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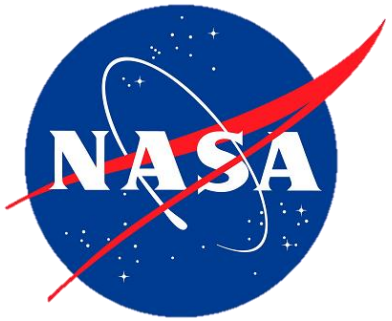

X-57 “Maxwell” High-Lift Propeller Testing and Model Development

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X-57 Introduction

The X-57 “Maxwell”, NASA’s next manned X-plane, incorporates relatively small diameter, folding, electrically-driven propellers along the wing leading-edge that provide lift augmentation at low speeds.

Credit: NASA

14 CFR § 23.2110(b)

X-57 Mod IV flights will be the backbone of a means of compliance for low-speed handling for advanced air vehicles in response to recent changes to FAA airworthiness rules.

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Introduction and Background

- Novel propeller designs for advanced air mobility (AAM) vehicles can have traits that make accurate performance prediction challenging using traditional methods.
  - Directly supports NASA ARMD ST3 & ST4:

Ultra-Efficient Subsonic Transports

Safe, Quiet, and Affordable Vertical Lift Air Vehicles

  - Testing, model maturation, and standards development ensure U.S. leadership in AAM and the sustainability of National airspace and aviation.
- X-57 and Revolutionary Vertical Lift Technologies (RVLT) Project collaborated to test two full-scale high-lift propellers (HLPs) in the Low Speed Aeroacoustic Wind Tunnel (LSAWT) at NASA Langley Research Center.
  - Gathered performance and acoustic data to support model validation and improvements.
  - Captured high-speed video to evaluate propeller stability, dynamics, and blade position.
  - Performed shakedown test of RVLT's new Propeller Test Stand (PTS).
- LSAWT test helped to qualify propeller design and quantify performance and noise data, a critical piece of getting these unique propellers in the air.

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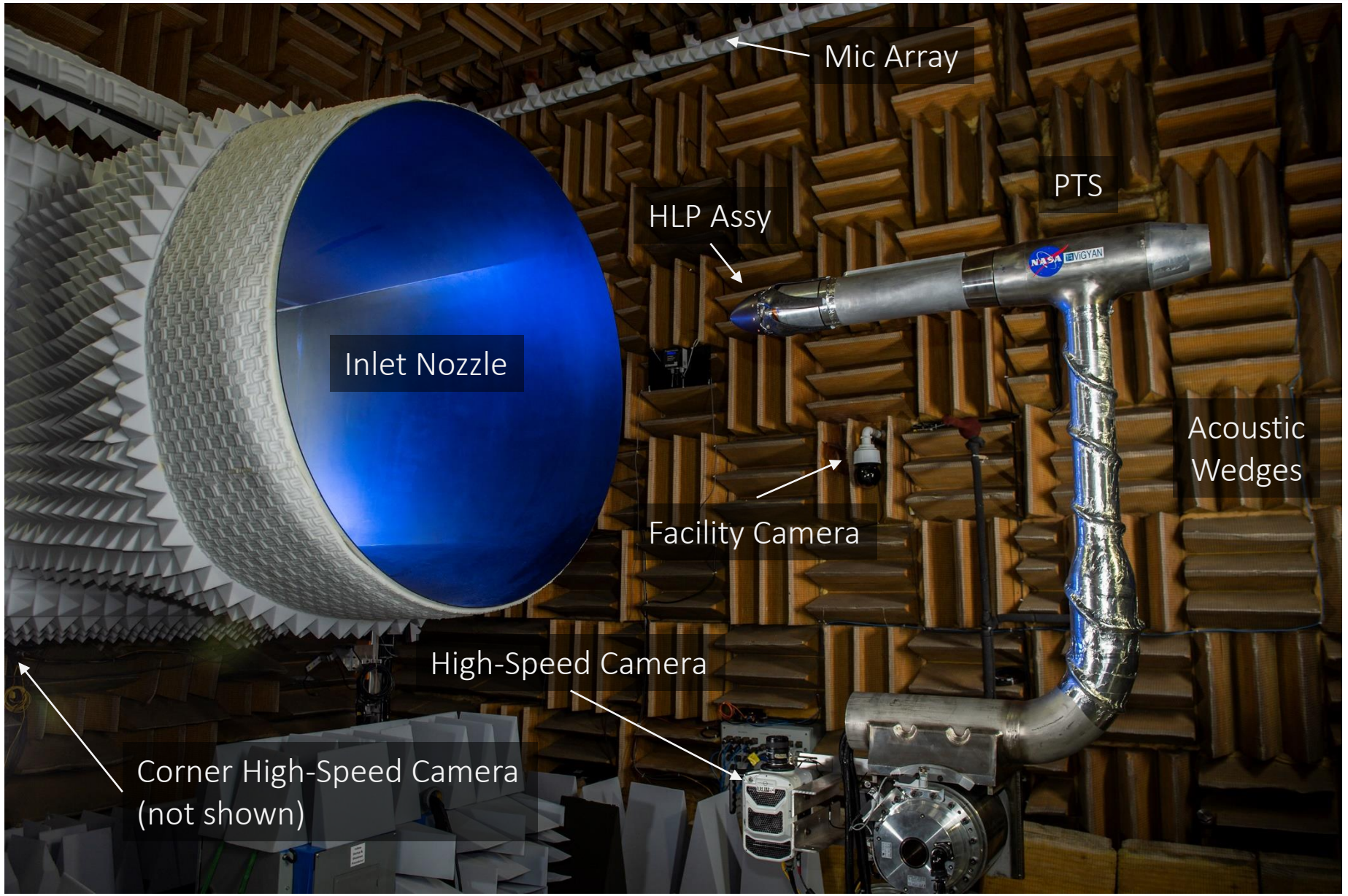
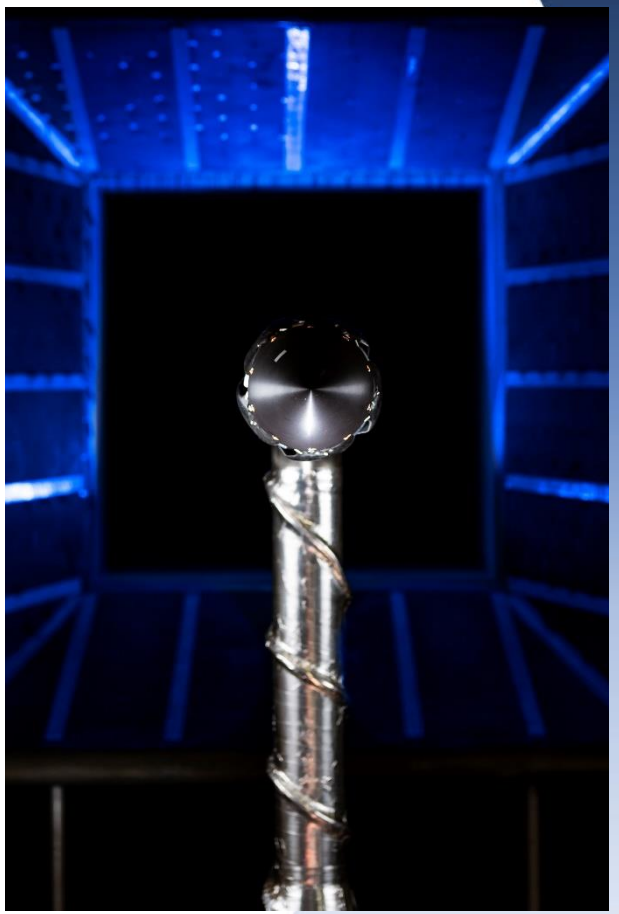
X-57 Maxwell High-Lift Propeller Test Setup





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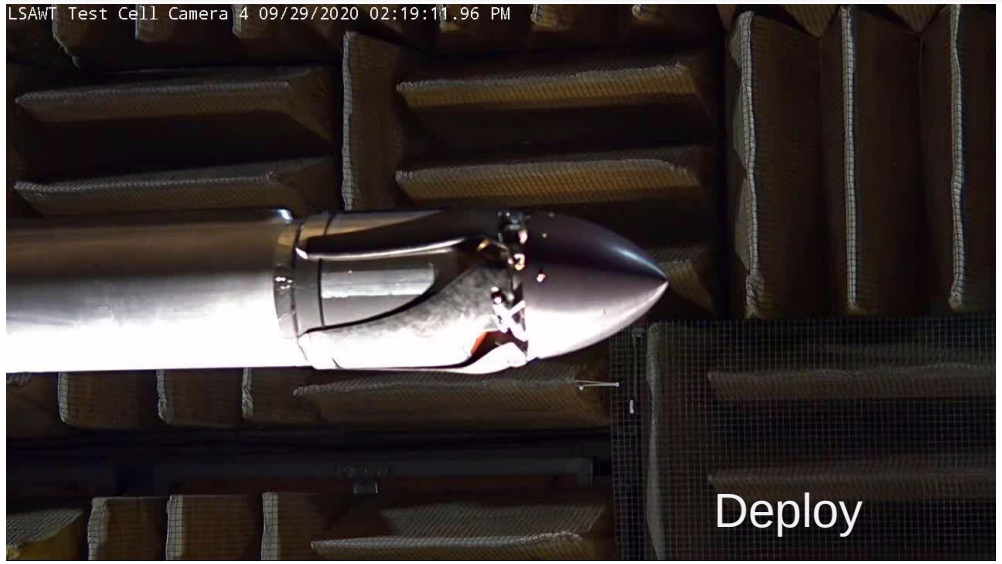
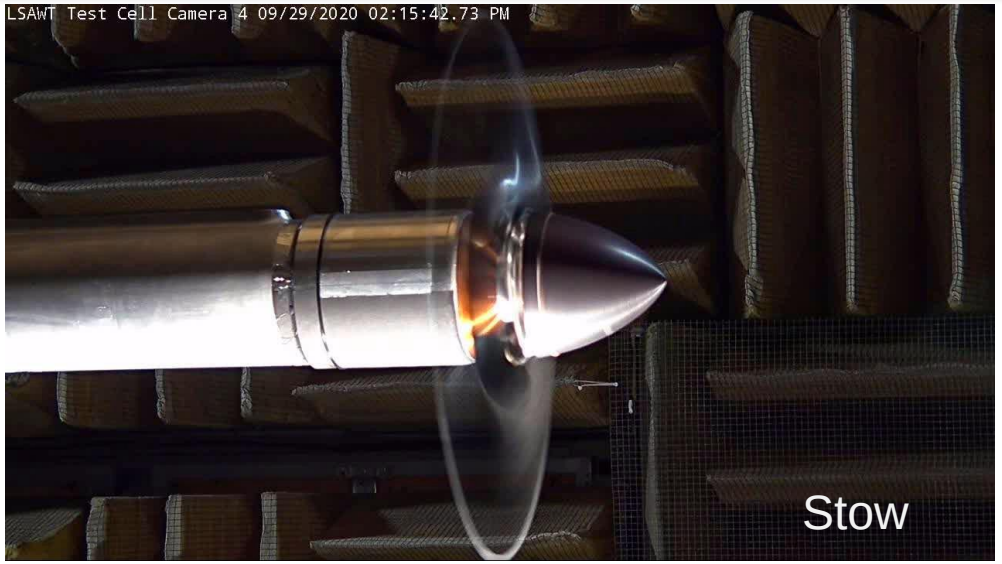
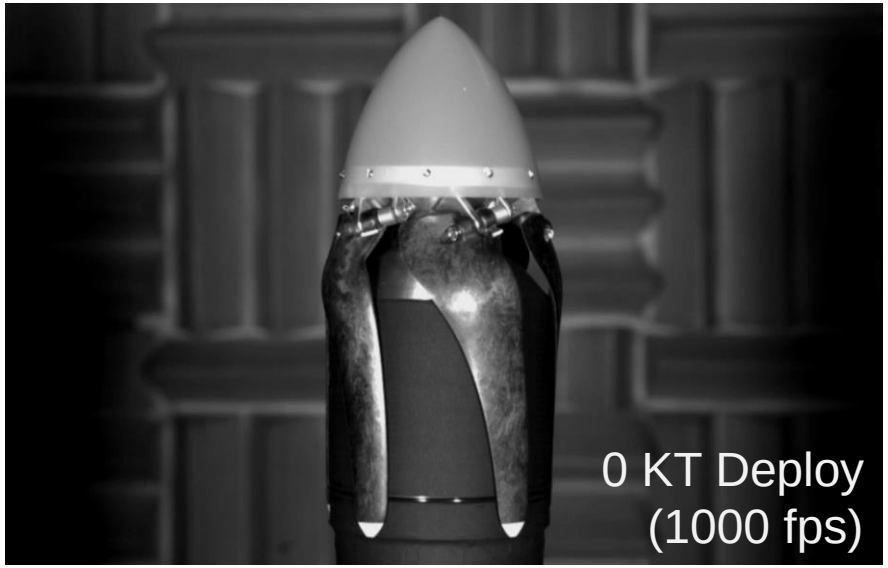
X-57 Maxwell High-Lift Propeller Operation





The HLP demonstrated smooth and stable behavior throughout the test.



High-speed view from bottom

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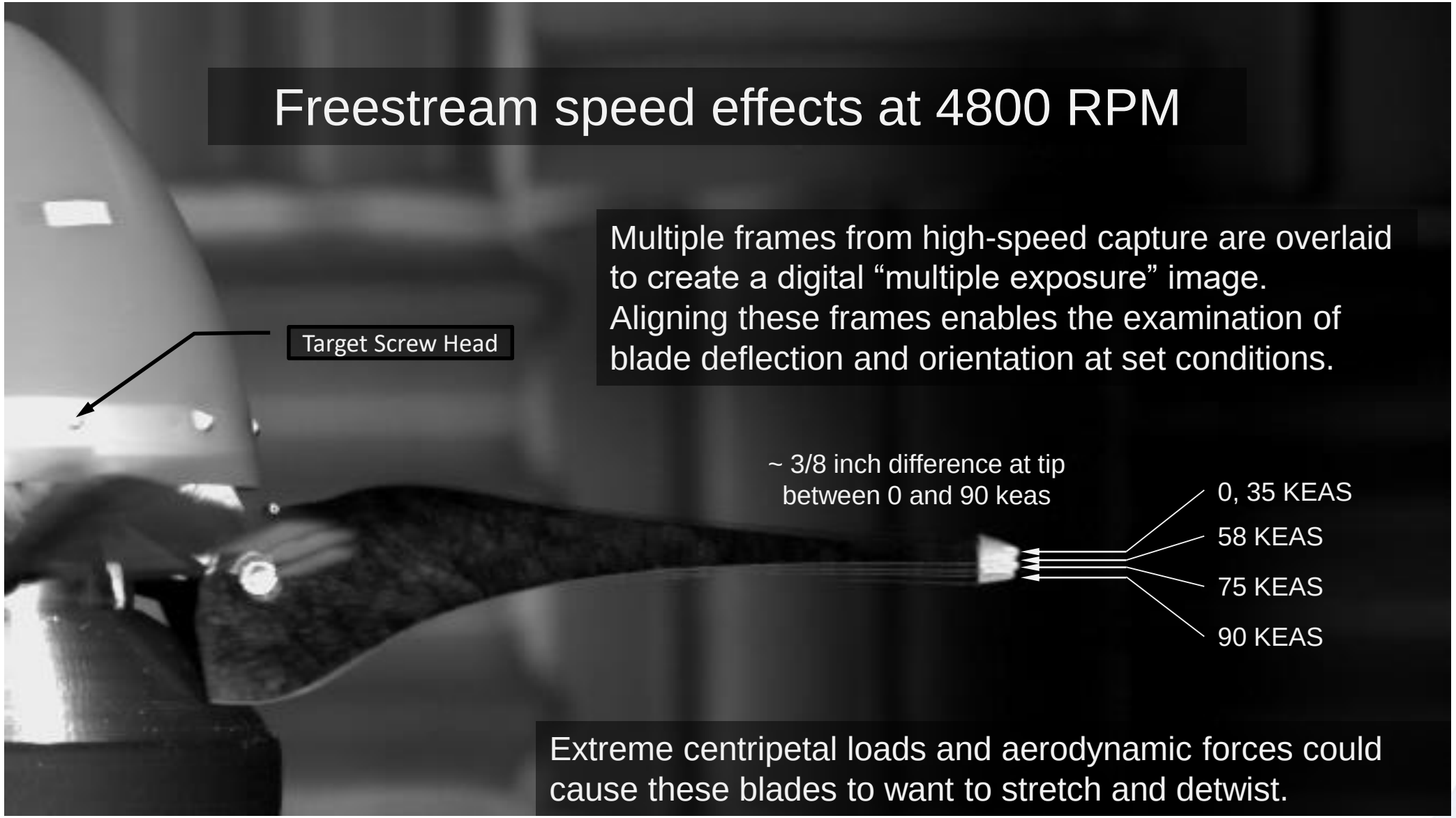
High-Lift Propeller Test High-Speed Imagery



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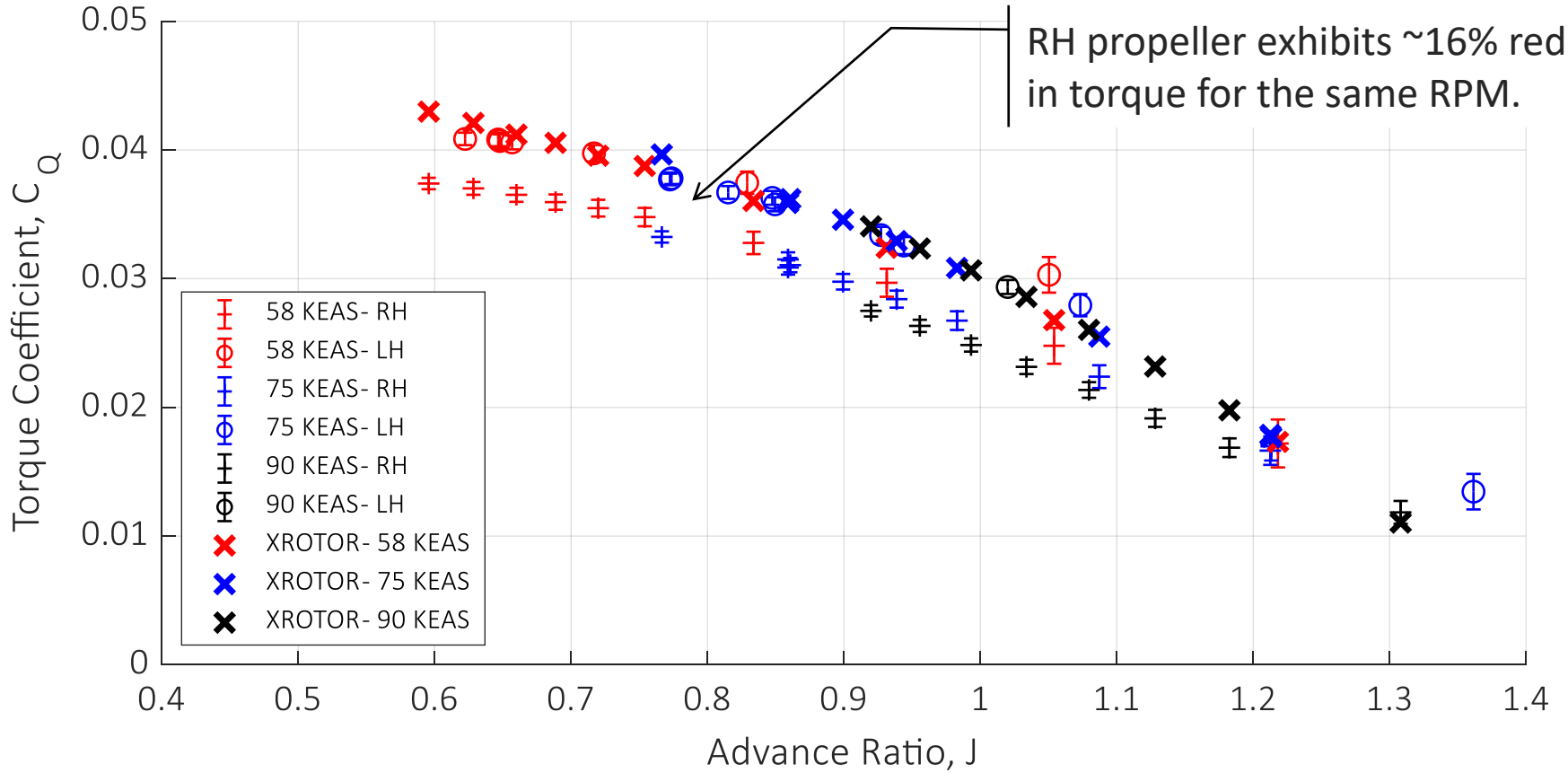
X-57 Maxwell High-Lift Propeller Test Results

- The LH propeller tracked with XROTOR model predictions remarkably well.
- Right-hand (RH) prop shows reduced performance compared to the left-hand (LH) prop.
- RH blades ~5% lower weight than LH blades. RH blades may partially unload at higher RPM.



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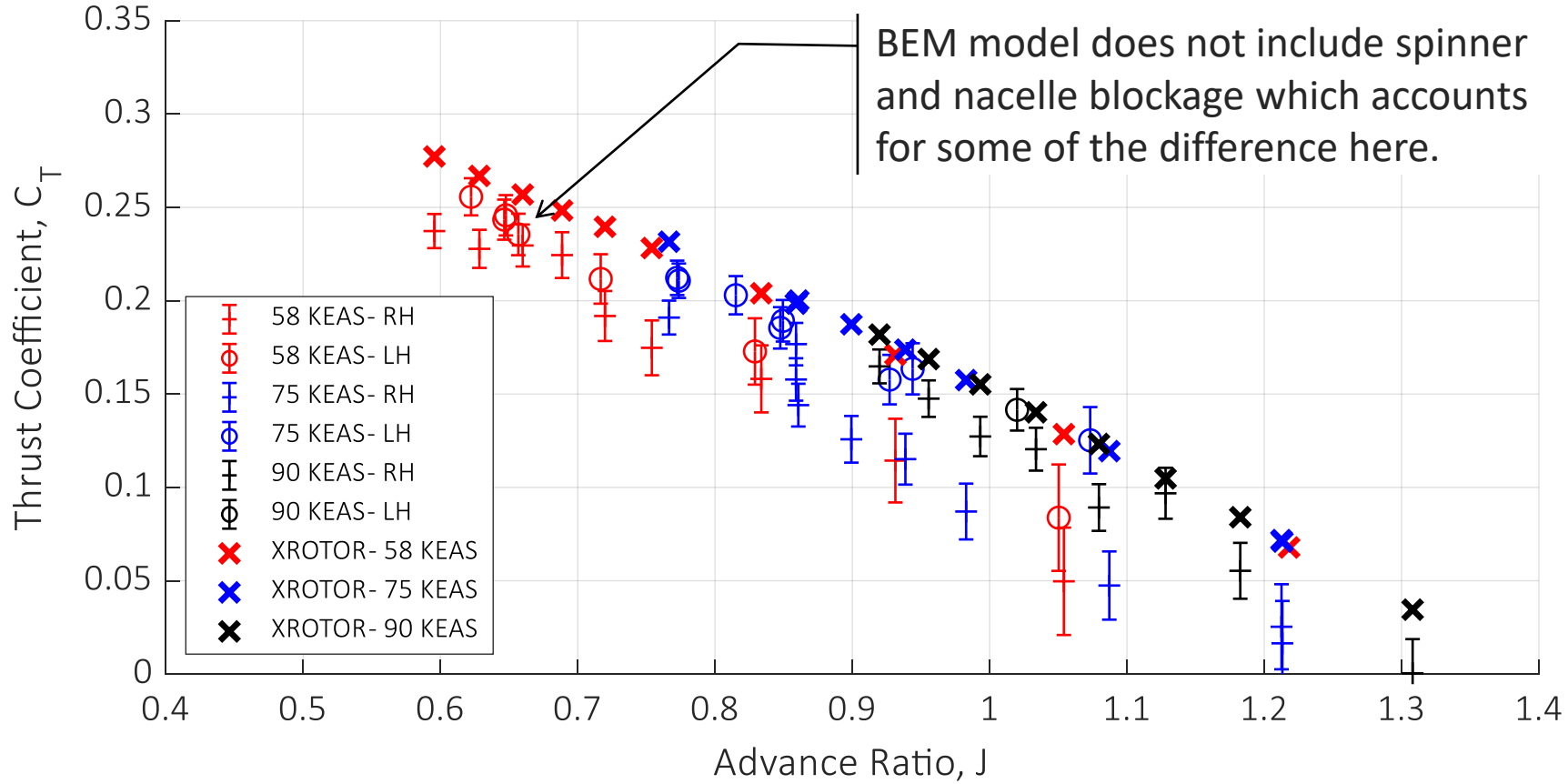
X-57 Maxwell High-Lift Propeller Test Results

- Thrust measurements varied considerably due to PTS load cell issues.
  - Load-cell cross-loading and heat soaking caused drift in data.
  - Lower CT values show increased error in part due to larger relative error to thrust.
- Fortunately, thrust data is more reliable at lower J where HLP is expected to operate.



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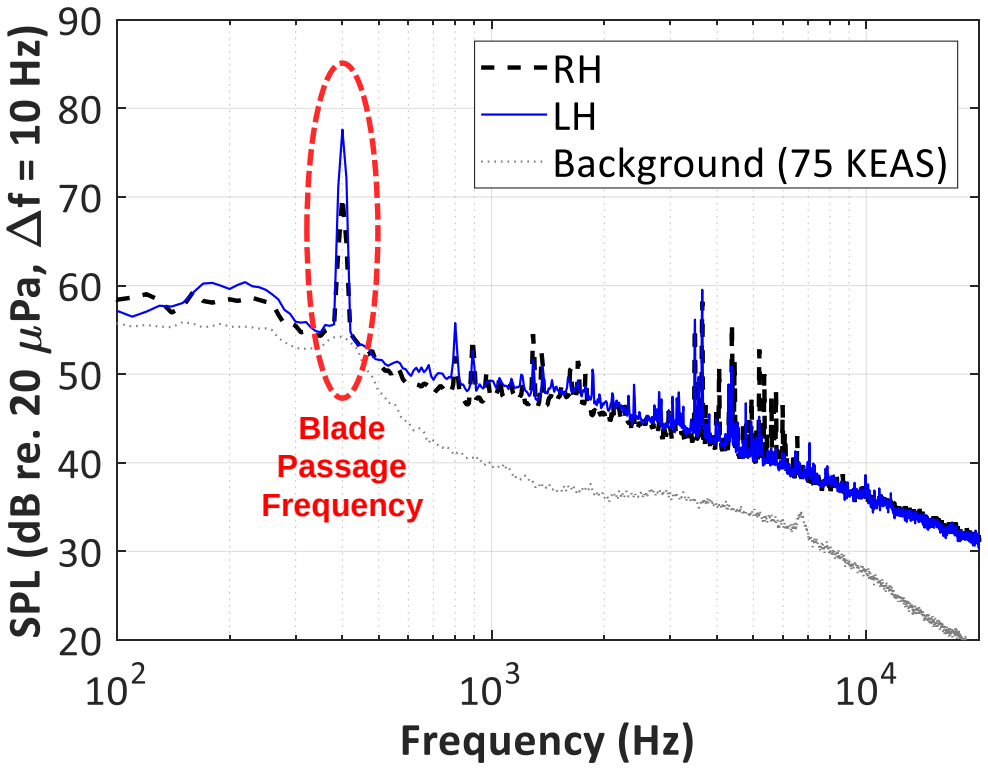
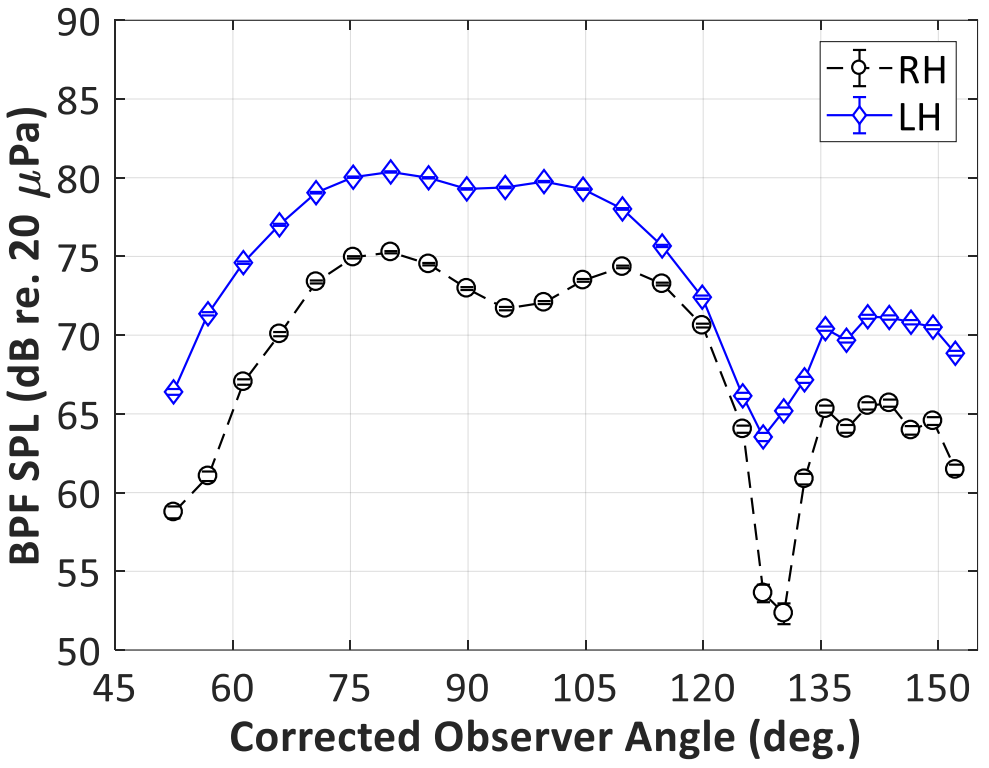
Test Results (contd.)

- Left-handed propeller found to exhibit higher fundamental tonal acoustic levels.
- Corroborated by higher torque levels and predictions revealing HLP to be dominated by aerodynamic loading noise.

4800 RPM, 75 KEAS High-Power Takeoff





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X-57 High-Lift Propeller Test Impacts & Future Work

- Provided significant benefit to X-57 Maxwell and AAM vehicle studies.
  - Verified operation of a full-scale prototype of the flight propeller (~15 hours runtime).
  - HLP blade-element momentum (XROTOR) model predicted propeller performance well.
  - Obtained experimental data to improve modeled performance and dynamics.
  - No instability or excessive vibration observed under all operating conditions.
  - Generated practices for static balancing of a 5-bladed, folding, spring-loaded propeller.
- Knowledge transfer to public, other Agencies, and industry partners.
  - X-57 Technical Publications Page
    - https://www.nasa.gov/aeroresearch/X-57/technical/index.html
  - Advances airworthiness standards and provides novel acoustic reference platform for comparison of AAM technologies.
- Future Work
  - X-57 folding HLP dynamics test to establish damping at the blade hinge.
  - Follow-up HLP performance test with similarly weighted blades from the same batch.

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Acknowledgments

NASA's Aeronautics Research Mission Directorate

Transformational Aeronautics Concepts Program

– Convergent Aeronautics Solutions Project –

– Transformational Tools and Technologies Project –

Integrated Aviation Systems Program

– Flight Demonstrations and Capabilities Project –

– – X-57 Maxwell Subproject – –

Advanced Air Vehicle Program

– Revolutionary Vertical Lift Technology Project –

High-Lift Propeller CAD/Fabrication

– Empirical Systems Aerospace, Inc. –

Propeller Test Stand Design/Build

– ViGYAN, Inc. –

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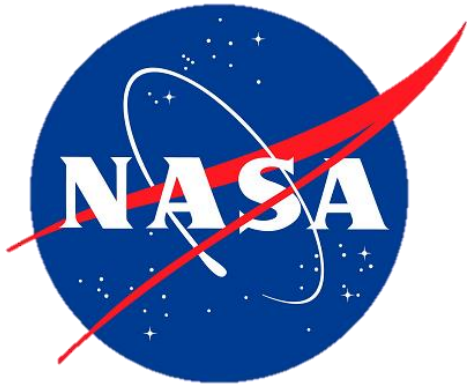

Questions?