Development and Capabilities of the NASA Flight Dynamics Research Facility

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Outline

- Background
- Legacy facilities
- FDRF design features
- Test rigs and techniques
- Construction status/timeline
- Concluding remarks
- Questions/discussion

Flight Dynamics Research Facility (FDRF)

Image credit: BL Harbert International

Background

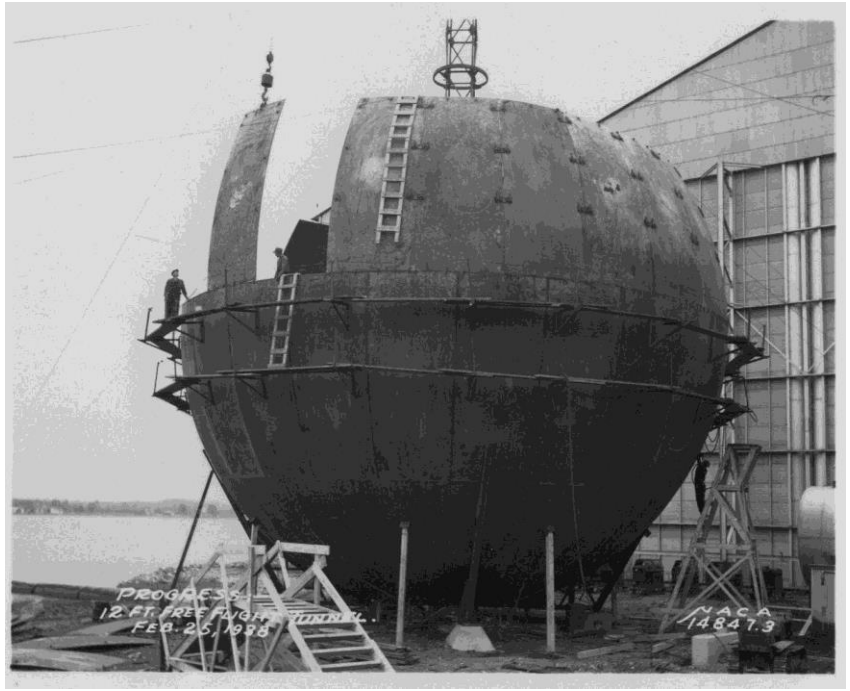
Flight Dynamics Research Facility (FDRF)

- State-of-the-art subsonic vertical wind tunnel at NASA Langley Research Center
- First major wind tunnel built by NASA in over 40 years
- Leverages and expands the capabilities of two legacy facilities being replaced
- Focuses on flow regimes that are difficult to predict using CFD
- **Key attributes:** relatively inexpensive, small operations staff, advanced test techniques, rapid integration/characterization, maximum flexibility/adaptability

Unique utility: FDRF will be the only modern U.S. wind tunnel capable of providing a comprehensive assessment of subsonic aeronautical vehicle stability and controllability via both captive and free-flight dynamic test techniques.

Legacy *12-Foot Free-Flight Tunnel** and *20-Foot Free Spinning Tunnel** Under Construction

*original facility names



1938

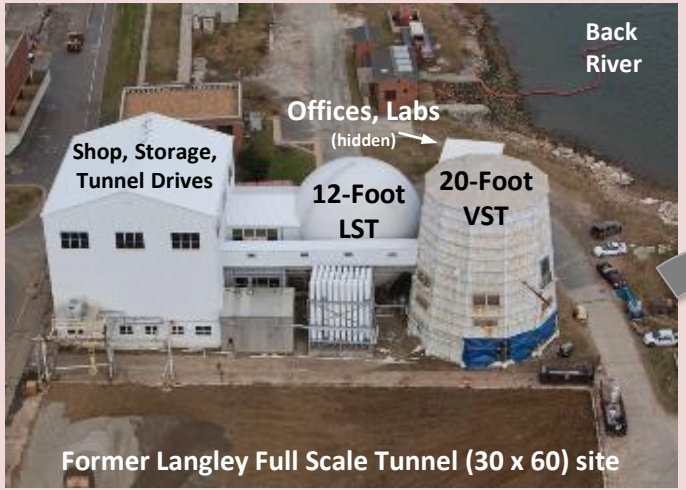
Designed for testing free-flight models to assess stability, controllability, and flying qualities

1940

Designed for free-spin testing to quantify spin modes and recovery characteristics

FDRF Will Replace the *20-Foot Vertical Spin Tunnel* and the *12-Foot Low Speed Tunnel*

Support of aeronautics research, human spaceflight, and science missions well into the future…



Current Flight Dynamics Research and Support Facilities

LaRC East Area (Langley AFB)

Image credit: NASA

Specifications

- **12-Foot LST:** max speed = 77 ft/s (7 psf)
- **20-Foot VST:** max speed = 85 ft/s (8.6 psf)
- Reynolds Number = 0.5×10^6/ft
- Long. Turbulence intensity 1.5% - 2%
- Four buildings (2 tunnels + 2 support)
- Major flood zone

Certain FDRF Requirements

- 20-foot test section
- Max speed = 172 ft/s (35 psf)
- Reynolds Number = 1.1×10^6/ft
- Long. Turbulence intensity < 0.5%
- Repurpose existing test rigs and DAS
- One building replaces four existing buildings
- Out of flood zone

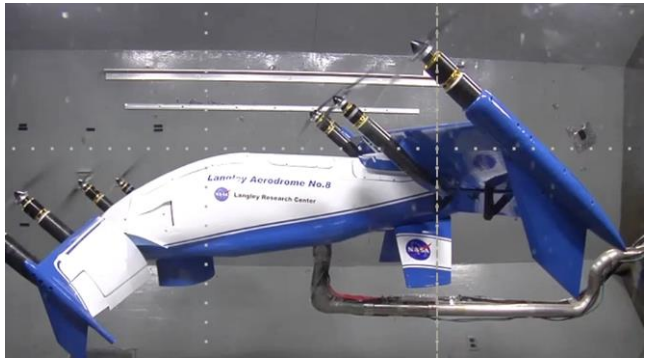
Flight Dynamics Research Facility (FDRF)

LaRC West Area

Image credit: BL Harbert International

Broad Support of NASA Missions Will Transfer to FDRF

Safety of Flight



Advanced Air Mobility

X-Planes

Human Spaceflight

Planetary Science

FDRF Design Features

Image credit: BL Harbert International

FDRF Flow Path

Overall FDRF Building Dimensions: 130’ (H) x 177’ (W) x 41’ (D)

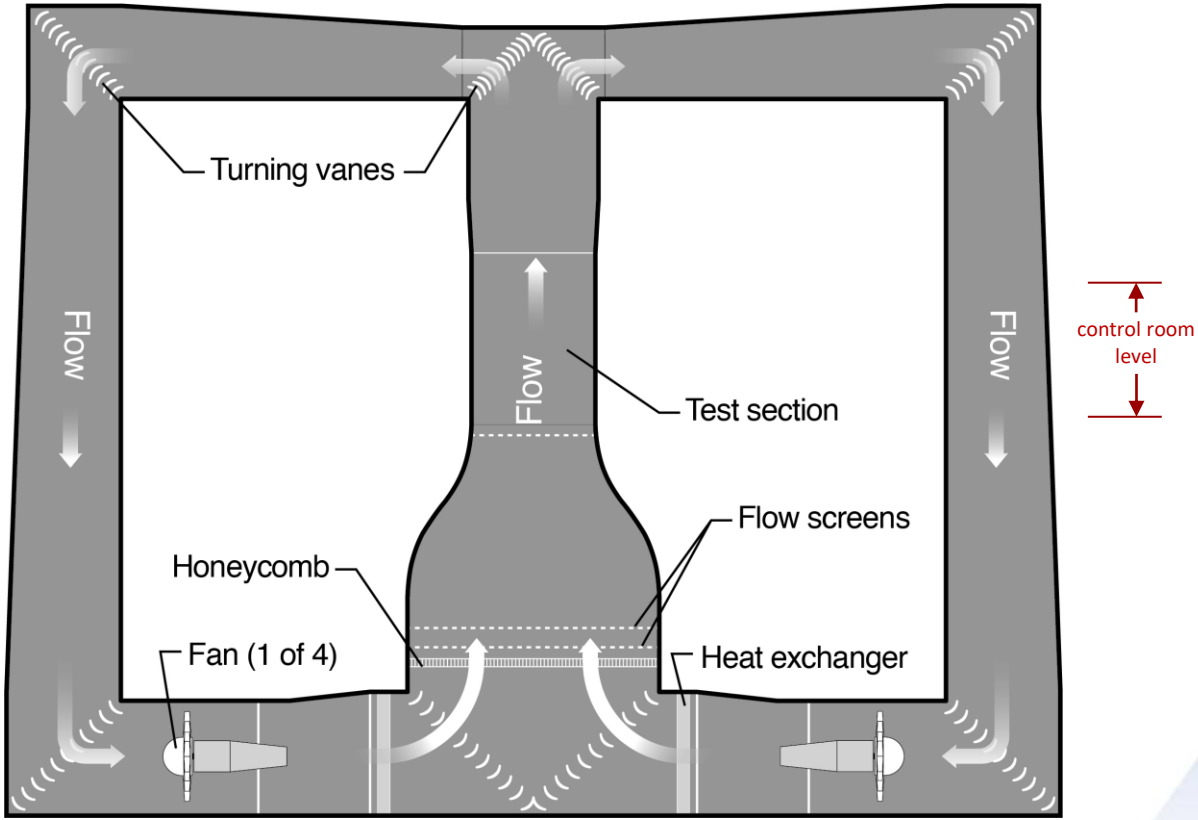


Image credit: BL Harbert International and North Wind

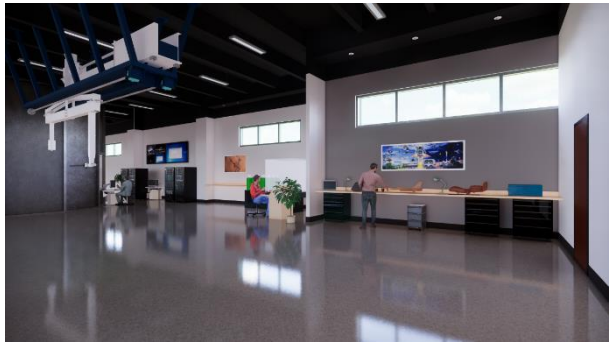
Return Air Tower Fan Inlets (2 of 4)

- Four 14-foot diameter fans; 8 blades per fan
- Carbon fiber blades to minimize rotating mass (for best acceleration and deceleration performance during free-flight testing)
- Four medium-voltage 750 HP motors; controlled by variable frequency drives

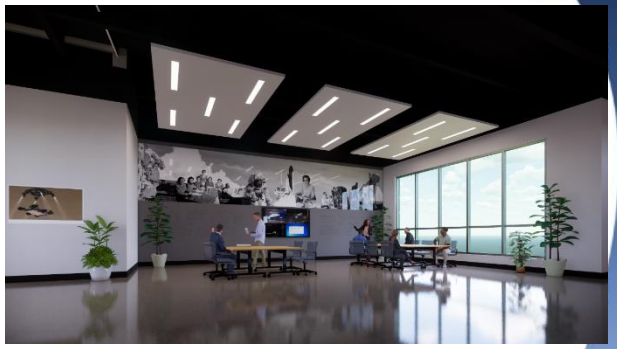
Image credit: NASA

FDRF Interior

Control room



Model build-up and shop area



Researcher collaboration area

Lobby with historical artifact display

Staff break area

FDRF building design emphasis

- Minimal operations staff
- Large, open spaces
- Maximum flexibility
- Adaptability for future requirements
- Maintainability
- Energy efficiency

Image credit: BL Harbert International

FDRF Control Room Layout

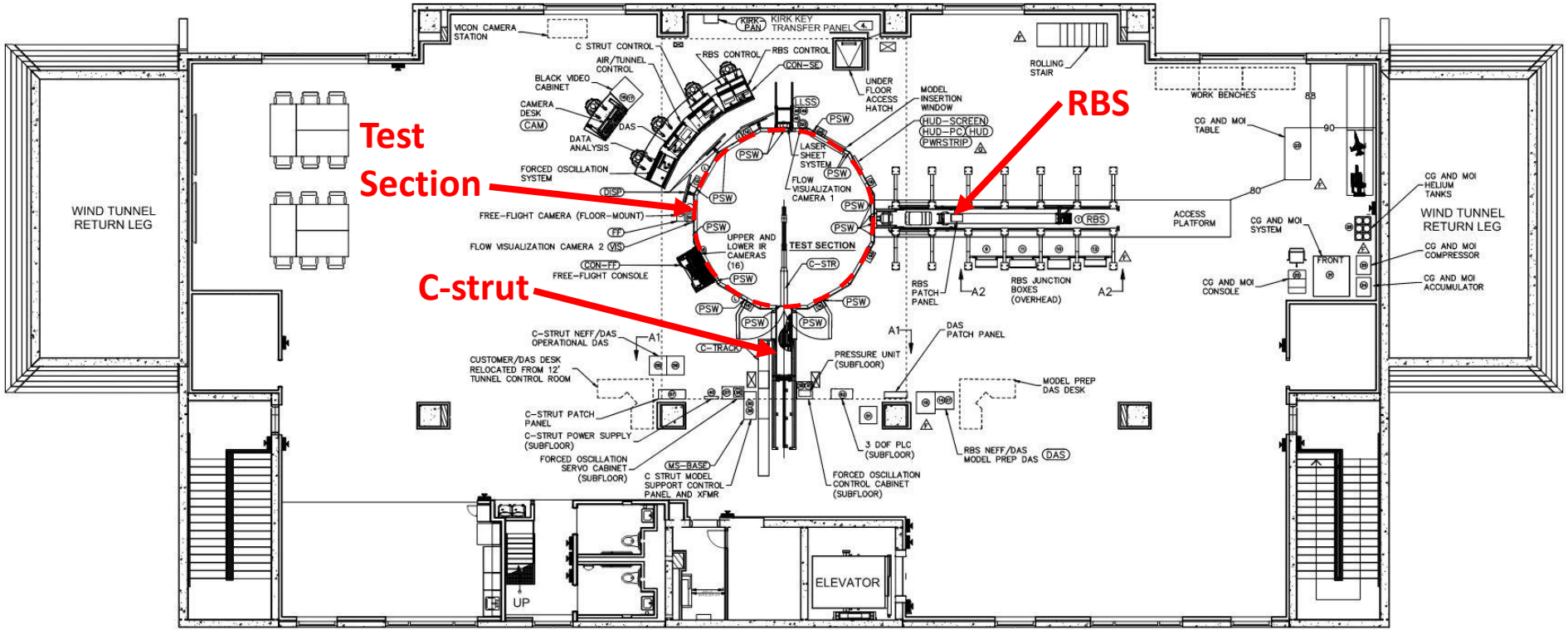


Image credit: BL Harbert International and North Wind

Comparison of FDRF and VST Control Room Floor Space

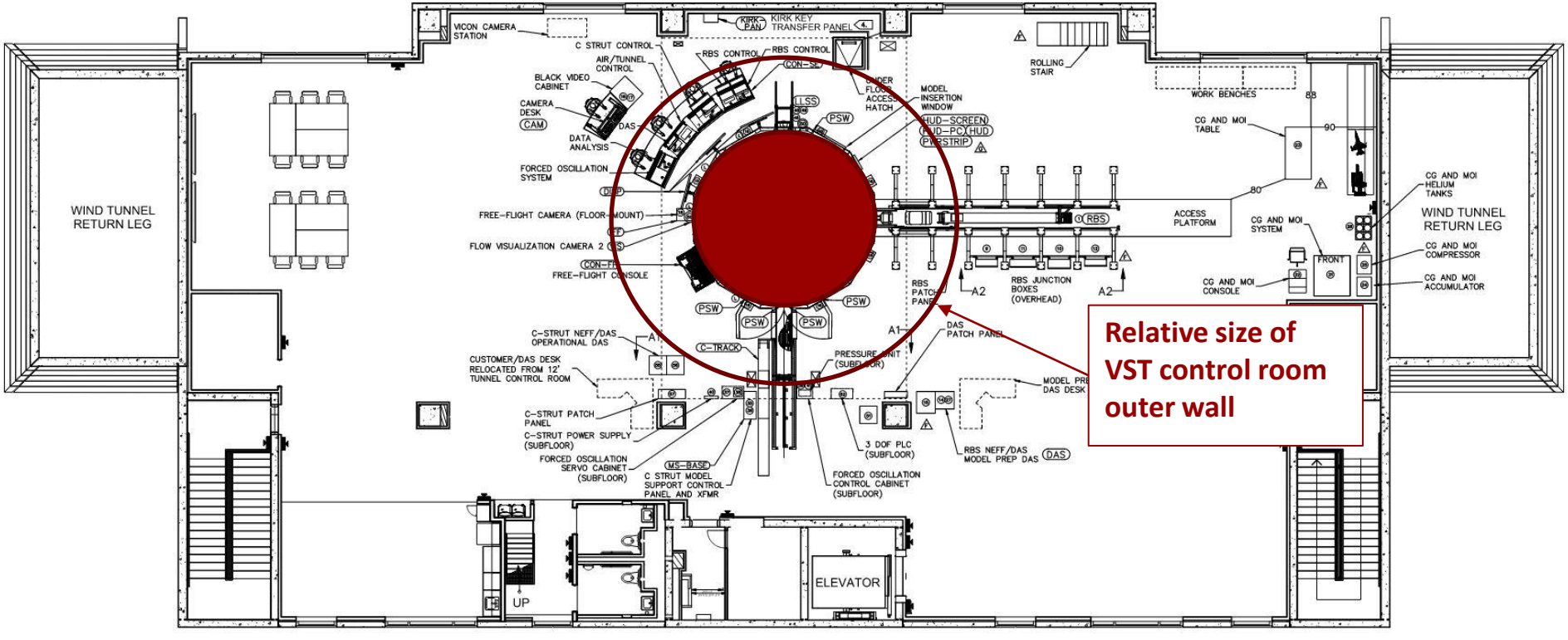


Image credit: BL Harbert International and North Wind

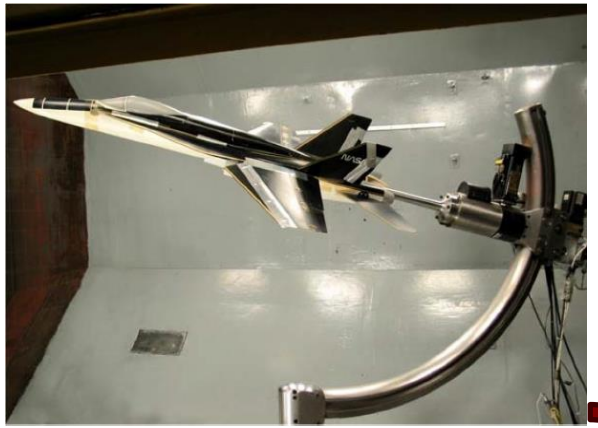
FDRF Test Rigs and Techniques

Image credit: BL Harbert International

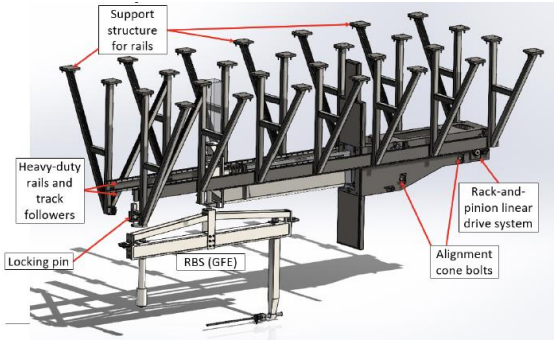
Primary Test Rigs Being Transferred to FDRF

Rotary Balance System (RBS) in VST

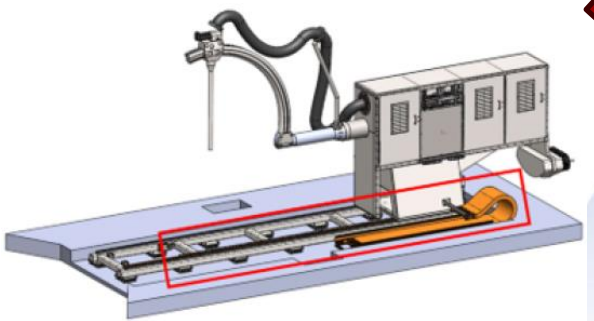
C-strut in 12-Foot



Sketch of RBS in FDRF



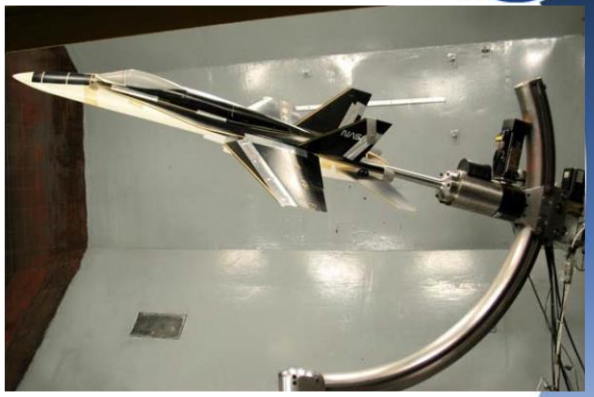
Sketch of C-strut in FDRF



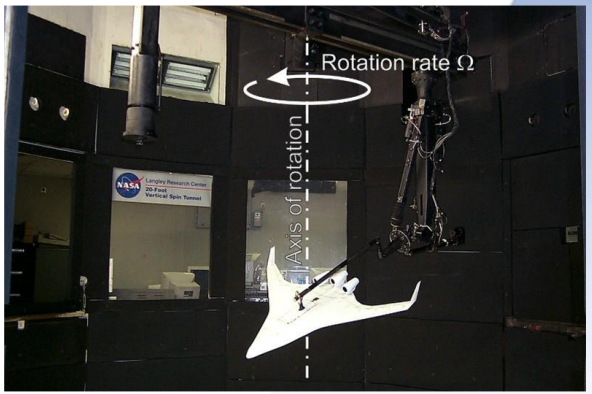
FDRF Test Techniques

FDRF will provide a single, state-of-the-art wind tunnel capable of performing:

- Six degree-of-freedom (6-DOF) dynamically-scaled free-spin
- 6-DOF dynamically-scaled entry vehicle free-flight
- Static force and moment with arbitrary model attitude
- Forced oscillation with arbitrary motion
- Steady velocity-vector rotation (coning)
- Combined coning and forced oscillation
- Captive three degree-of-freedom (3-DOF) free motion
- Design of experiments (DOE); programmed test inputs (PTI)
- Laser light sheet/smoke flow visualization
- Surface pressure measurements



Model mounted on C-Strut



Model mounted on RBS

Image credit: NASA

Test Techniques Transferred from the 20-Foot Vertical Spin Tunnel

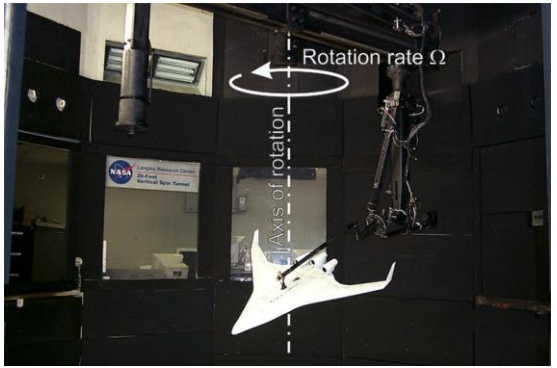
Dynamically-scaled 6-DOF free flight

Aircraft free spin

Entry vehicle free fall

Captive dynamic testing

Steady coning



Combined coning/forced oscillation

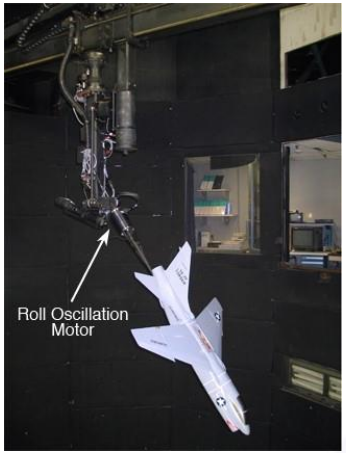
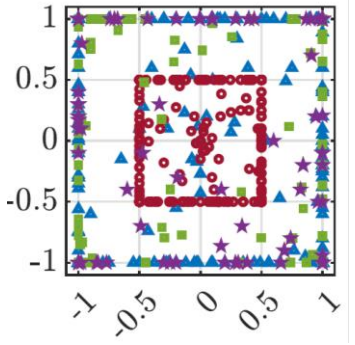


Image credit: NASA

Test Techniques Transferred from the 12-Foot Low-Speed Tunnel

Static force and moment

Laser light sheet/smoke flow visualization



Design of experiments

Forced oscillation

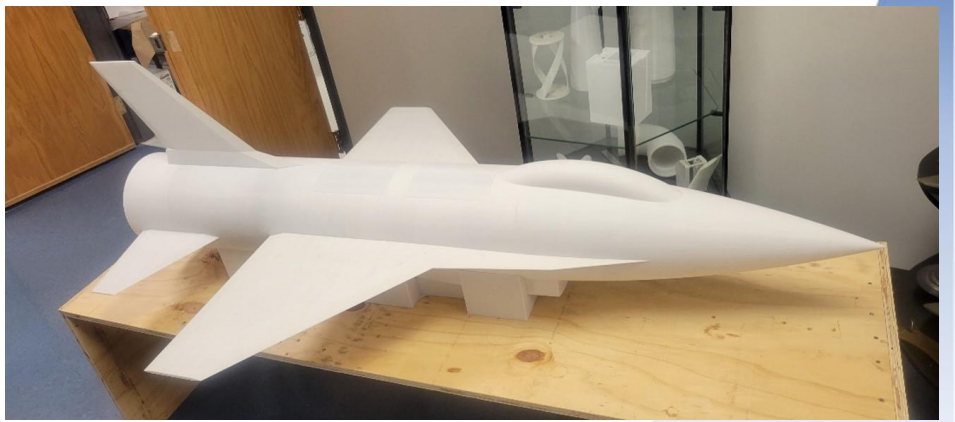
Three degree-of-freedom

Image credit: NASA

Check Standard Tests

- Check standard tests have recently been performed in the two legacy tunnels
- Both check standard models have been tested extensively in other facilities
- Comparison to data collected in FDRF using the relocated test rigs
- FDRF check standard tests will be run on a regular schedule

Common Research Model (CRM)



Standard Dynamics Model (SDM)

Image credit: NASA

FDRF Project Status

Image credit: BL Harbert International

FDRF Project Timeline

- NASA worked with the General Services Administration (GSA) to award the design-build contract in September 2021, with support from Jacobs Engineering
- Awarded to the team of B.L. Harbert International, Mason & Hanger Group, and Calspan ASE (now North Wind)
- To minimize downtime, the project was divided into two phases:
  - **Phase 1:** design and construction of a fully-functional vertical wind tunnel
  - **Phase 2:** removal, modification, and installation of repurposed test equipment
- Anticipated future timeline:
  - **Late Spring 2025:** Project achieves substantial completion
  - **Summer 2025:** NASA personnel will conduct flow surveys and tunnel calibrations
  - **Fall 2025:** FDRF will become operational

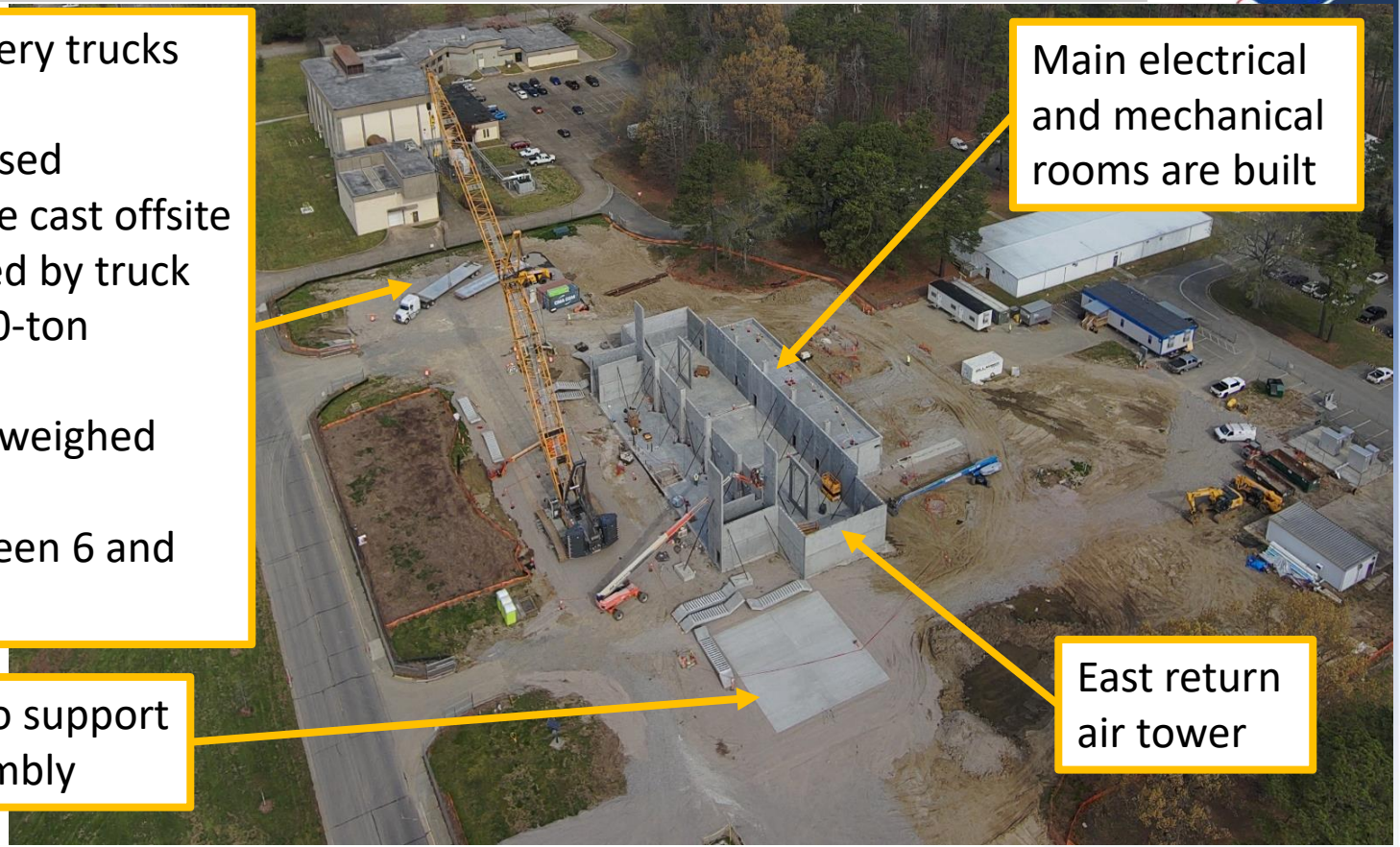
FDRF Construction Site – 1/5/23

Image credit: G. Banziger, NASA

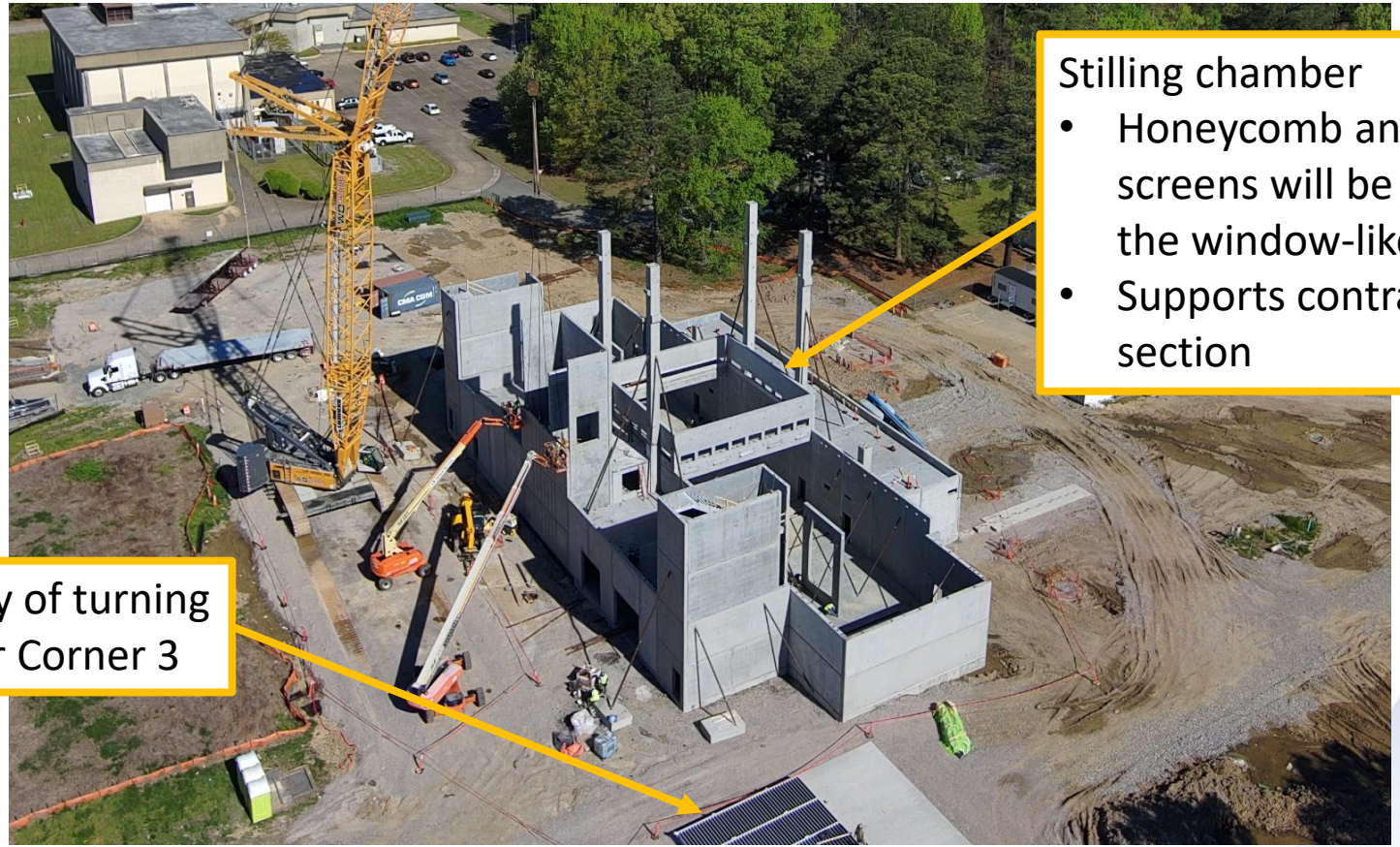
FDRF Construction Site – 3/24/23

Precast concrete delivery trucks and crawler crane

- Nearly 450 pre-stressed concrete panels were cast offsite
- Panels were delivered by truck and erected by a 230-ton crawler crane
- The heaviest panels weighed 80,000 lbs
- Crews erected between 6 and 20 panels per day



FDRF Construction Site – 4/11/23



Stilling chamber
- Honeycomb and flow screens will be installed in the window-like openings
- Supports contraction section

Assembly of turning vanes for Corner 3

FDRF Construction Site – 6/5/23

FDRF Construction Site – 8/30/23

FDRF Construction Site – 9/14/23

Control Room level
- The floor and roof decks are installed
- Facade pieces are being installed

One module of the turning vanes for Corner 2

Image credit: G. Banziger, NASA

FDRF Construction Site – 7/15/24

Artistic rendering

Construction photograph

FDRF Construction Site – 11/22/24

FDRF Construction Site – 12/16/24

Image credit: C. West, NASA

Concluding Remarks

Flight Dynamics Research Facility (FDRF)

- State-of-the-art subsonic vertical wind tunnel at NASA Langley Research Center
  - Replaces, combines, and expands capability of two legacy facilities
  - Supports rapid testing for all forms of aeronautical vehicles
  - Enables development of new atmospheric flight technologies
  - Extensive applications
- Flexibility and adaptability emphasized throughout the design process
- Small, highly-skilled staff combined with cutting-edge test techniques
- Expected to become operational in Fall 2025
- Will serve as a unique, enabling facility for NASA missions and other organizations' experimental testing needs for decades to come

Questions/Discussion

Thank you for your attention.

For FDRF testing inquiries, please email:

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