DGEN380 Aero-propulsion Research Turbofan (DART) – Status Update

Acoustics Technical Working Group Meeting

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NASA Glenn Research Center
Cleveland, OH
1-November-2023

DGEN380 TURBOFAN ENGINE

2 spool, geared fan (3.32 ratio), unmixed, separate flow exhaust

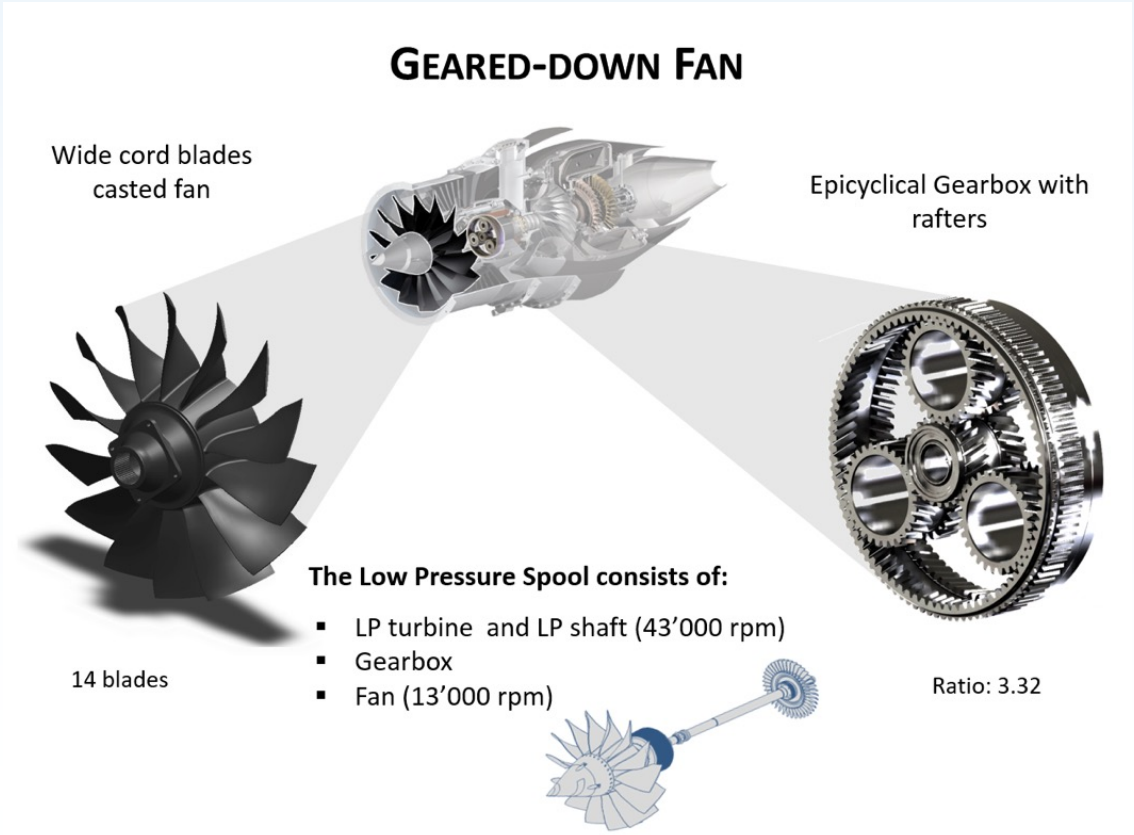
Centrifugal compressor, LP turbine (43,000 rpm), HP turbine (52,000 rpm)

14 inch diameter fan, 14 fan blades (13,000 rpm)

Thrust 560 lbf, 6.8 BPR,1.2 FPR, 5.3 OPR, 28.7 lb/s

Inlet mass flow, V_{tip} = 785 fps subsonic tip speed

Low component count/easy disassembly
Drawings Available

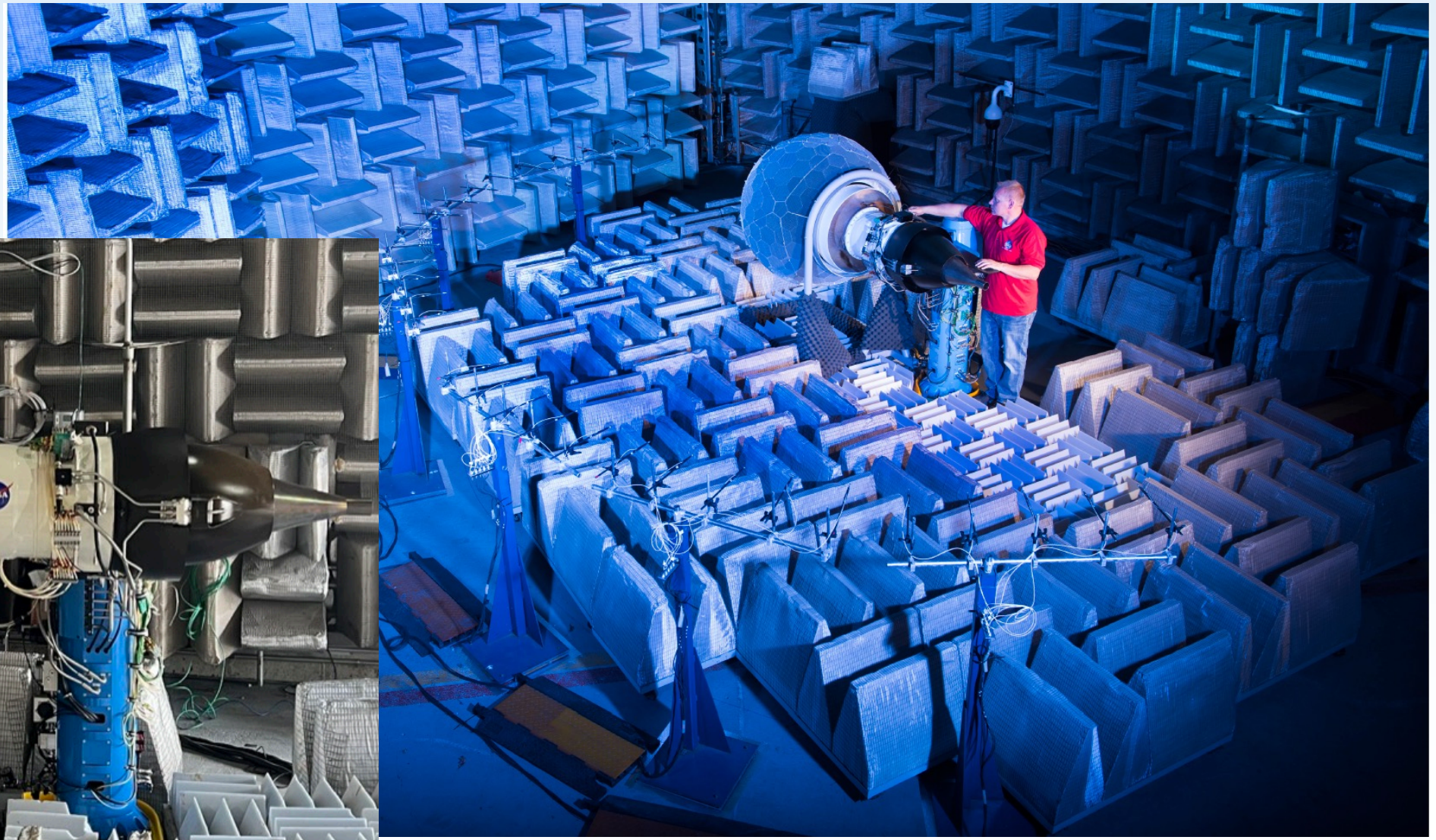


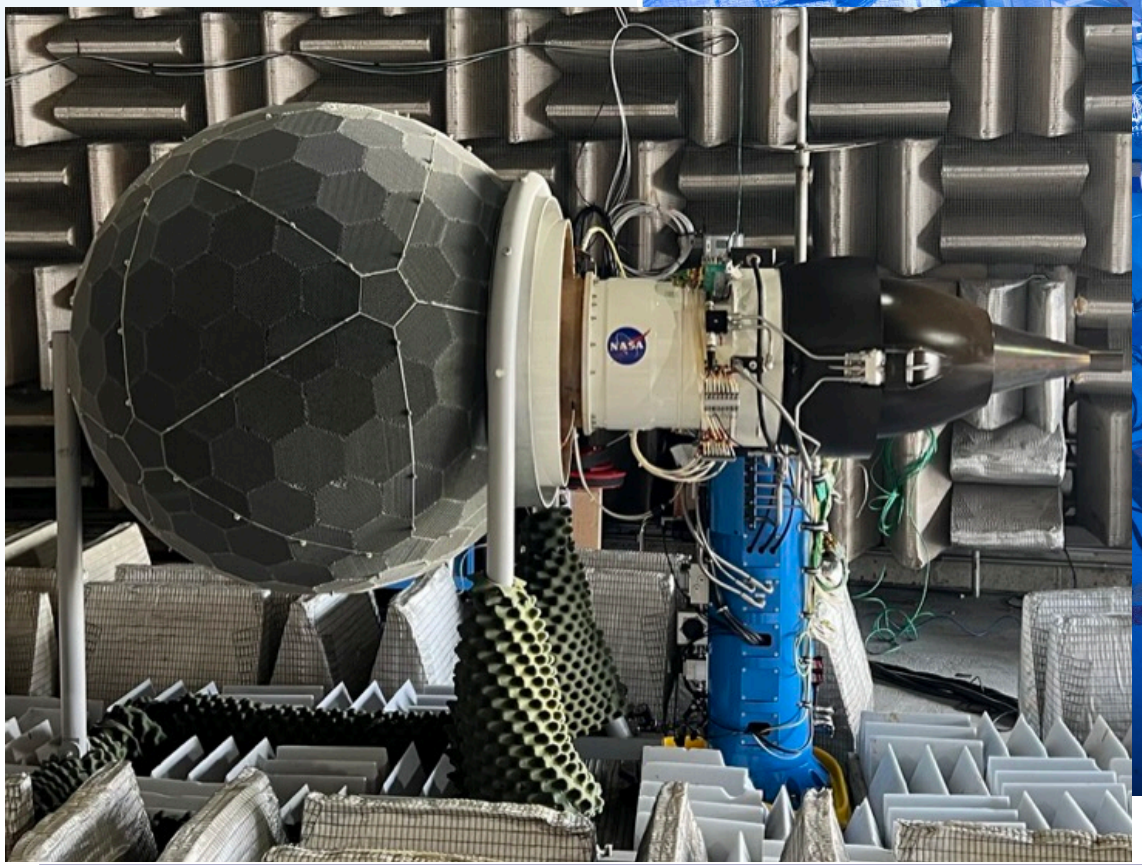
DART

DART in GRC
AeroAcoustic Propulsion Laboratory (AAPL) Facility – “the Dome”

DGEN380 TURBOFAN ENGINE

DART in AAPL





LABORATORY INNOVATION FUND

The LIF fund is intended to support laboratory investments that are aligned with GRC's core competencies and are of strategic interest to the Center but otherwise uncovered by a project.

Key Highlights

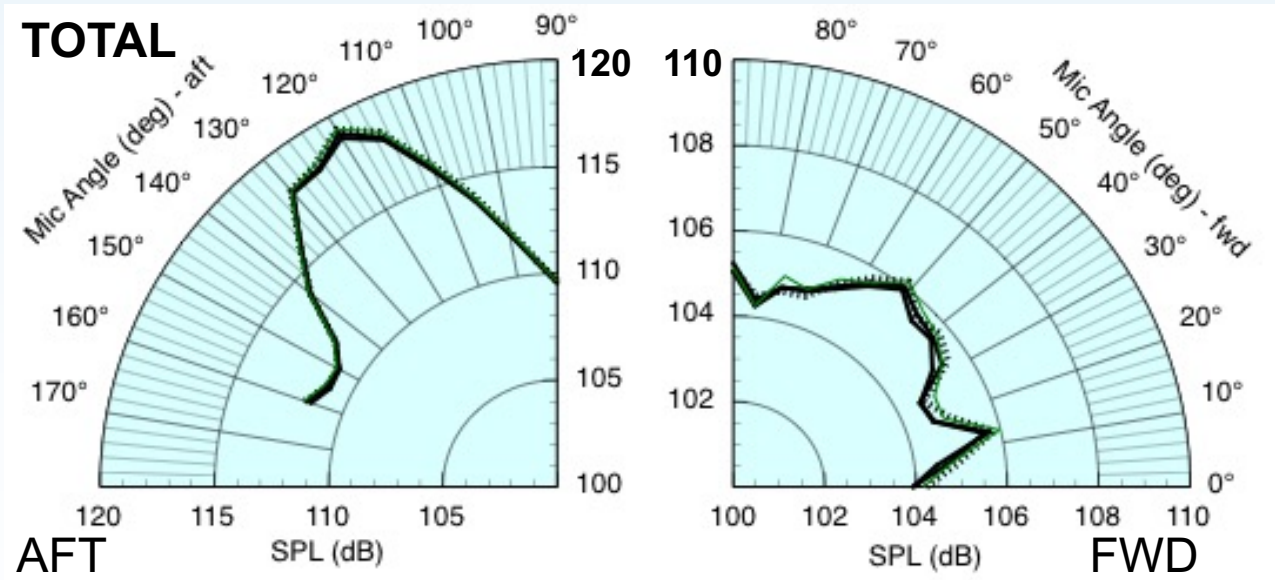
- Heavy Maintenance (required) completed by vendor.
- HPT and shaft replaced.
- 2 T-FOME mechanics trained in inspection process & maintenance procedures.
- Spare Combustor chamber and injector set obtained.
- Critical spare parts obtained.
- New control computer procured with latest OS per IT security requirements.
- Baseline acoustic data acquired in support of FY24 tasks.

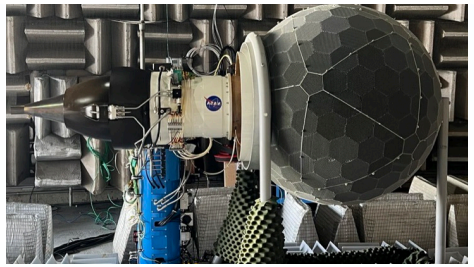
TRAINING at AKIRA FACILITY

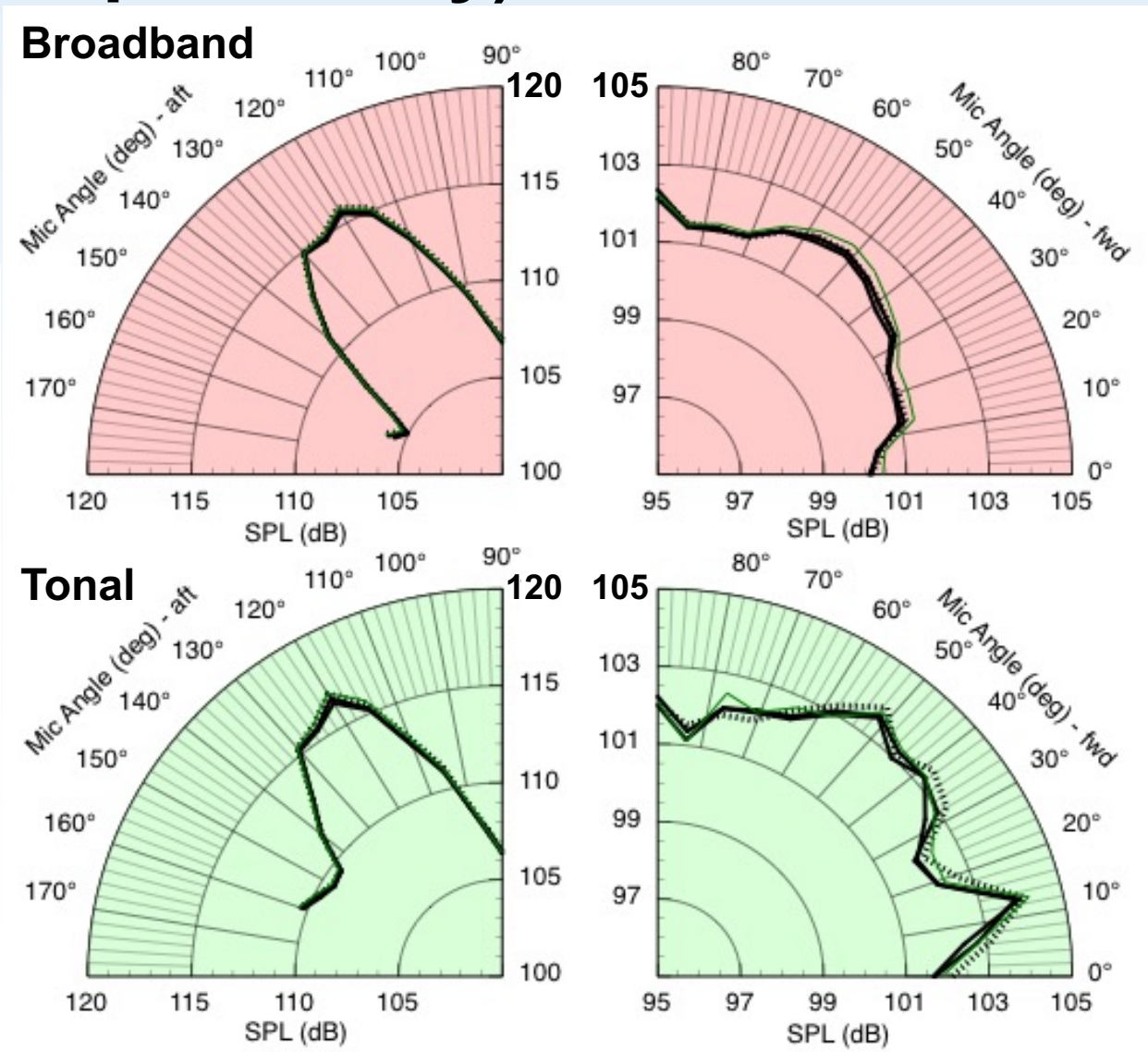
ACOUSTIC DATA BASELINE (2023 repeatability)

OASPL : 100 Hz to 40kHz
@92.5% N1c

removal technique:
D. Sree, “A novel signal processing technique for separating tonal and broadband noise components from counter-rotating open-rotor acoustic data”, *International Journal of Aeroacoustics,* vol. 12, no. 1+2, pp. 169-188, 2013.







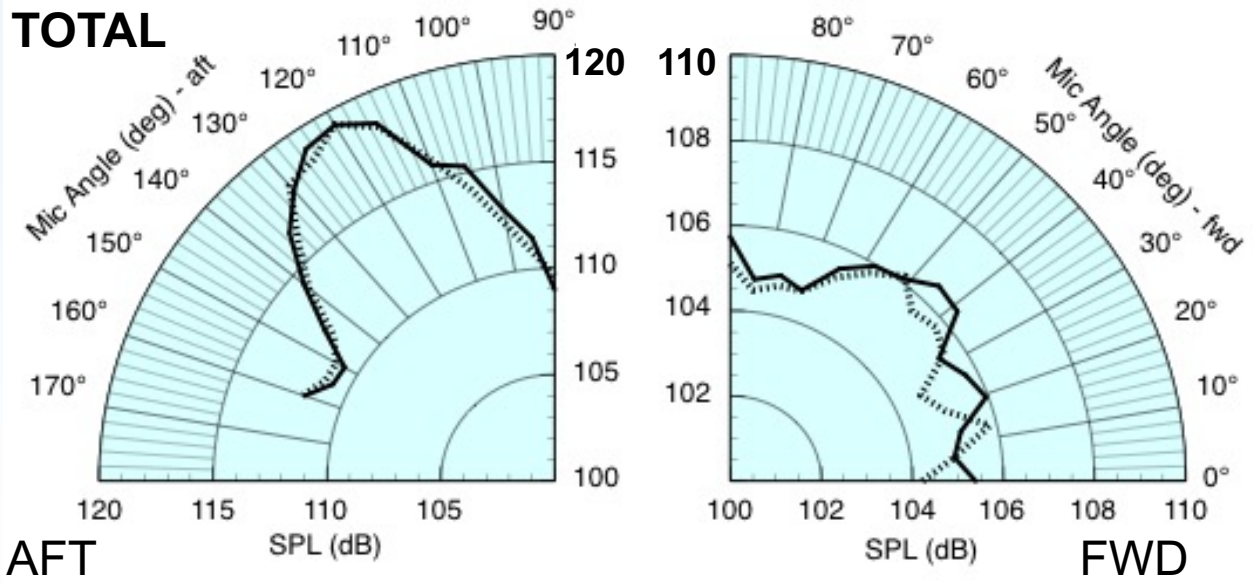
ACOUSTIC DATA BASELINE (2017vs2023)

OASPL : 100 Hz to 40kHz
@92.5% N1c

removal technique:

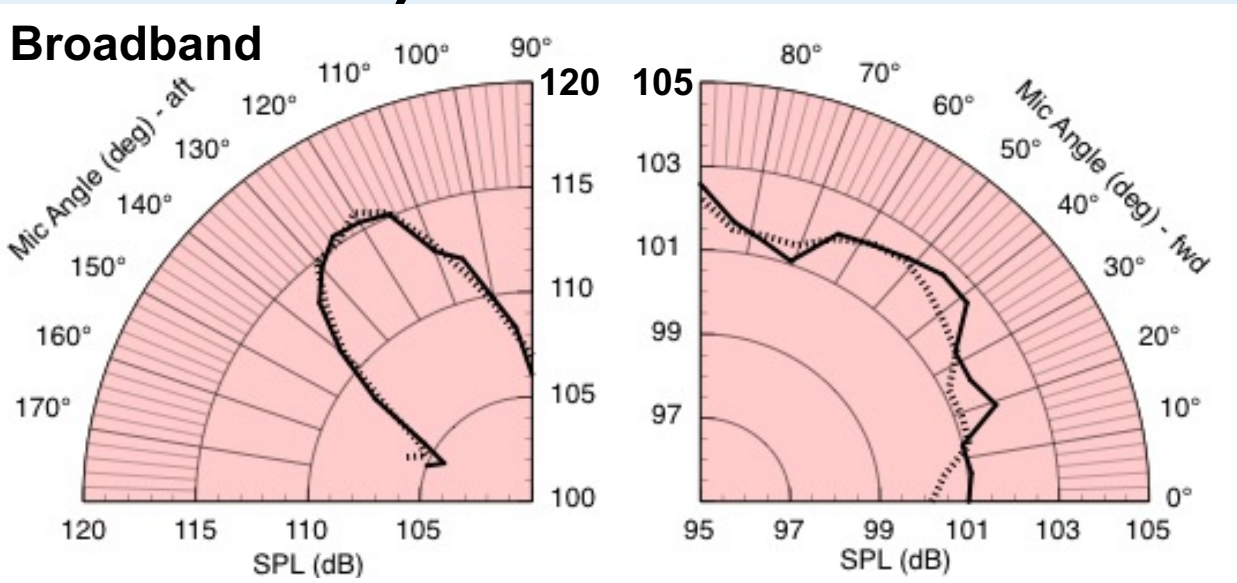
D. Sree, “A novel signal processing technique for separating tonal and broadband noise components from counter-rotating open-rotor acoustic data”, *International Journal of Aeroacoustics,* vol. 12, no. 1+2, pp. 169-188, 2013.

TOTAL

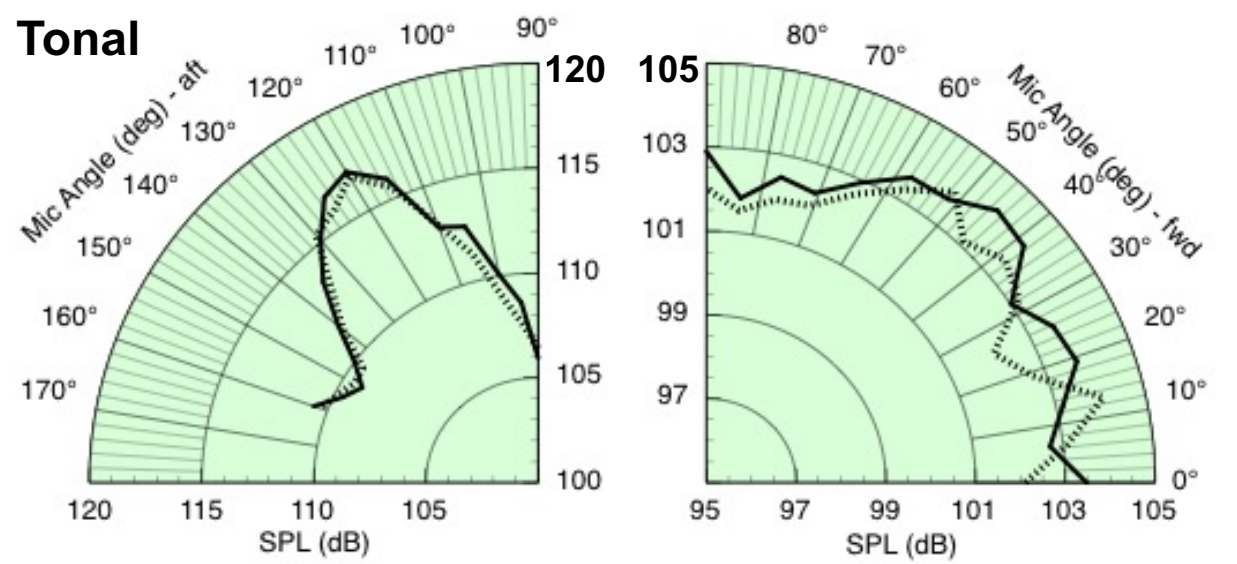


AFT FWD

Broadband



Tonal

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DGEN AEROPROPULSION RESEARCH TURBOFAN


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ACOUSTIC DATA BASELINE
(GEN3i vs HBK LAN-XI Tescia)

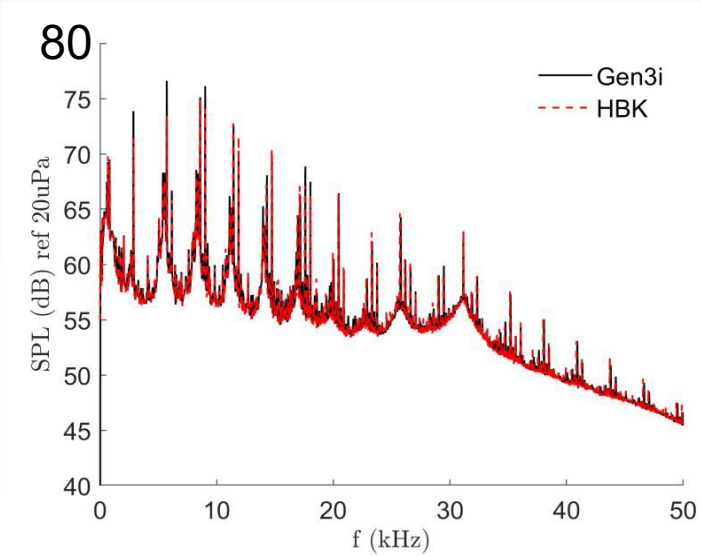
- Far field mic data recorded with the new unsteady data acquisition system
  – Hottinger Bruel and Kjaer's (HBK) **LANXI** Data Acq. hardware and **Tescia** Repetitive Testing software
- Successful validation of hardware setup, calibration and data acquisition routine
- Excellent agreement with Gen3i data at various RPMs

HBK LANXI DAQ system

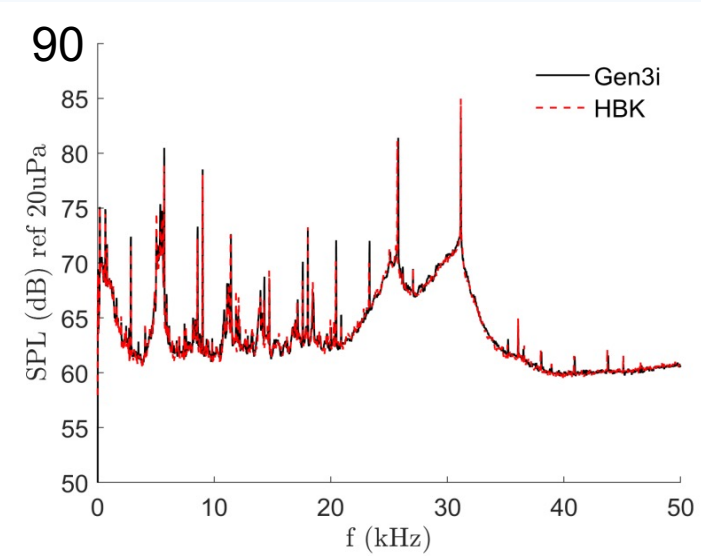
- ✓ Bandwidth: **DC – 102 kHz**
- ✓ Dynamic range: **160 dB**
- ✓ Low noise floor
- ✓ Multi-purpose input: direct voltage, CCLD, mic preamp (0 or 200 V polarization)
- ✓ LAN interface
- ✓ Real-time signal processing (e.g., FFT) with **Tescia**

Averaged spectra comparison at 92.5 % RPMc

FWD Arc

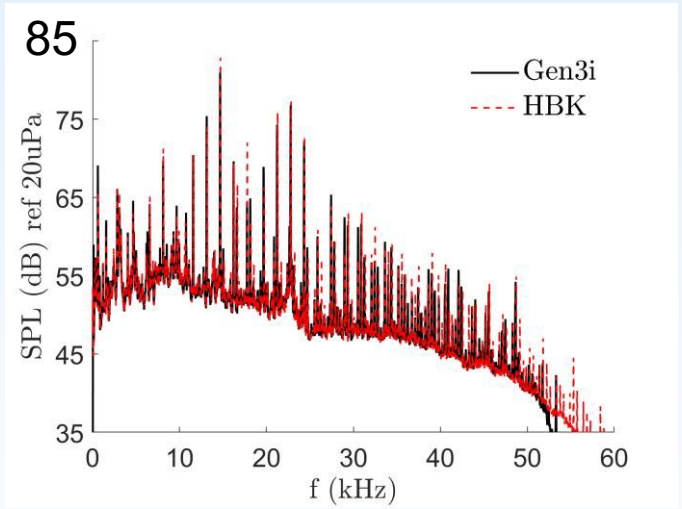
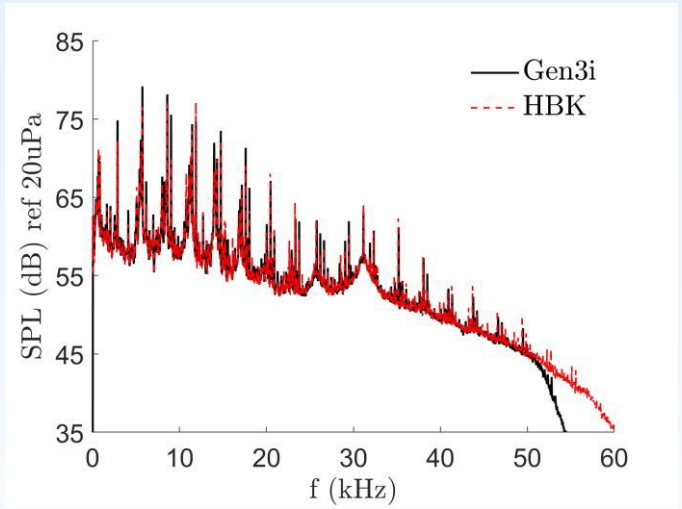
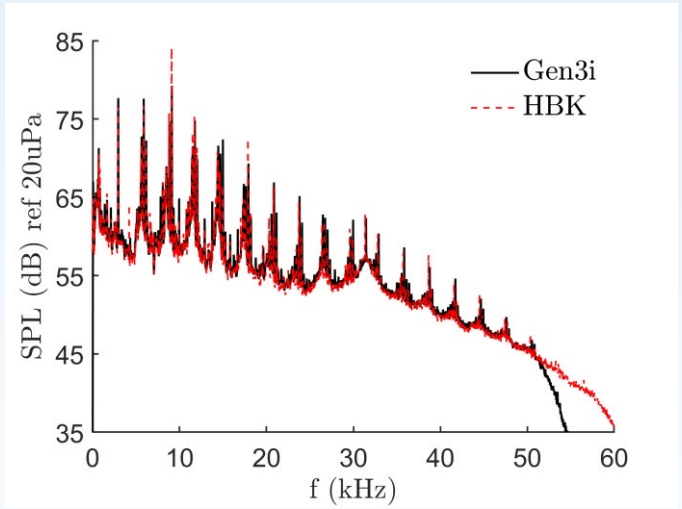
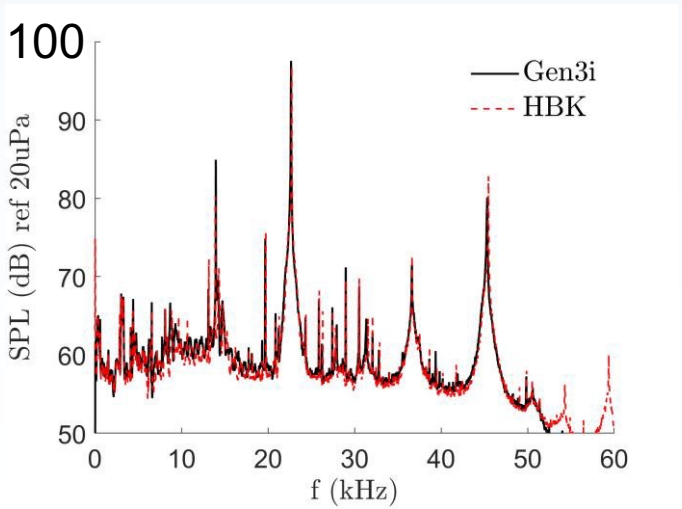
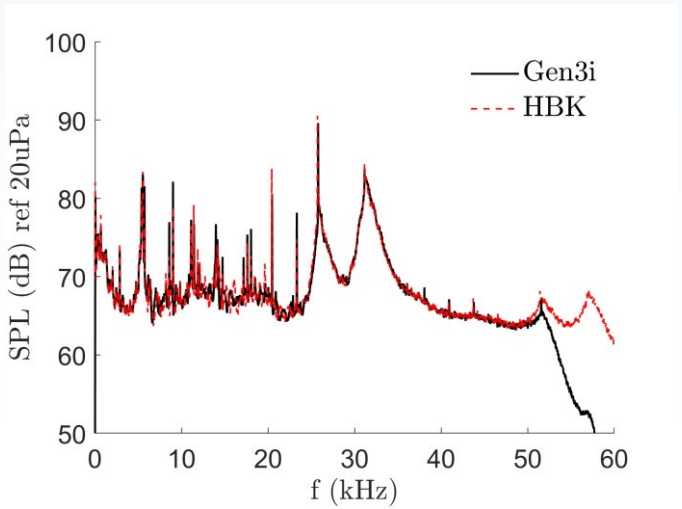
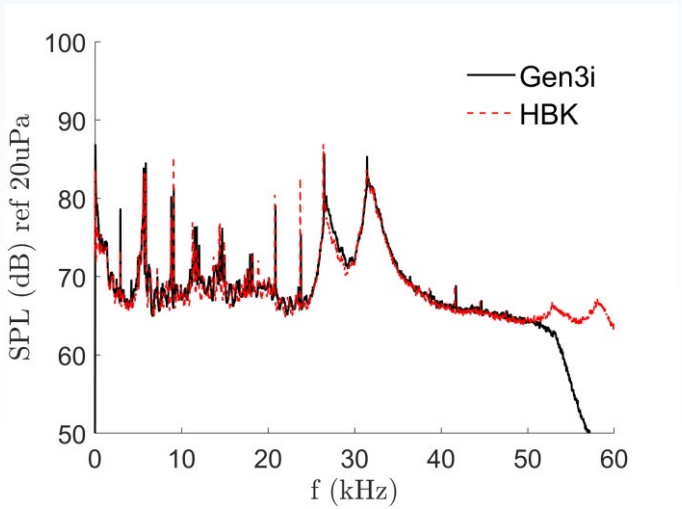


AFT Arc



ACOUSTIC DATA BASELINE

(GEN3i vs HBK LAN-XI Tescia)

	RPMc = 50%	RPMc = 92.5%	RPMc = 95%
FWD ARC Mic at 38.6°			
AFT ARC Mic at 125°			

Good agreement at all mic locations for various RPMs. Small differences due to variations in operating conditions.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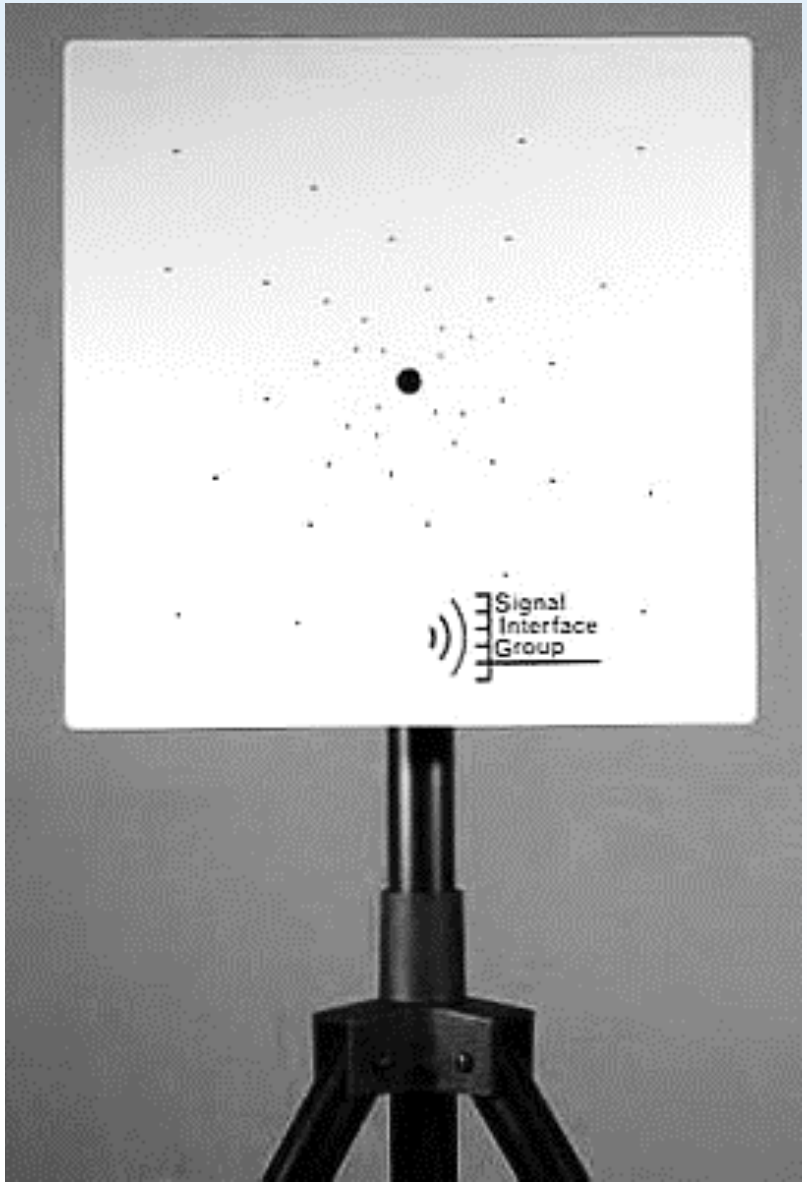
ACOUSTIC DATA BASELINE

(SigArray)



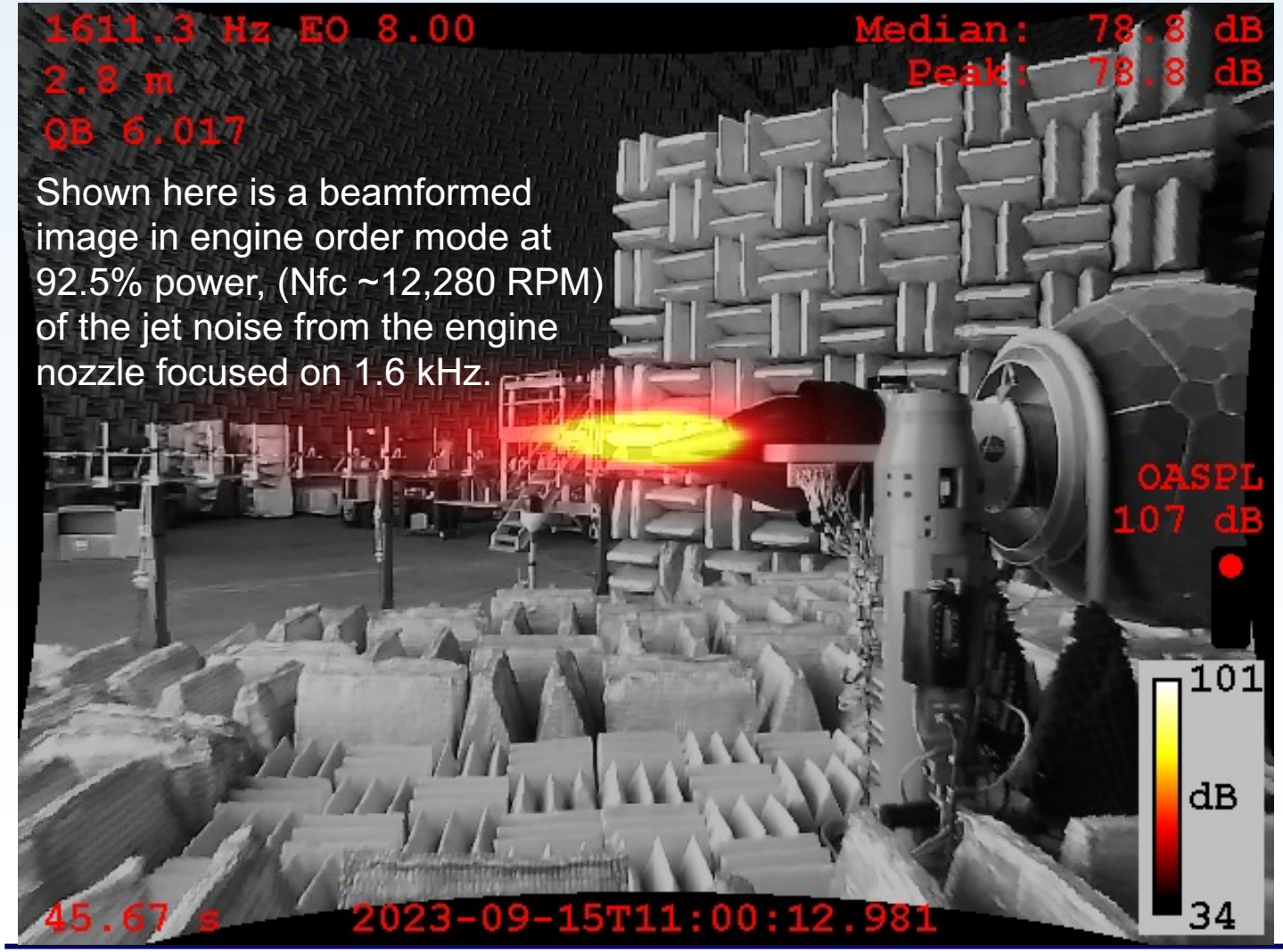
Phased array images acquired for design bracketing of acoustic aspect of Multi-Functional Liner concept.

- The SIG (Signal Interface Group) array is a 40-microphone acoustic phased array that contains a webcam and FPGA in one package. The array is bus powered, allowing for convenient and rapid deployment.
- Maximum recording bandwidth is 50 kHz allowing for a working frequency range of 1 to 24 kHz.
- The array was placed 110 inches (2.8m) from the centerline of the DGEN nozzle. Placement was such that the exhaust plane was perpendicular to the measurement plane of the array.
- This test was performed to review the working operation of the SIG array, **as well as to test the engine order mode with the addition of a 1/rev tachometer signal.**

ACOUSTIC DATA BASELINE

(SigArray)

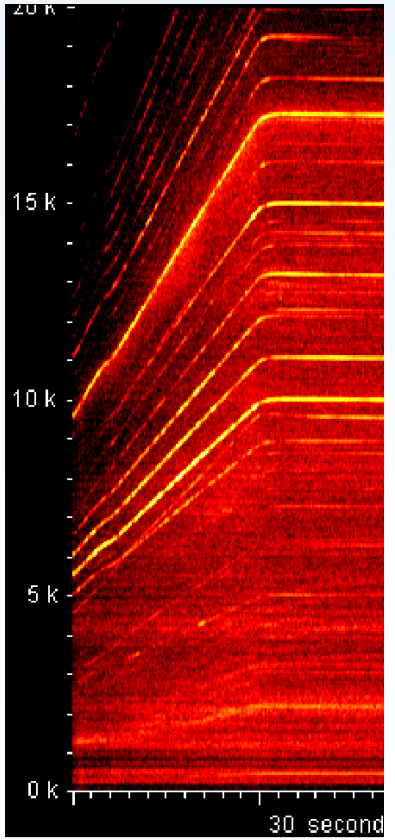
Data were recorded for several engine conditions: Idle, 50%, 92.5%, and 95% engine power.



Shown here is a beamformed image in engine order mode at 92.5% power, (Nfc ~12,280 RPM) of the jet noise from the engine nozzle focused on 1.6 kHz.

One limitation of using the SIG array for this test was that the frequency response of the array did not cover all the tones generated by the engine.

The spectrogram reveals core tones moving beyond the range of the capture before the engine was on condition.

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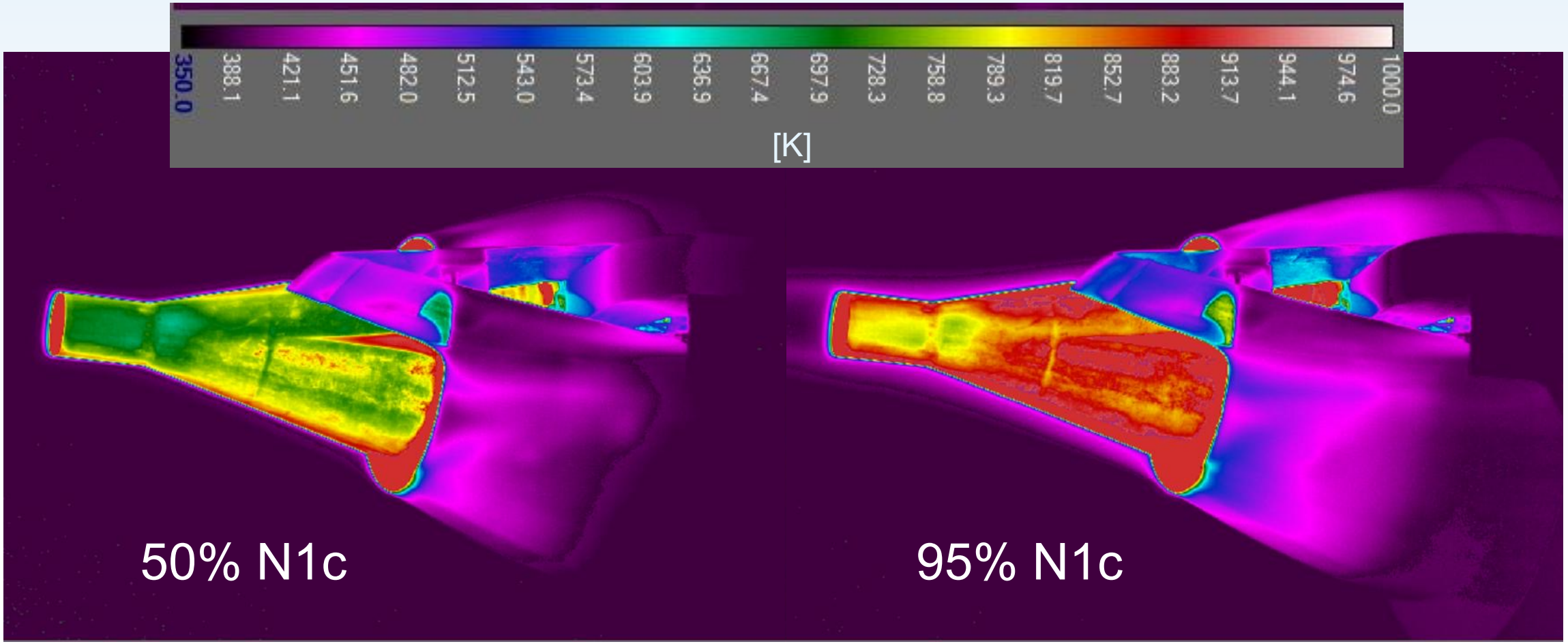
THERMAL DATA BASELINE

(IR Camera)

IR camera images acquired for design bracketing of thermal aspect of Multi-Functional Liner concept.

- temperatures approximate based on a constant emissivity value.
- compares favorably to vendor supplied thermal couple data



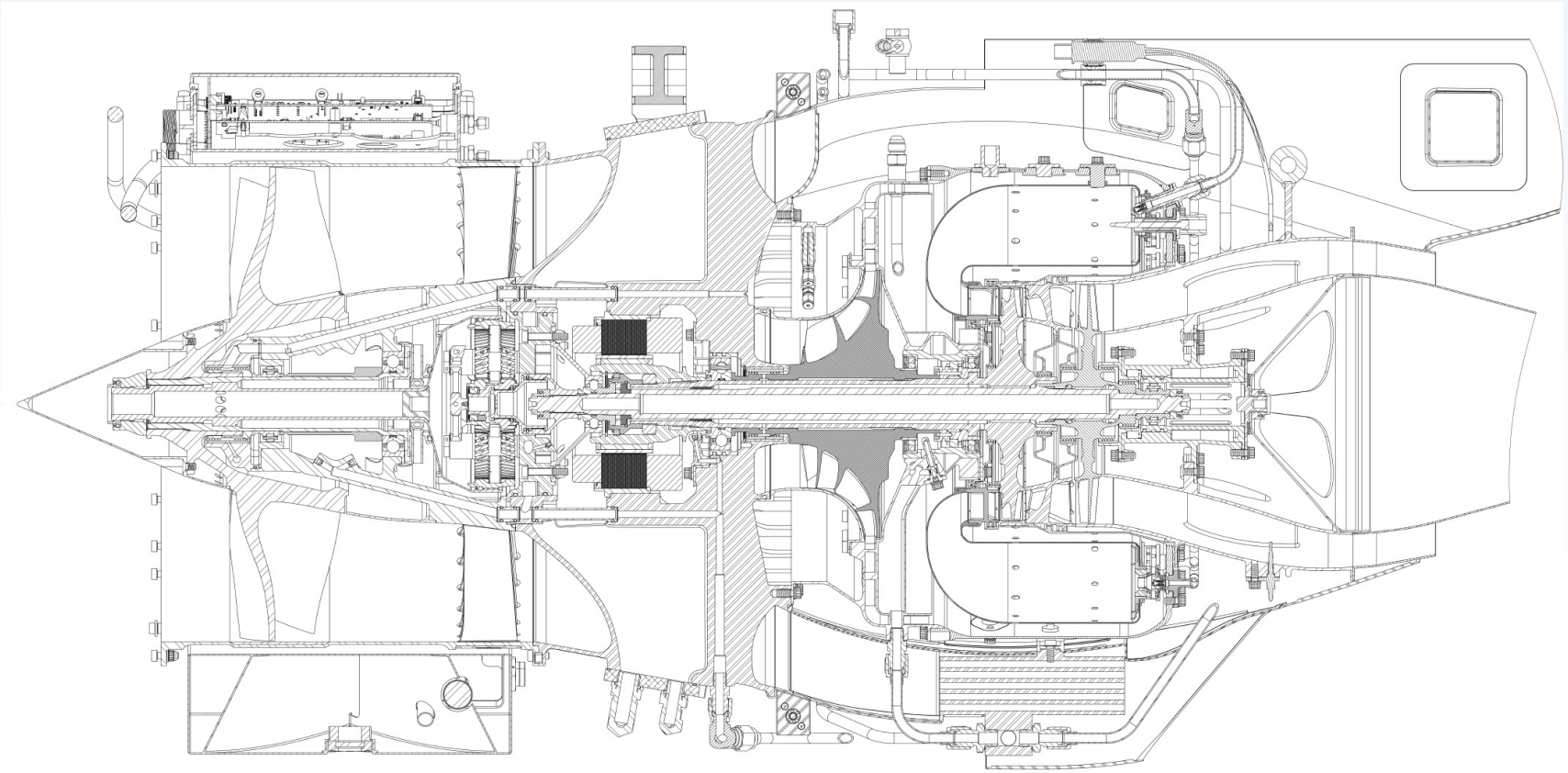
GENERAL INFO

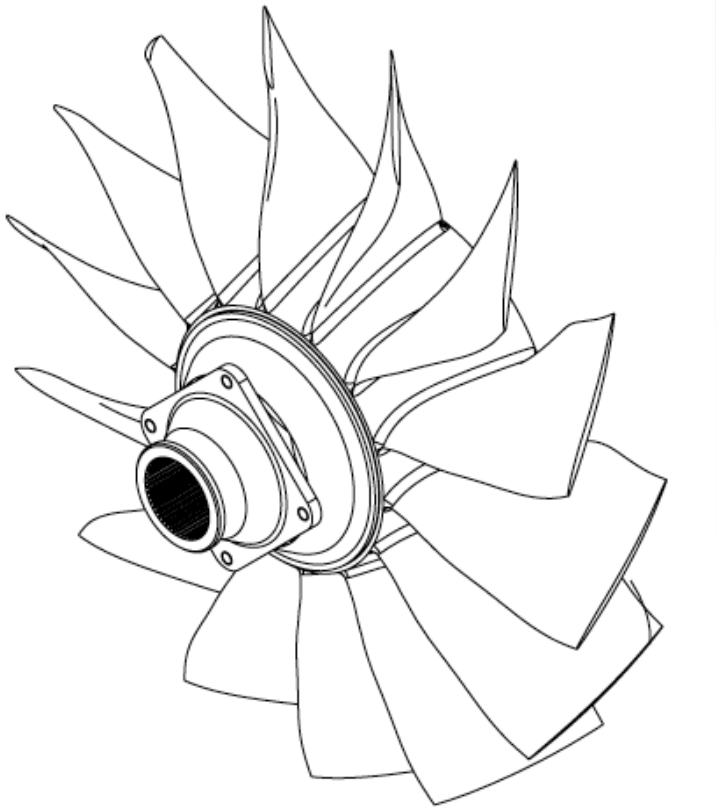
Shareable:

1)NASA acquired farfield data
2)Data acquired by FADEC & Acquisition unit
3)PDF cross section drawings of the engine

AKIRA is available for consultation/analysis

"detail drawings of static and rotational parts –you have to ask us case-by-case"





COMMENTS?