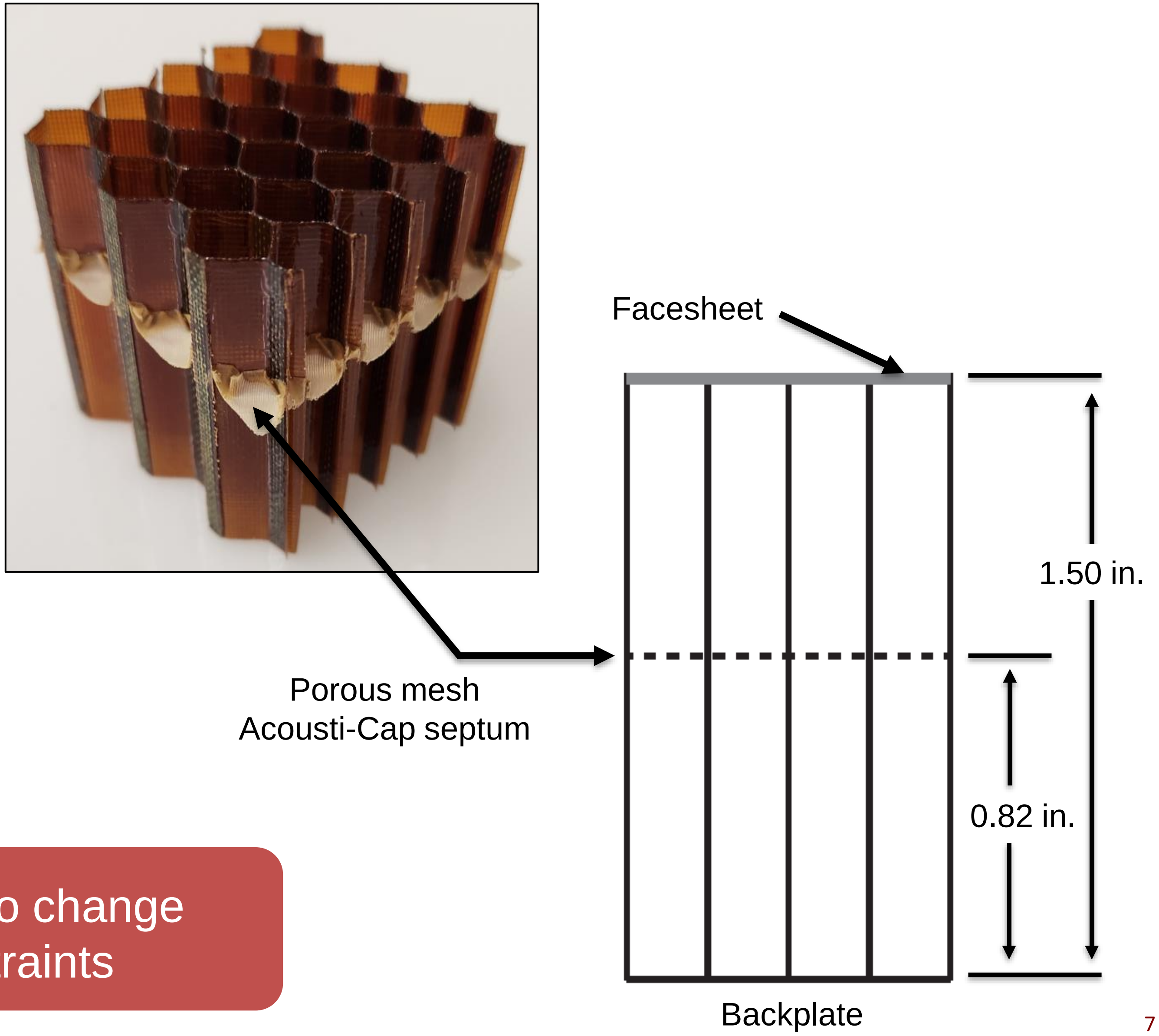
Hole diameter: 0.030 in.

Cavity depth: 1.424 in.

Septum depth: 0.82 in.

Septum resistance: 615 MKS Rayls

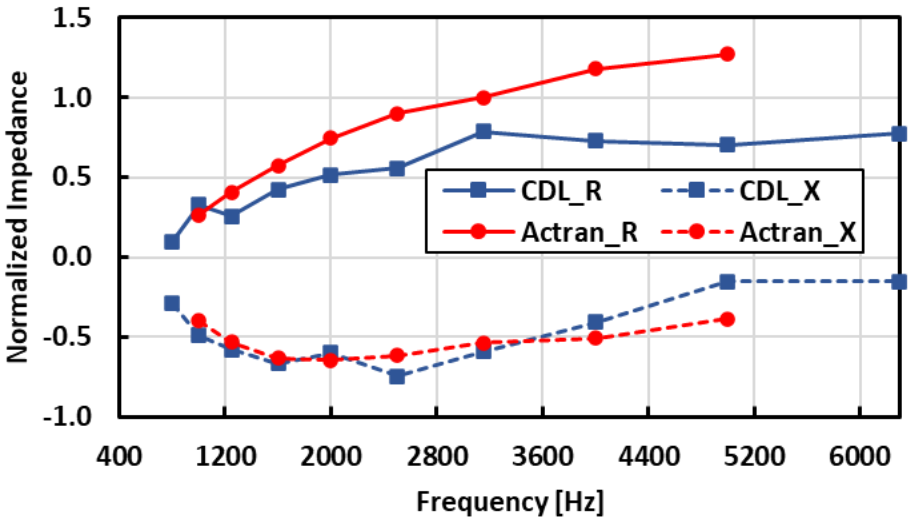
Acousti-Cap Core



Liner design parameters subject to change based on manufacturing constraints

Pre-test Predictions – Approach

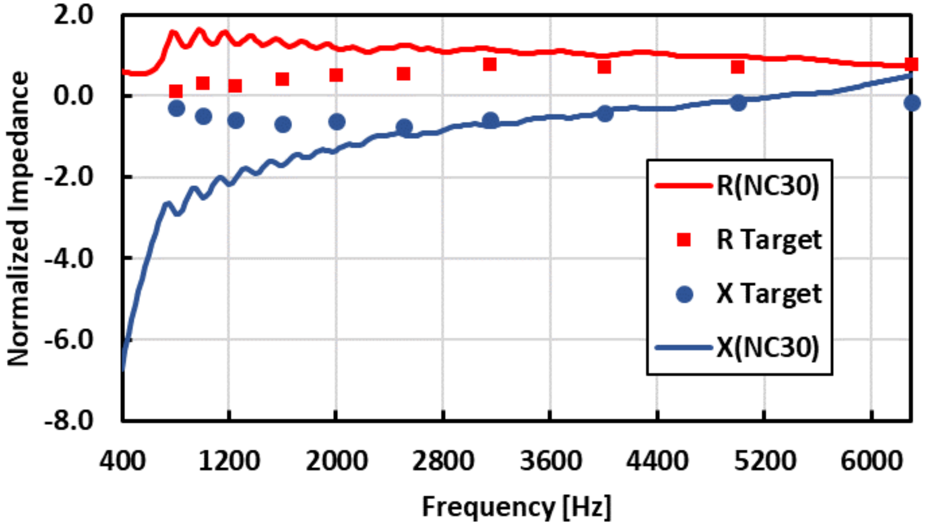
Optimal Impedance – Removable Doors



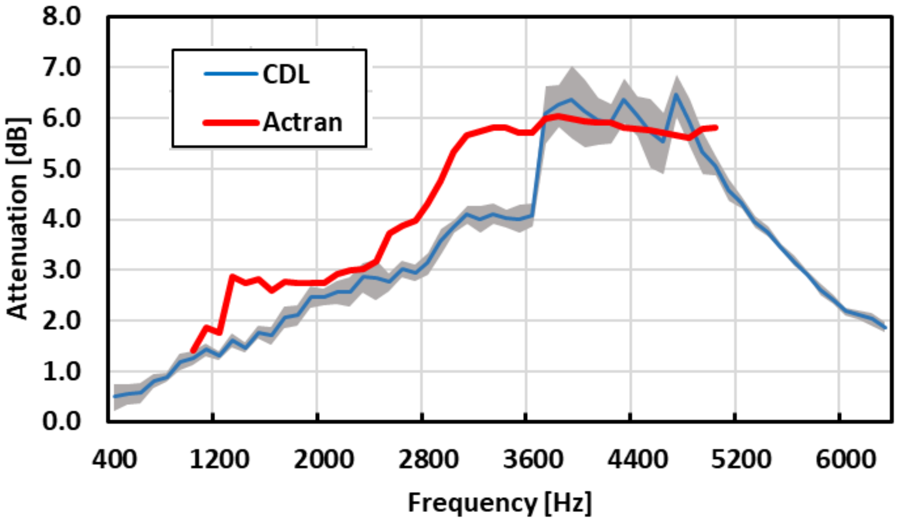
Combined Predicted Acoustics

- Optimal Impedance
  - Good agreement between CDL and ACTRAN
  - Similar resistance trends w/ near identical reactance
  - **Not physically achievable**
- NC-30 Design Impedance
  - Optimized to best match reactance
  - Resistance allowed to deviate from targets
- Significant predicted attenuation for all liner configurations
- Jump at 3.6kHz due to source modal content

Design Impedance - NC-30 Removable Doors



In-Duct Attenuation - NC-24 fixed panels w/ NC-30 doors

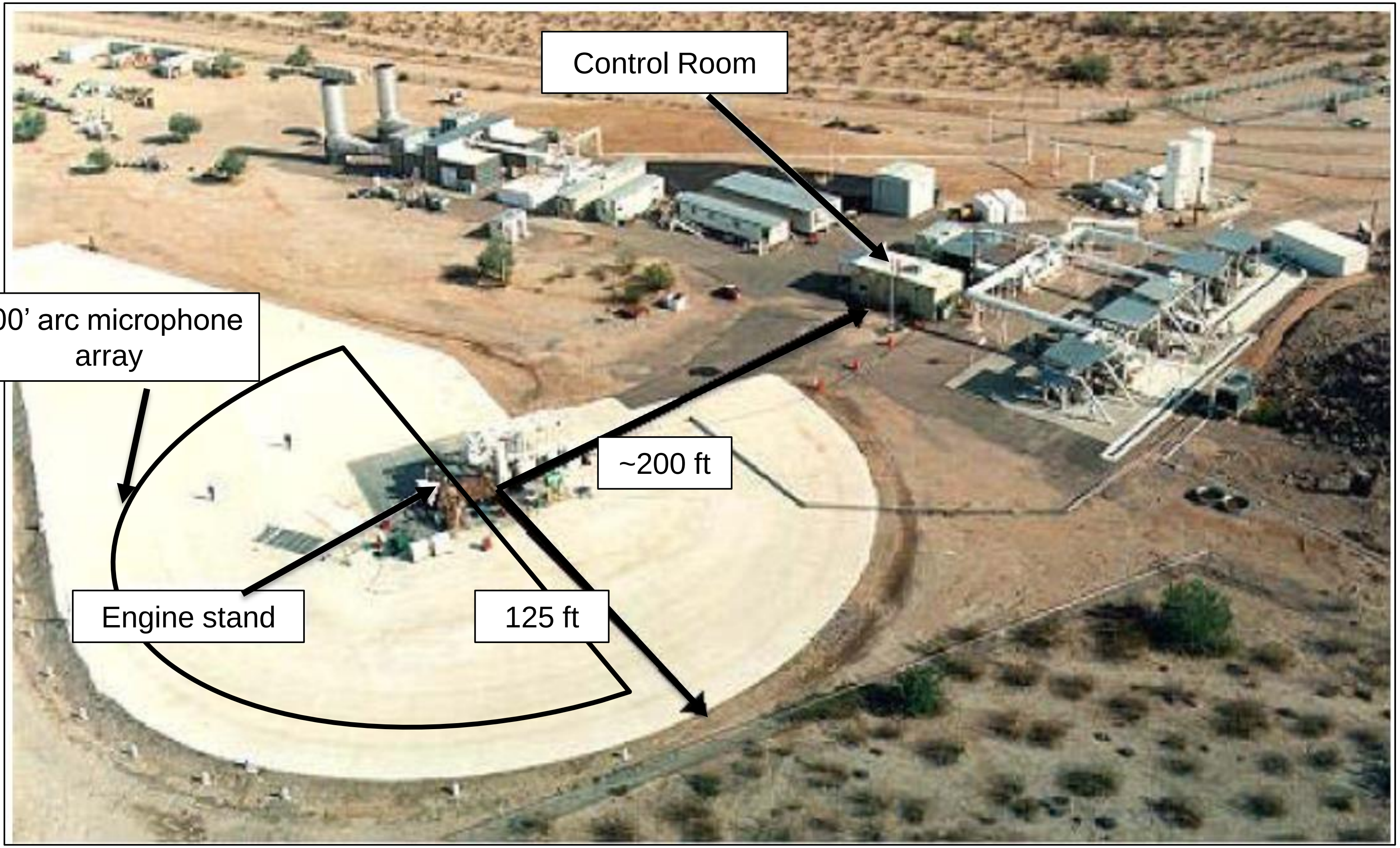


Honeywell Test Facility – San Tan

Key details
- South of Chandler, AZ
- Operational for over 50 years
- Measure engine performance and acoustics
- 32 microphones spaced at 5° increments*

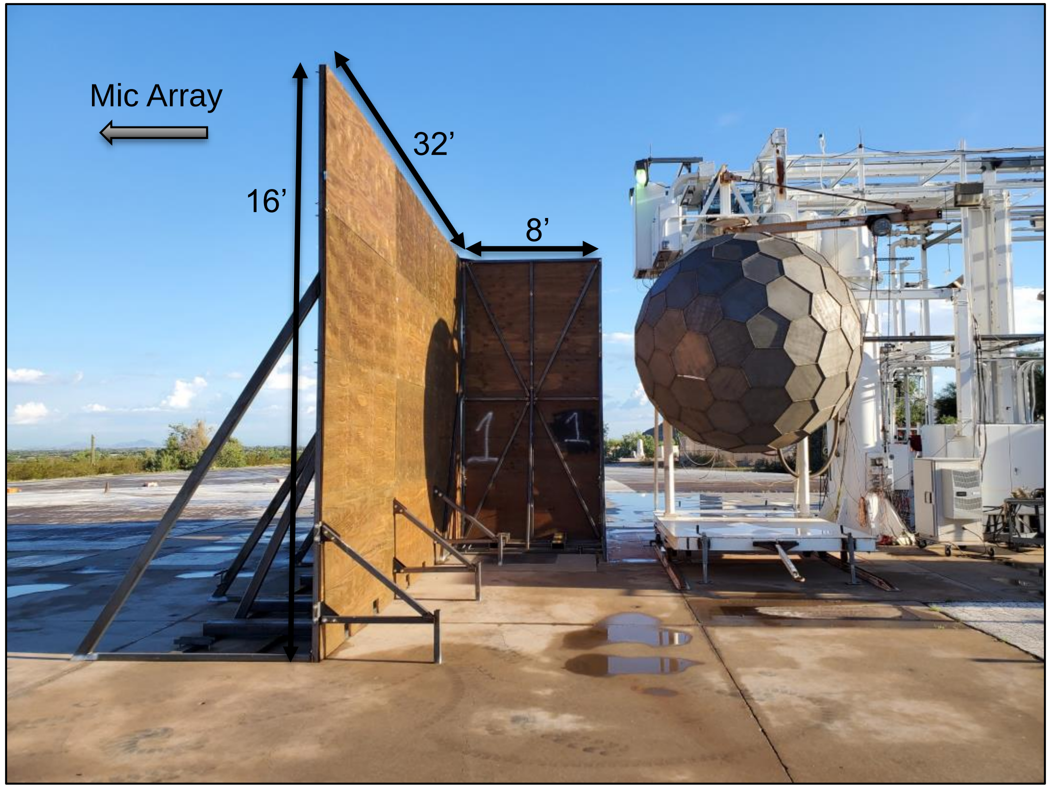
* 4 additional mics for scattering data off arc (if needed)

Previous NASA collaborations
- EVNERT (2005)
- EVNRC (1999)

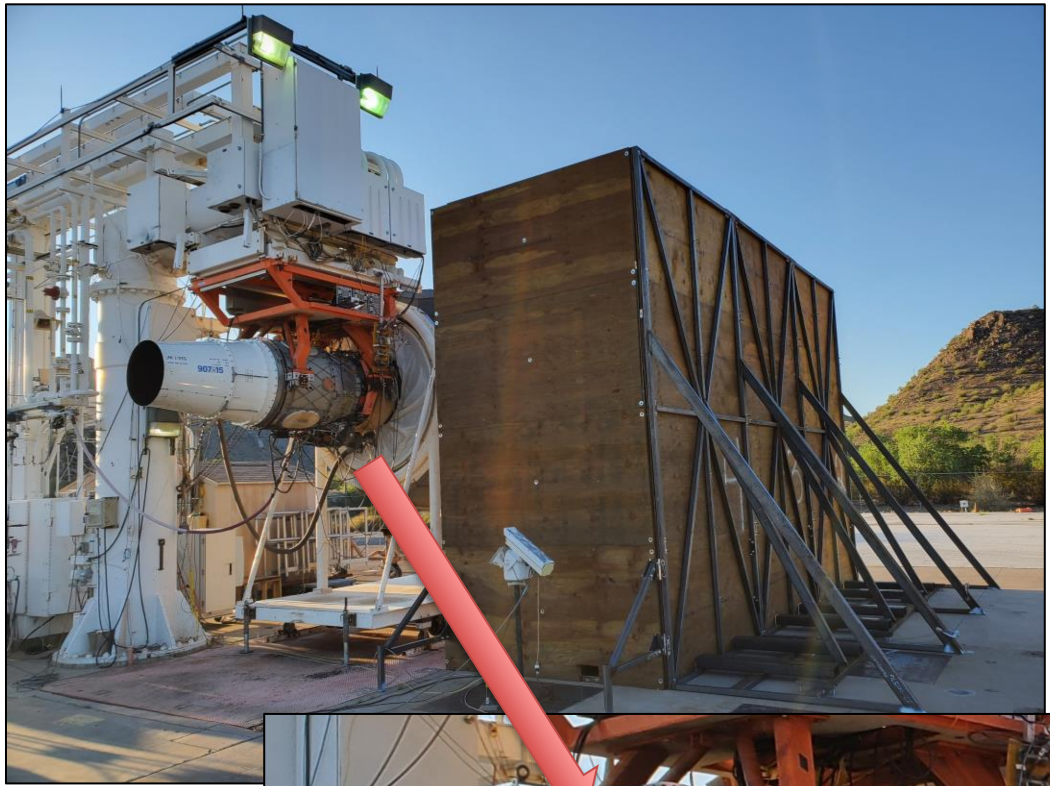


Honeywell Aerospace

Honeywell Test Facility – San Tan



Honeywell Aerospace



Honeywell Aerospace

- Engine centerline @ 10ft height
- Acoustic barriers to block engine inlet noise from mic array
- Potential runs with acoustically treated barriers to get scattering data (time permitting)

Proposed Test Plan

Order	Priority	Doors	Panels	Barrier	Comments
1	1	HW	HW	Fwd	Baseline configuration, hardwall panels/doors
2	3	NC-30	HW	Fwd	
3	3	2DOF	HW	Fwd	
4	3	HW	NC-24	Fwd	
5	2	2DOF	NC-24	Fwd	Downselect between these configurations if test time becomes critical
6	2	NC-30	NC-24	Fwd	
7	4	NC-30	NC-24	None	
8	5	HW	HW	Fwd w/ treatment	Dependent on available time and earlier results. Barrier placement is TBD and may also include treatment.

Isolate door effects

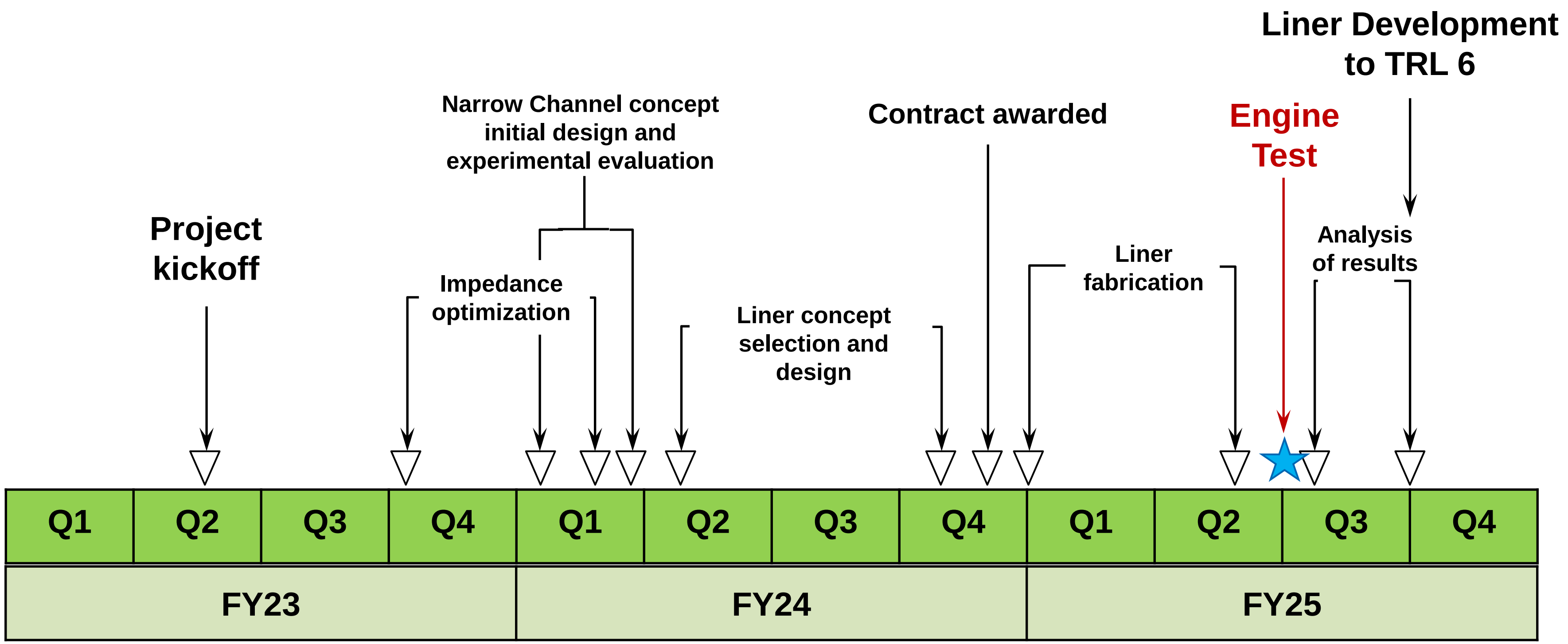
Isolate panel effect

Combined treatment

Barrier scattering effects

- Five days of testing
- Test order driven by time to install *fixed liner panels*
- Potential scattering effects add-on for TDFAST development/validation

Project Schedule



- Contract awarded last month ($250K)
- Fabrication schedule driven by material availability
- Results to support TRL 5 liner development (will achieve TRL 6)
- Scattering effects add-on for TDFAST development/validation (future need for open-fan configurations)

NASA

Backup Material

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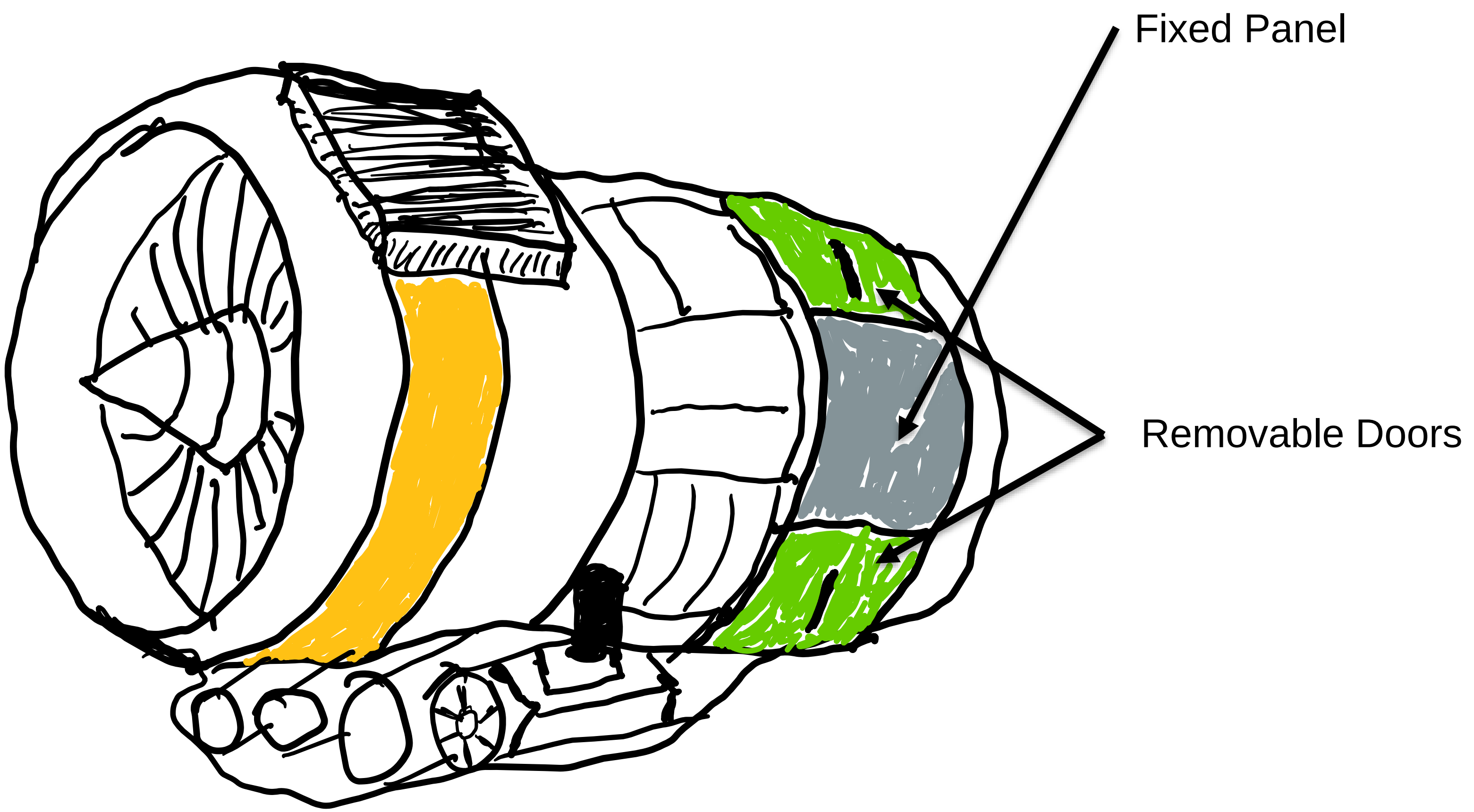

Opportunity to test advanced liner concepts at TRL 6