Highlights of the Test of the QUiet Electric Engine (QUEEN V1) in the NASA GRC Acoustical Testing Laboratory (ATL)



L. Danielle Koch, P. E.
Aerospace Engineer
NASA Glenn Acoustics Branch
Hybrid Acoustics Technical Working Group Meeting
October 8, 2024
L.Danielle.Koch@nasa.gov

This work has been supported by NASA's ARMD Convergent Aeronautics Solutions (CAS) project.

Outline

- Description of NASA's Subsonic Single Aft Engine (SUSAN) Concept Aircraft
- Description of the SUSAN 25% Flight Research Vehicle (SUSAN 25% FRV)
- Description of the QUEEN V1 for the ATL test
- Test objectives
- Experiment overview
- Selected preliminary results
- Conclusion
- Acknowledgements
- Questions

Highlights of the Test of the QUEEN V1 n the NASA GRC ATL
SUSAN

SUSAN: SUbsonic Single Aft ENgine Aircraft Concept

- SUSAN is a hybrid-electric aircraft concept intended to guide our imagination as we study distributed electric propulsion for large single-aisle aircraft (~180 passengers).
- One tail-mounted turbine engine is proposed to provide thrust and generate electricity onboard.
- Sixteen wing-mounted motor-driven fans are also proposed to propel the plane.



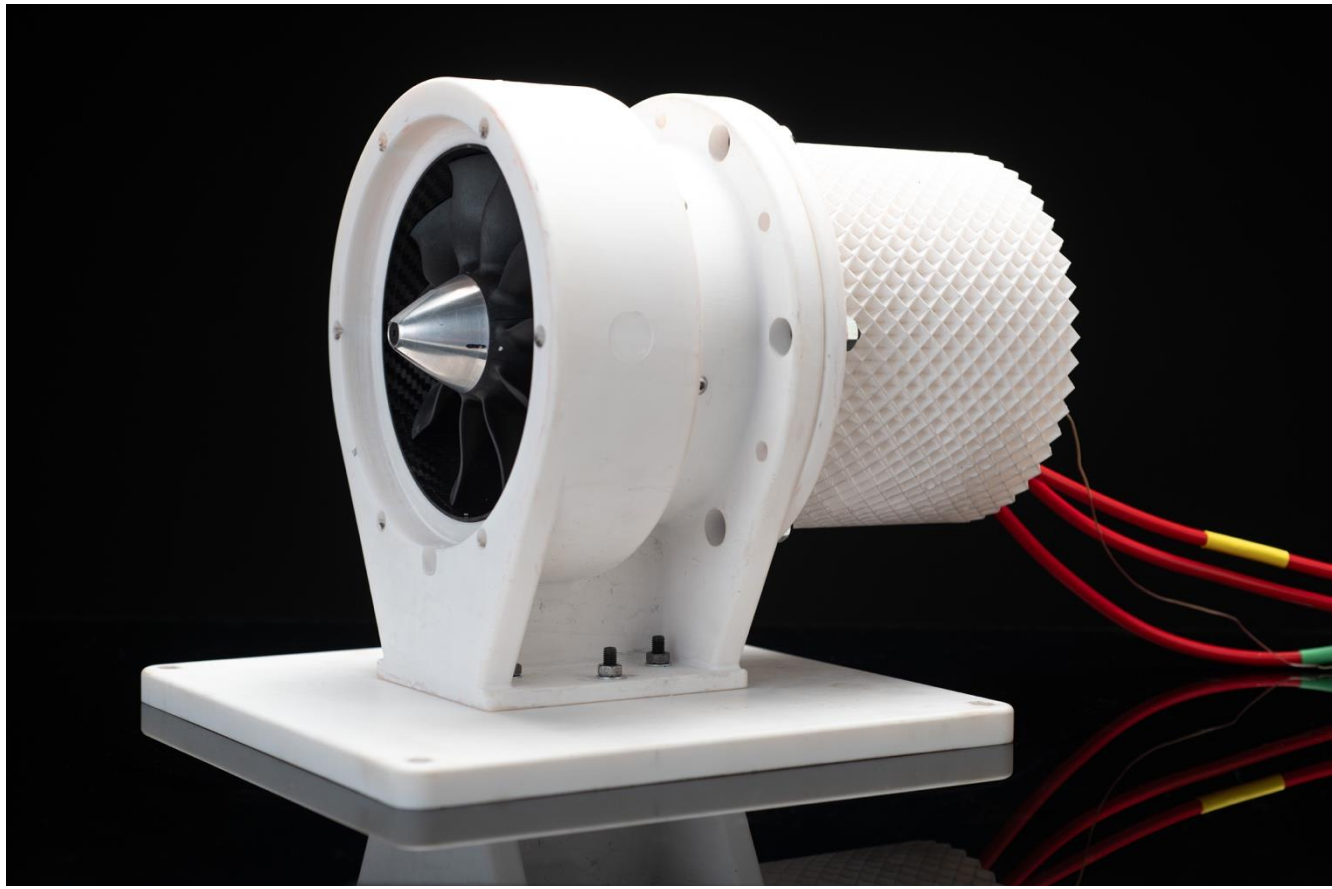
NASA's SUSAN, the Subsonic Single Aft Engine Concept Aircraft with eight Quiet Electric Engines (QUEENs) mounted on each wing.

SUSAN 25% FRV: SUbsonic Single Aft ENgine 25% Flight Research Vehicle

- A manufacturing prototype of the SUSAN 25% FRV was on display at NASA AeroDayz, NASA GRC August 2024.
- The QUEEN team is testing prototypes of the wing mounted engines for the SUSAN 25% FRV.

QUEEN V1 for the ATL

- The QUEEN V1 features a Commercial-Off-the-Shelf (COTS) fan and motor.
- The COTS fan was mounted in a 3D printed housing attached to a base.
- 3D printed parts were manufactured with a glass reinforced polymer resin using stereolithography at NASA GRC.



Photograph of the QUEEN V1 without the inlet section installed.

QUEEN V1 for the ATL

Other 3D printed parts of the QUEEN V1 ducted fan system included:

1. a bellmouth
2. an inlet duct acoustic liner section
3. and an aft duct section

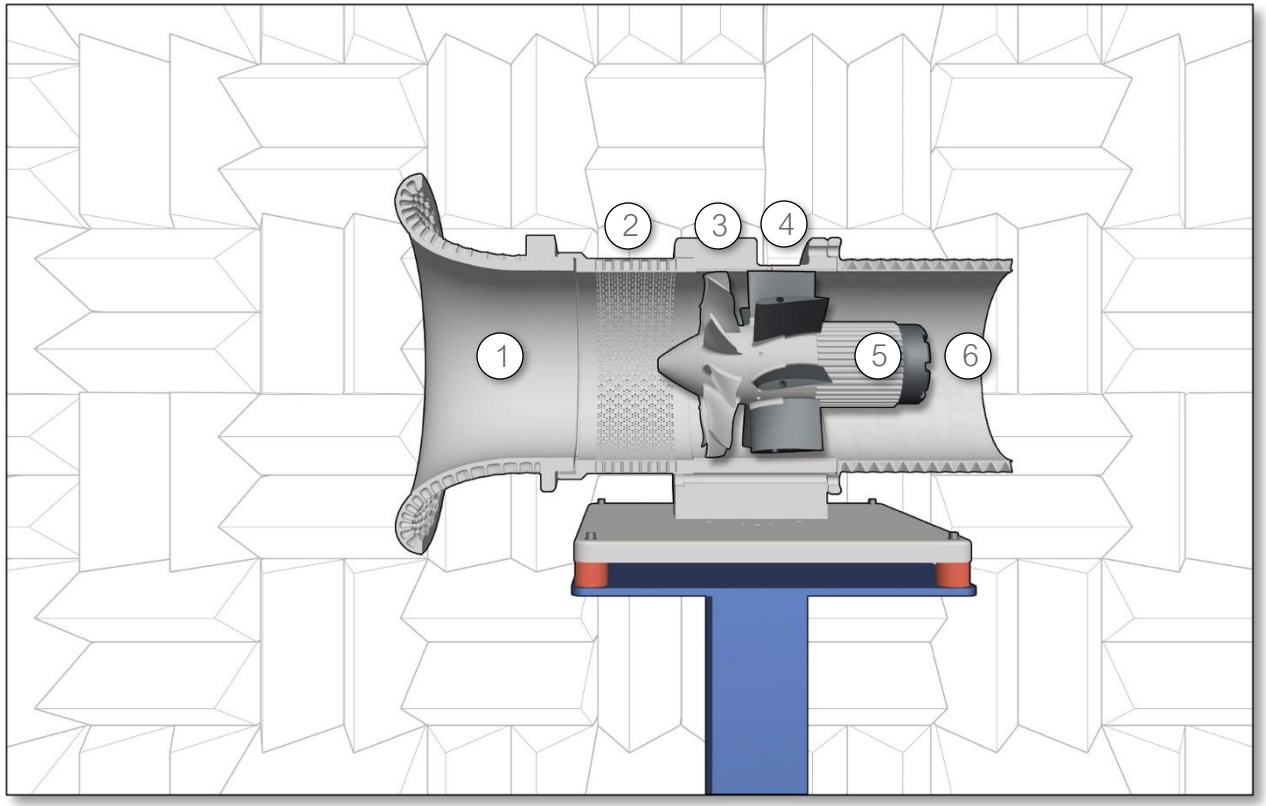


Illustration of the QUEEN V1:
1. Bellmouth 2. Duct Acoustic Liner Section
3. Rotor 4. Stator 5. Motor 6. Aft Duct.

QUEEN V1 for the ATL

Four inlet duct acoustic liner prototypes were designed, fabricated, and tested:

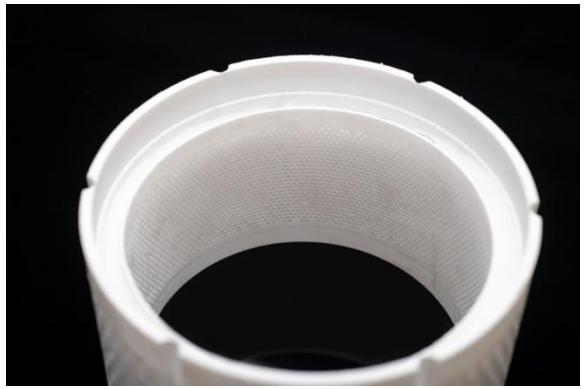
1. Hardwall liner
2. Perforate over honeycomb liner
3. Perforate over bulk absorber liner
4. Perforate over bio-inspired broadband acoustic absorber liner



1. Hardwall Liner



2. Perforate Over Honeycomb Liner



3. Perforate Over Bulk Absorber Liner



4. Perforate Over Bio-inspired Broadband Acoustic Absorber

Photo credit: NASA

QUEEN V1 for the ATL

- The experiment was performed in the NASA GRC Acoustical Testing Laboratory (ATL).
- The ATL was configured as a fully anechoic chamber, though the chamber bay doors were open to reduce air recirculation.
- The QUEEN V1 was mounted on a pedestal near the center of the chamber.



Photograph of the QUEEN V1 test set-up in the NASA GRC Acoustical Testing Laboratory, forward looking aft.

Photo credit: NASA

Test Objectives

1. The first objective was to measure noise of the QUEEN V1 with and without inlet duct acoustic liners at different speeds.
2. The second objective was to characterize the performance of the Electronic Speed Controller at different speeds using two different methods of cooling: air cooling and a cold plate.

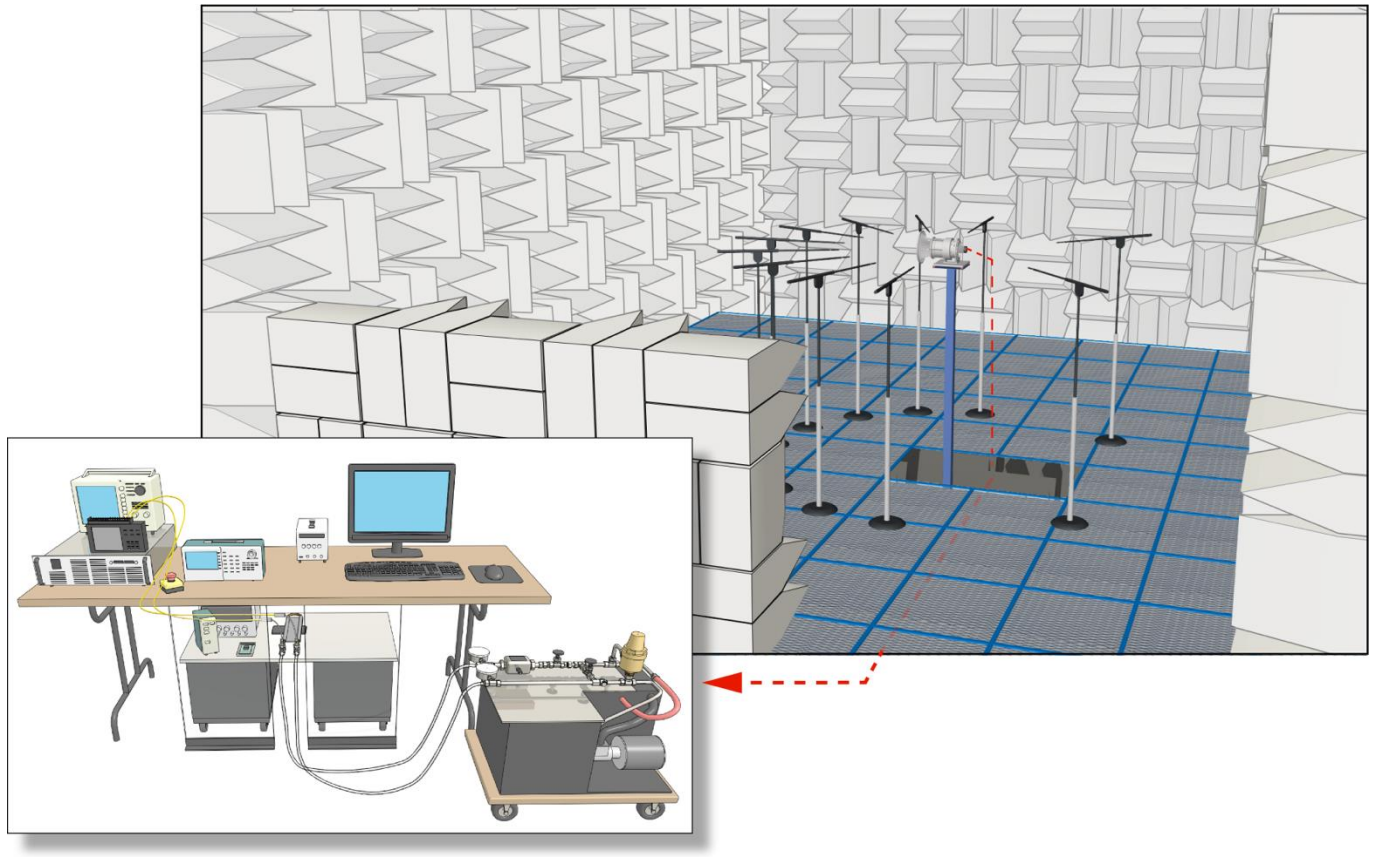


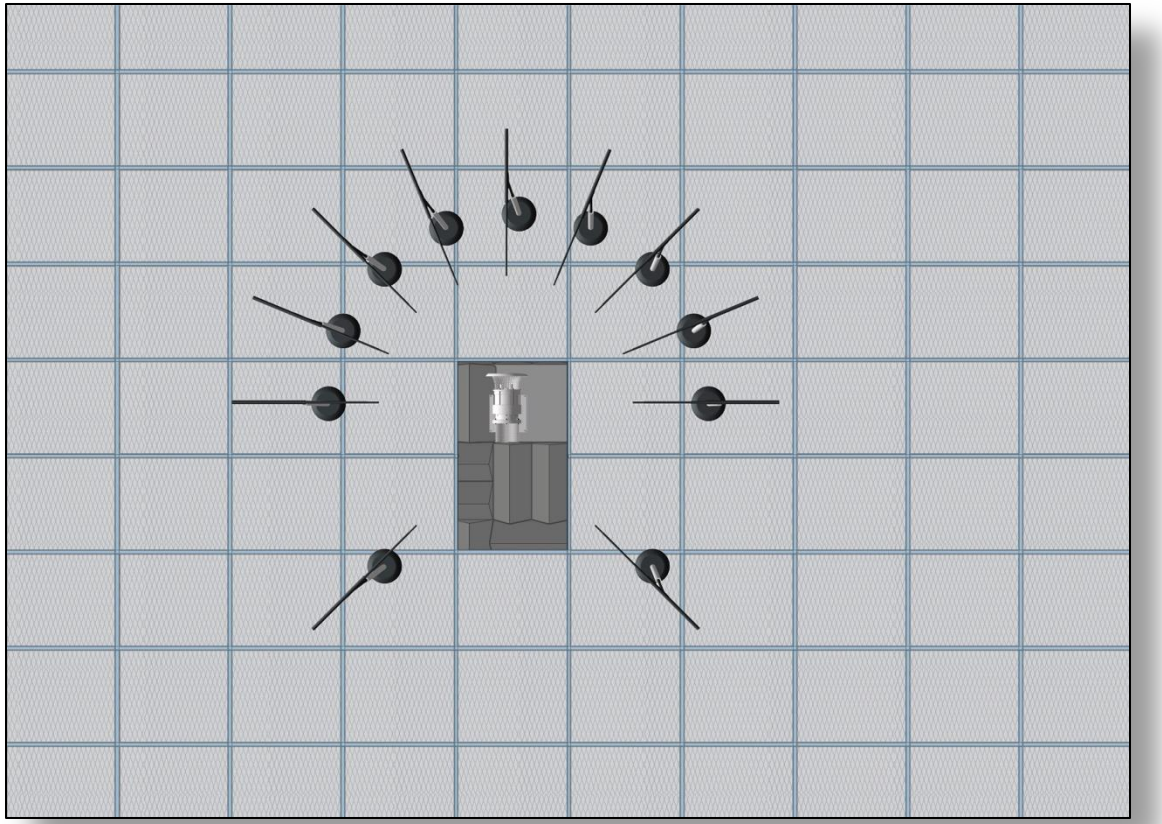
Illustration of the QUEEN V1 test set-up in the ATL anechoic chamber (upper right) and control room (lower left).

Image credit: NASA

Highlights of the Test of the QUEEN in the NASA GRC ATL
Selected preliminary results

Preliminary acoustic results

- Nine microphones were equally spaced around the fan inlet and used to measure noise and characterize performance of the four inlet-duct acoustic liners.
- Two microphones were also placed at +/- 45 degrees from the fan centerline in the fan exhaust.



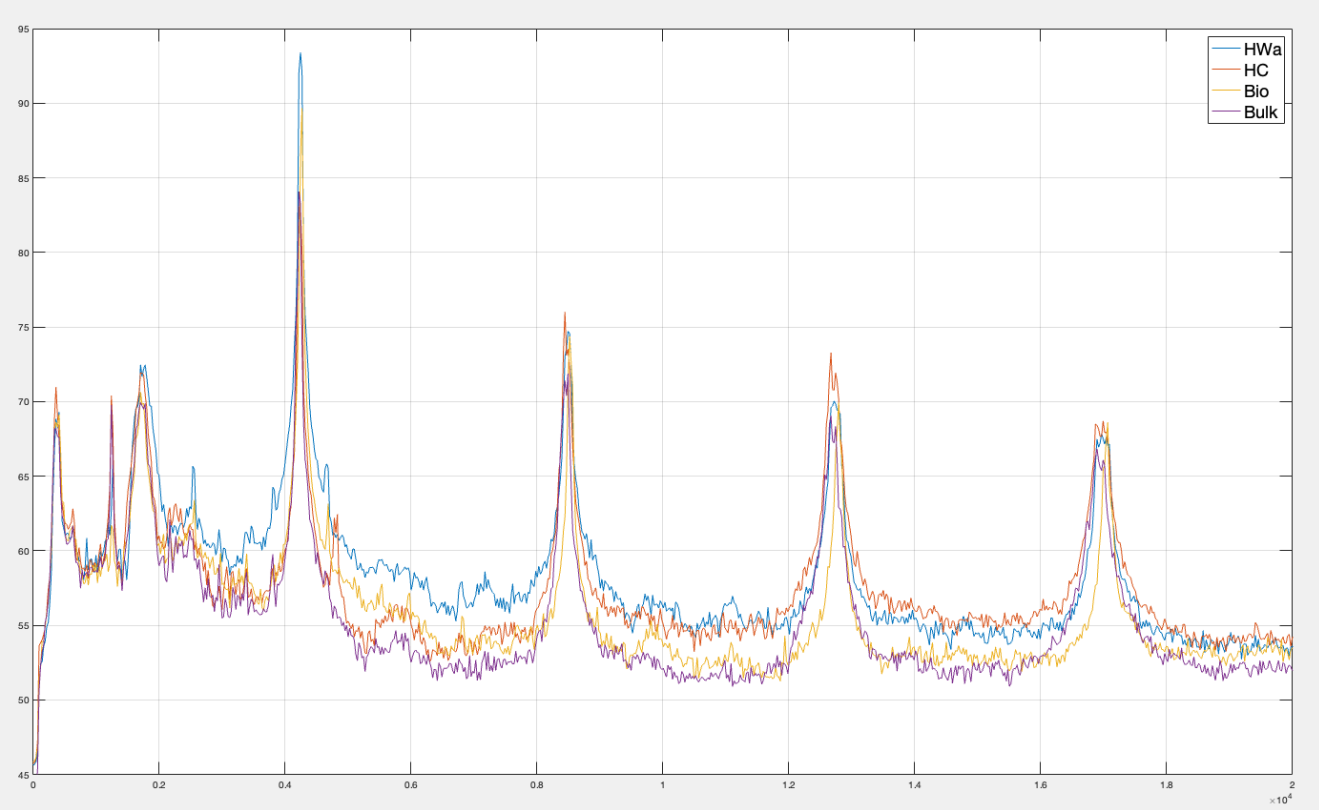
An array of microphones were equally spaced around the fan inlet to characterize the inlet radiated noise.

Image credit: NASA

Highlights of the Test of the QUEEN in the NASA GRC ATL
Selected preliminary acoustic results

Preliminary acoustic results

- Fan blade passing tones were evident in the acoustic data.
- Differences between the different liner prototypes were measured.
- Post-processing of the data is ongoing.
- Results will be interpreted at AIAA SciTech 2025.



Spectra from one of the microphones in the inlet array for each of the four inlet-duct acoustic liners.

Highlights of the Test of the QUEEN in the NASA GRC ATL
Selected preliminary results

Preliminary thermal results

- Temperature of the Electronic Speed Controller (ESC) was one variable measured for different fan speeds.
- A closed loop cooling cart recirculated deionized water through a cold plate attached to the ESC.

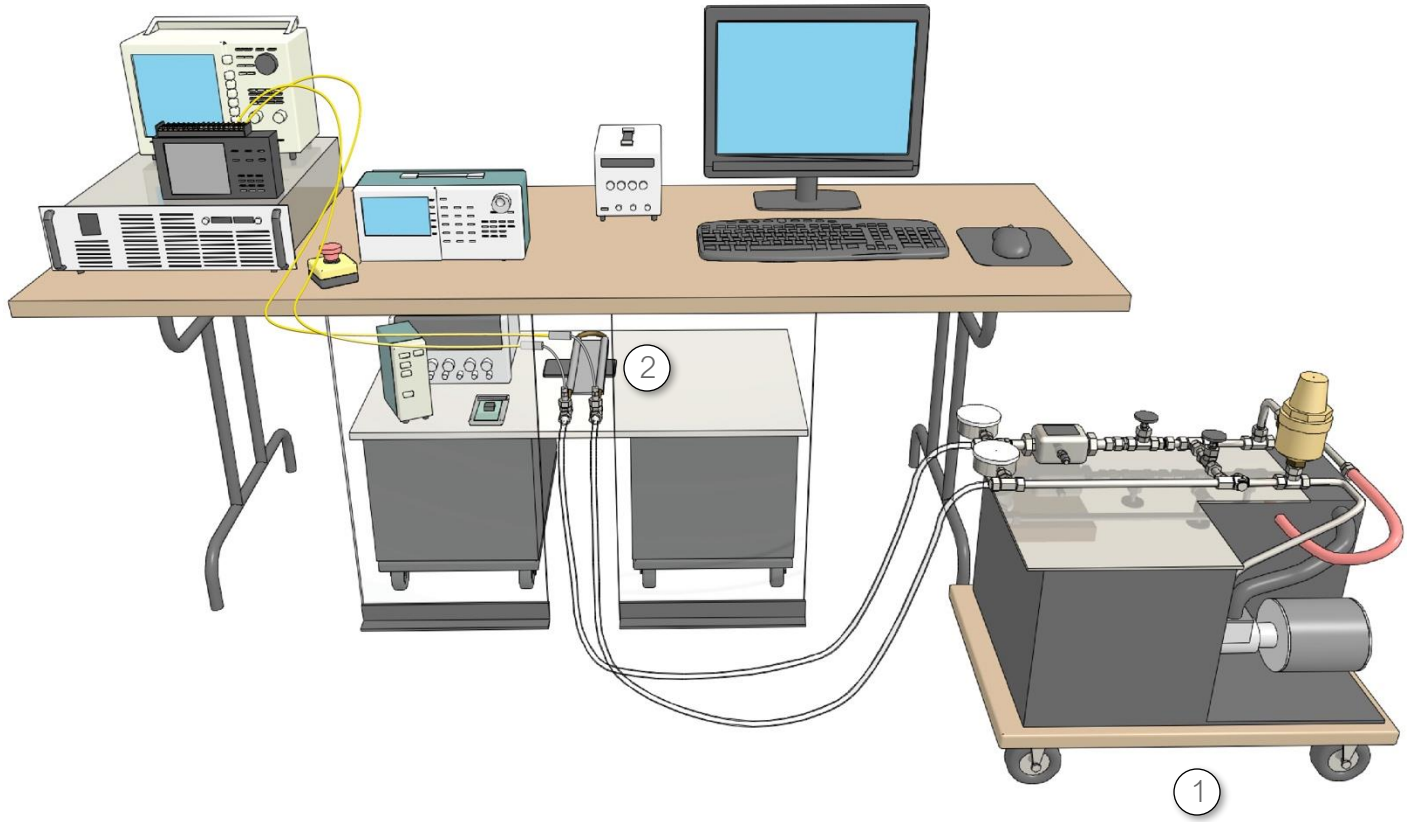


Illustration of the QUEEN V1 Thermal Test Hardware:
1. Cooling cart 2. Cold plate and Electronic Speed Controller

Image credit: NASA

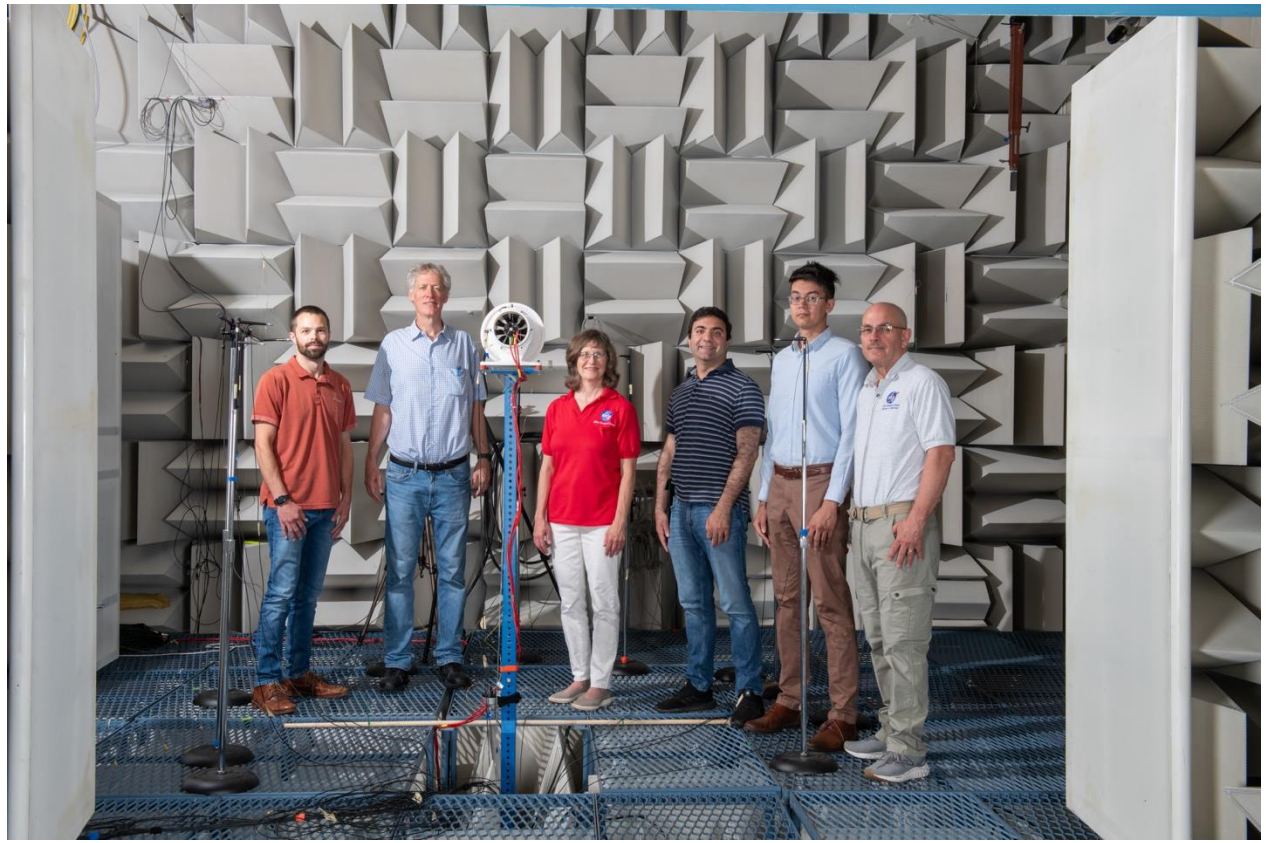
Preliminary thermal results

- Comment 1 on thermal data
- Comment 2 on thermal data

Sample of thermal data.

Conclusion

- The QUEEN V1 electric ducted fan was designed, built, instrumented, and tested at NASA GRC Acoustical Testing Laboratory in spring 2024.
- The QUEEN V1 features a single Commercial-Off-the-Shelf fan with outlet guide vanes.
- Four inlet duct acoustic liners were tested.
- Measurements of the Electronic Speed Controller (ESC) temperature were recorded for two different cooling methods: air cooling and a cold plate.
- Results will be presented at AIAA SciTech 2025.



Some members of the QUEEN V1 Test Team in the NASA GRC Acoustical Testing Laboratory, May 2024.

Photo credit: NASA

Highlights of the Test of the QUEEN in the NASA GRC ATL
Acknowledgements

NASA Glenn QUEEN Team

Danielle Koch, Acoustics Branch

Dan Sutliff, Acoustics Branch

Alexander Svetgoff, Acoustics Branch

Firas Asfoor,
Thermal Systems and Transport Processes Branch

Erik Stalcup,
Thermal Systems and Transport Processes Branch

Jonathan Goodman,
Mechanical Systems Design and Integration Branch

Jan Sobon,
Mechanical Systems Design and Integration Branch

Mark Turner, Propulsion Division

Tim Dever, Diagnostics and Electromagnetics Branch

Matt Granger, Power Management and Distribution Branch

NASA GRC Support

Sara Lowthian-Hanna, Photography

Terence Condrich, Technical Illustrations

NASA Project Management Team

Research Funding provided by

NASA's Convergent Aeronautic Solutions (CAS) Project

Jeff Chin, CAS GRC Center Integration Lead

Ralph Jansen, Principal Investigator SUSAN

Brad French, Co-PI SUSAN

Questions

Thank you!

Questions?