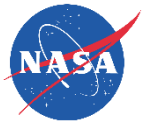


Quiet Supersonic Technology (QueSST) X-Plane Test

Ray Castner,

from

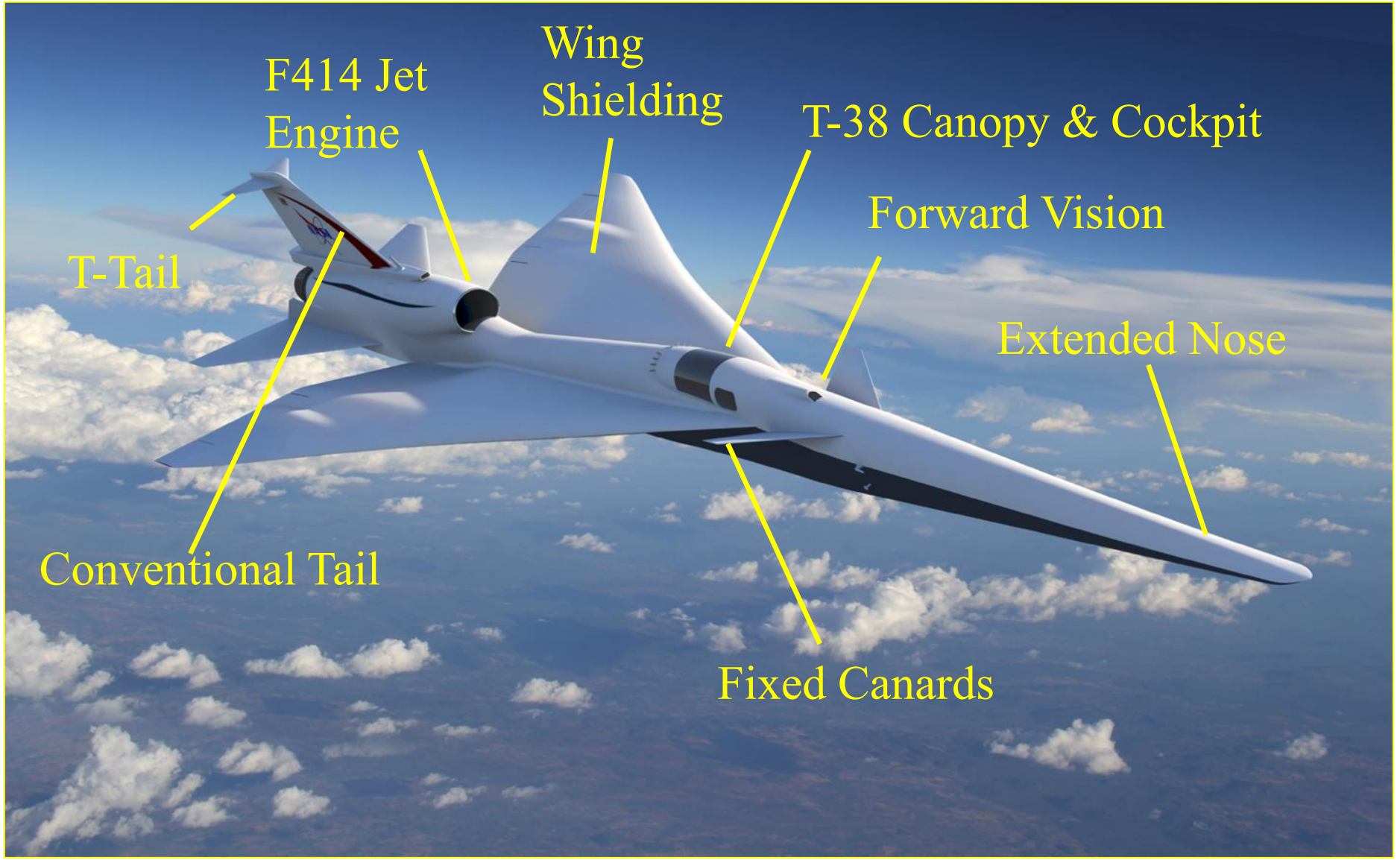
NASA Glenn Research Center,

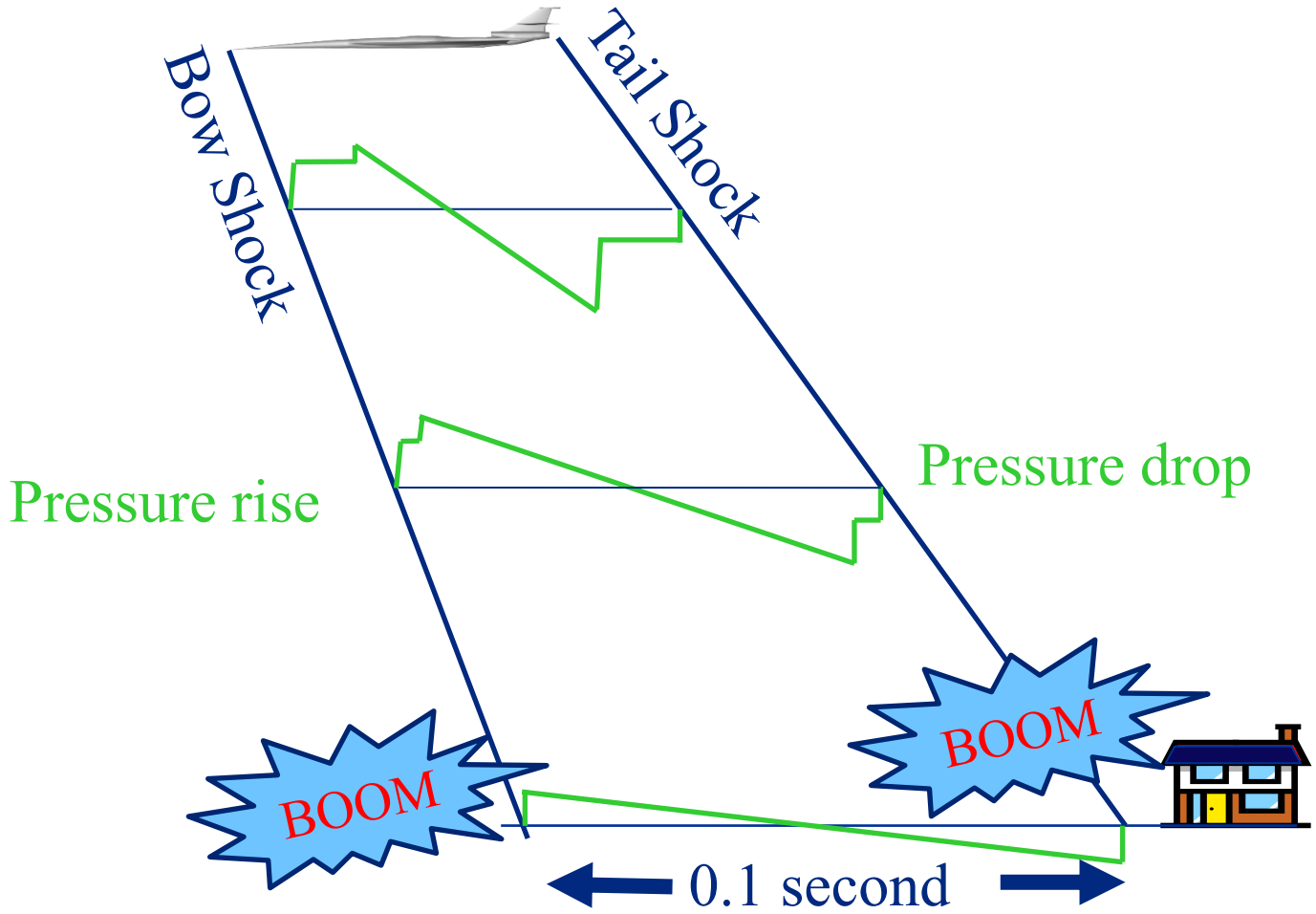
Cleveland OH

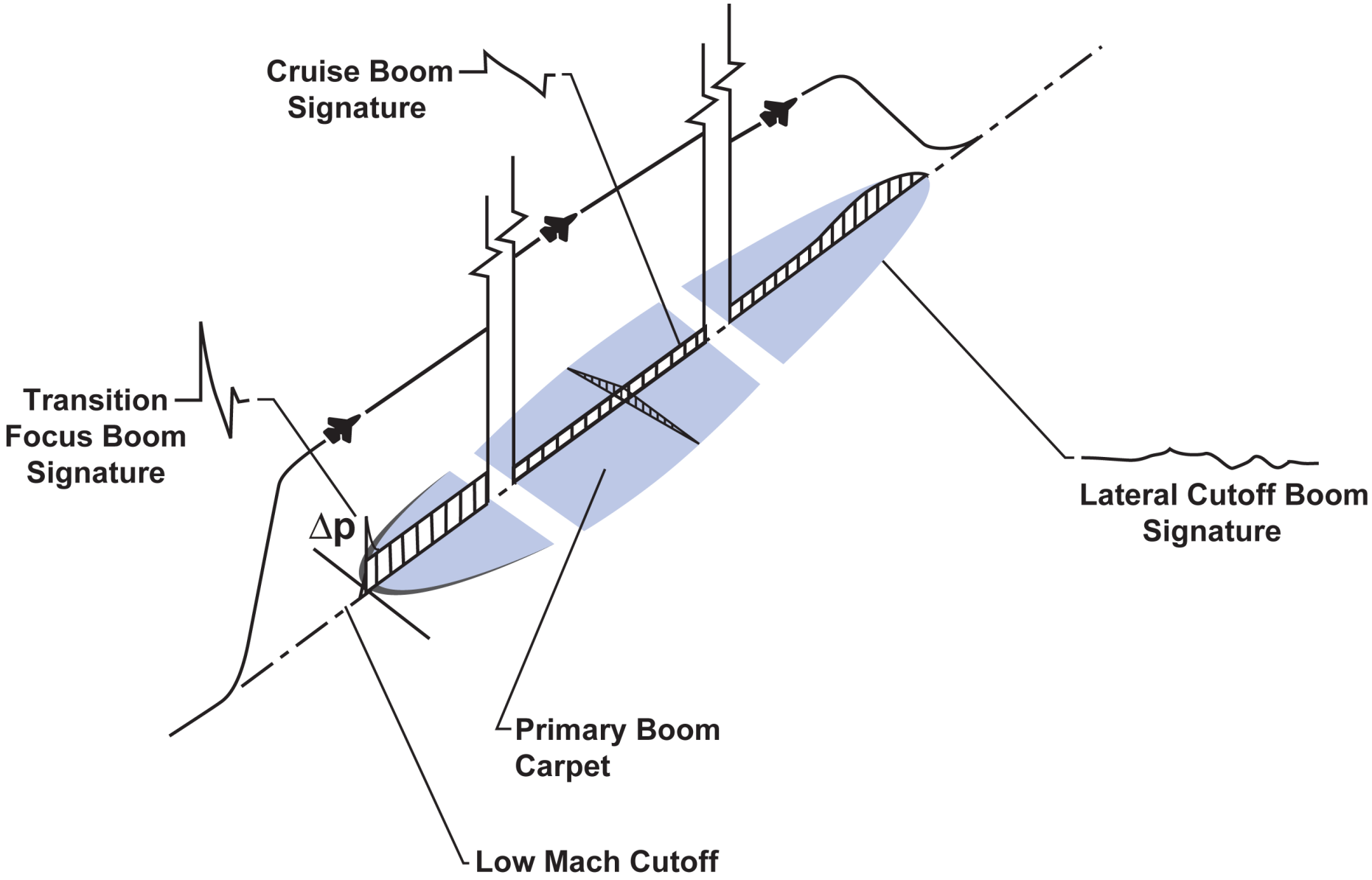
Outline

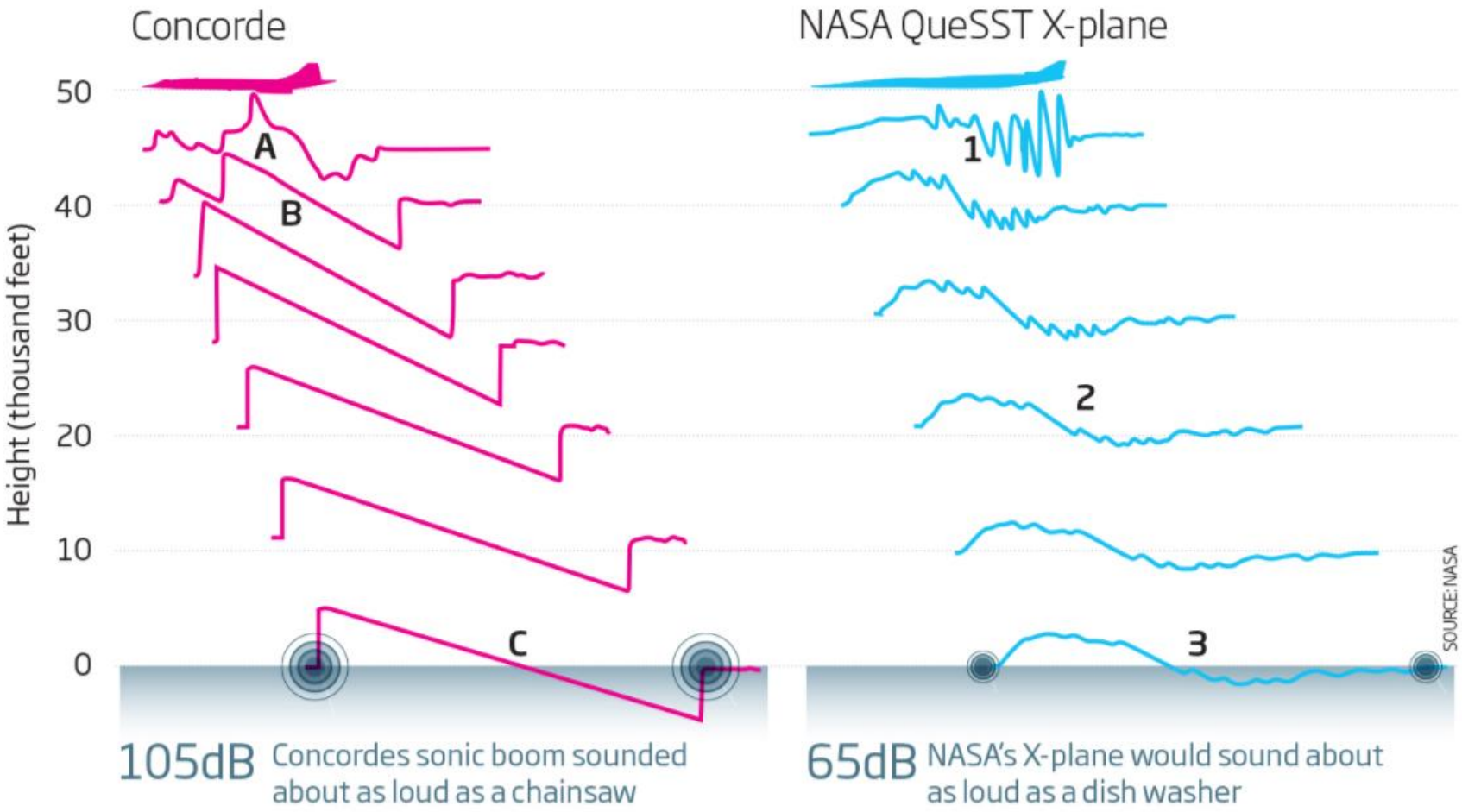
- Why QueSST?
- 8x6 Wind Tunnel
- QueSST Model
- Fabrication Progress

WHY QUESST?


F414 Jet Engine
Wing Shielding
T-38 Canopy & Cockpit
Forward Vision
T-Tail
Extended Nose
Conventional Tail
Fixed Canards

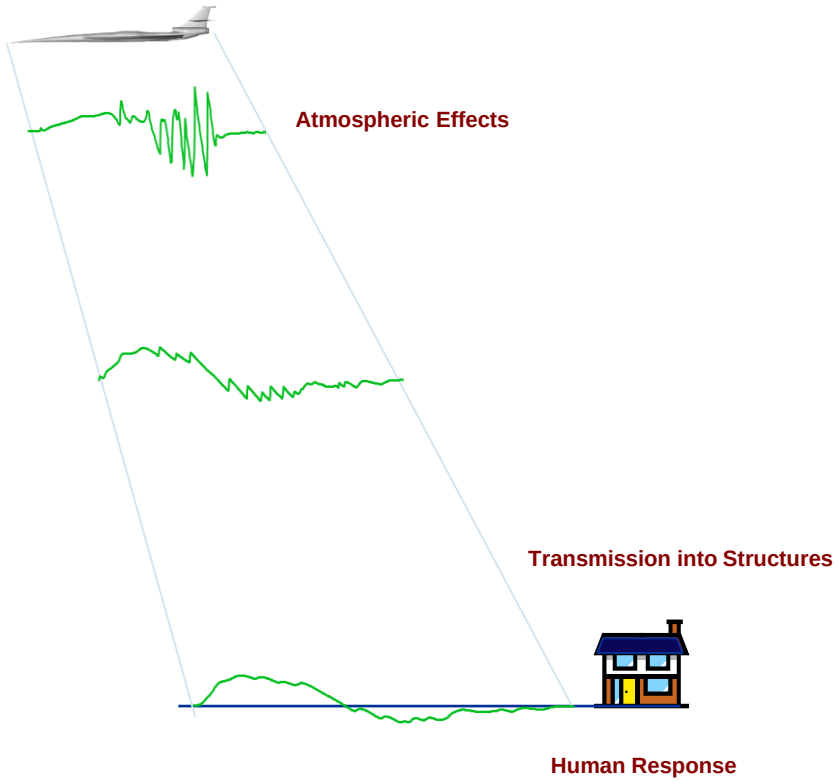

Bow Shock
Tail Shock
Pressure rise
Pressure drop
BOOM
BOOM
0.1 second


Cruise Boom Signature
Transition Focus Boom Signature
Δp
Lateral Cutoff Boom Signature
Primary Boom Carpet
Low Mach Cutoff


Concorde
NASA QueSST X-plane
Height (thousand feet)
50
40
30
20
10
0
A
B
C
1
2
3
SOURCE: NASA
105dB Concordes sonic boom sounded about as loud as a chainsaw
65dB NASA's X-plane would sound about as loud as a dish washer

NASA Sonic Boom Research:

- Low Boom Vehicle Design
- Atmospheric Propagation
- Outdoor & Indoor Acoustics
- Human Response
  - Laboratory Studies & Metrics
  - Field Studies & Community Response



Human Response

Specialized simulation facilities

Community tests

Jury tests

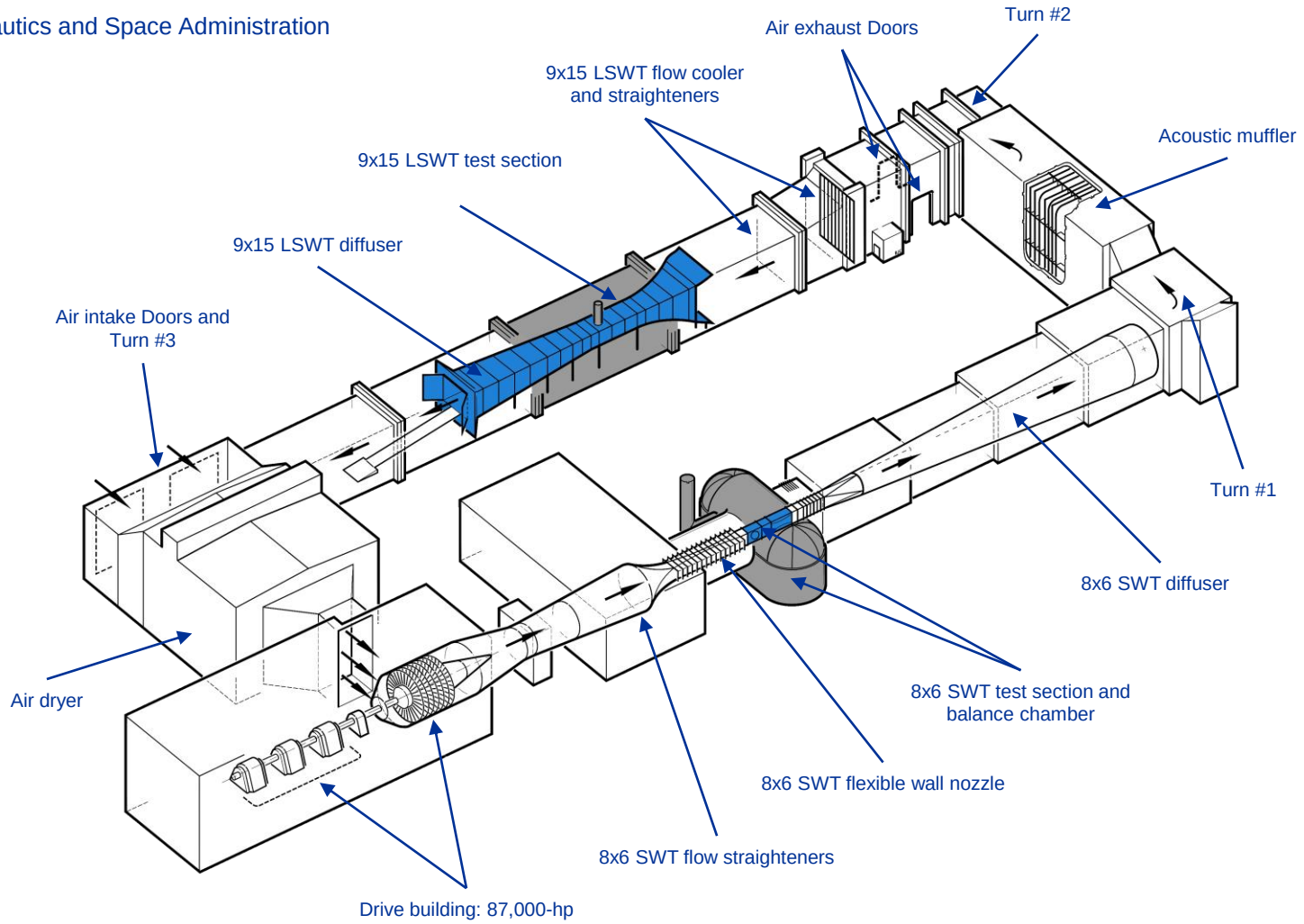
Next Step – Low Boom Flight Demonstration X-Plane

Awarded to Lockheed Martin

Wind Tunnel Testing at 8’x6’ SWT

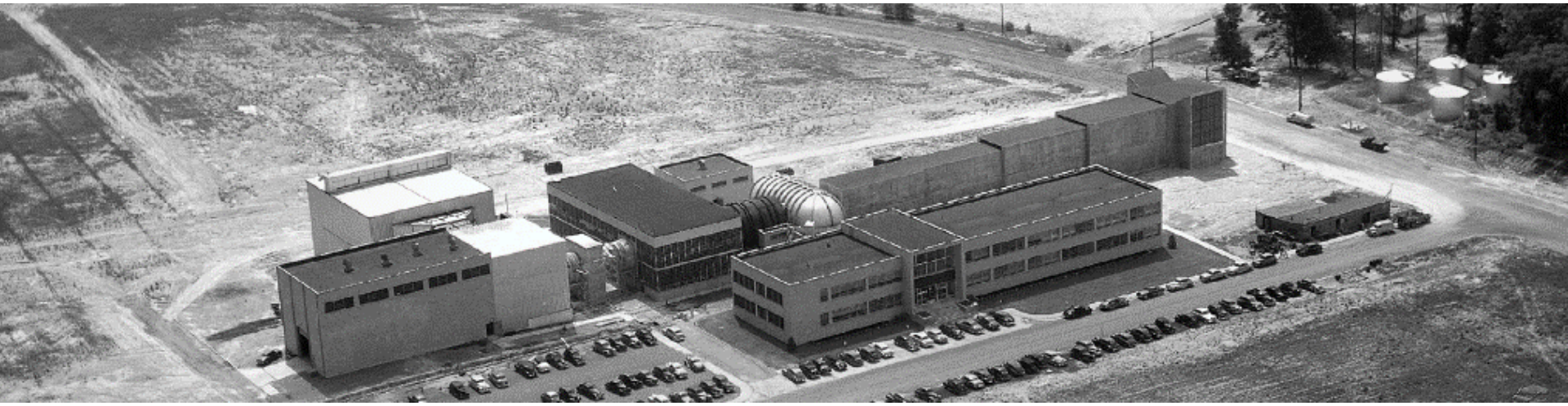
Verify Vehicle S&C

Propulsion Performance



8- BY 6-FOOT AND 9- BY 15-FOOT WIND TUNNEL COMPLEX

8- by 6-foot and 9- by 15-foot Wind Tunnel Complex



1949 overhead image of 8x6 complex

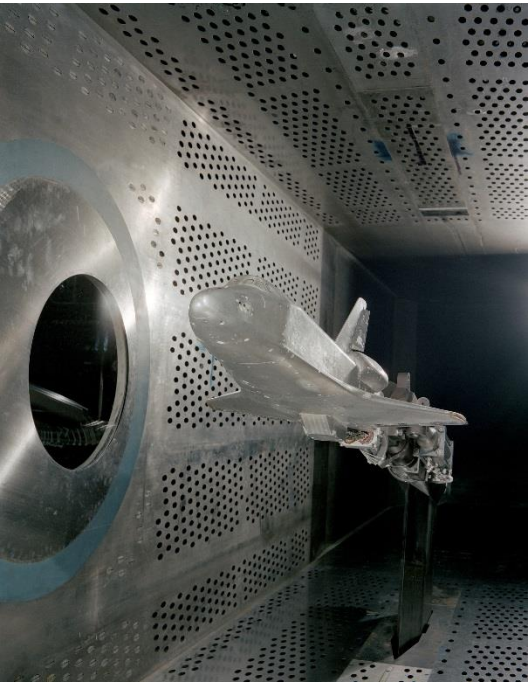
2015 overhead image of 8x6/9x15 complex

Historical Relevance

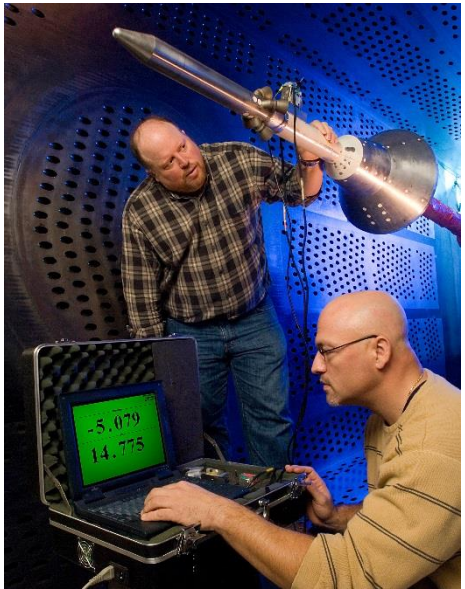
↑ C-1960-54465

↓ C-2007-2471

↓ C-1970-1385



↓ C-1983-6425

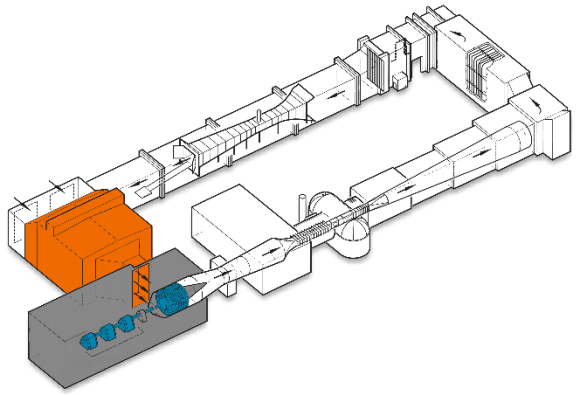


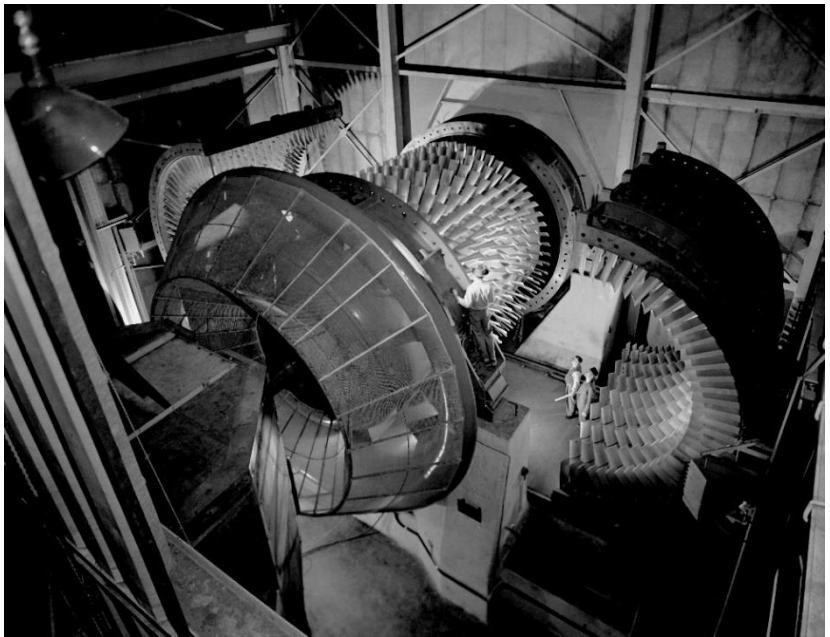
↑ C-1986-4703

↑ C-1964-72479

Wind Tunnel Drive & Air Dryer

Three 29,000-hp drive motors set in series drive a single shaft



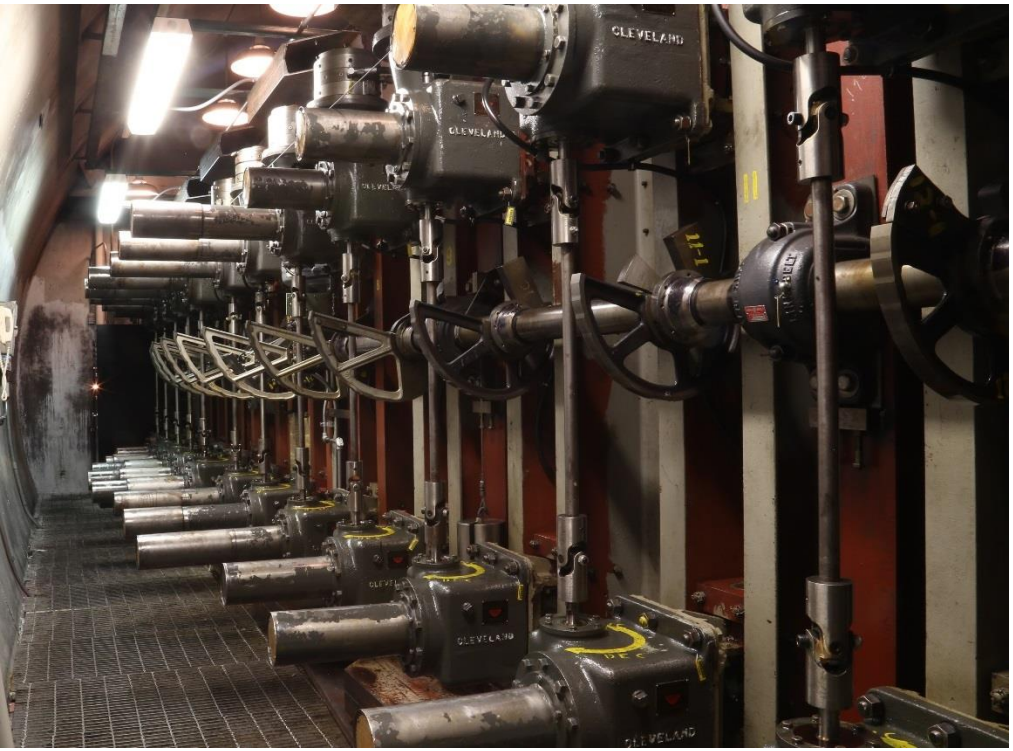


C-1945-23277

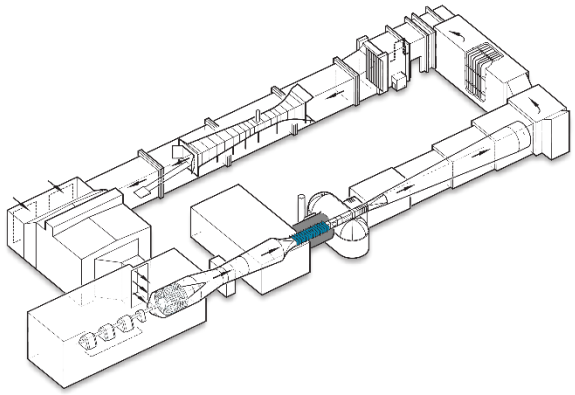
7-stage axial compressor with outer shell opened for inspection; max 870-RPM and 2500-lbs/sec mass flow

Air-dryer beds upstream of compressor with 8-layers of desiccant

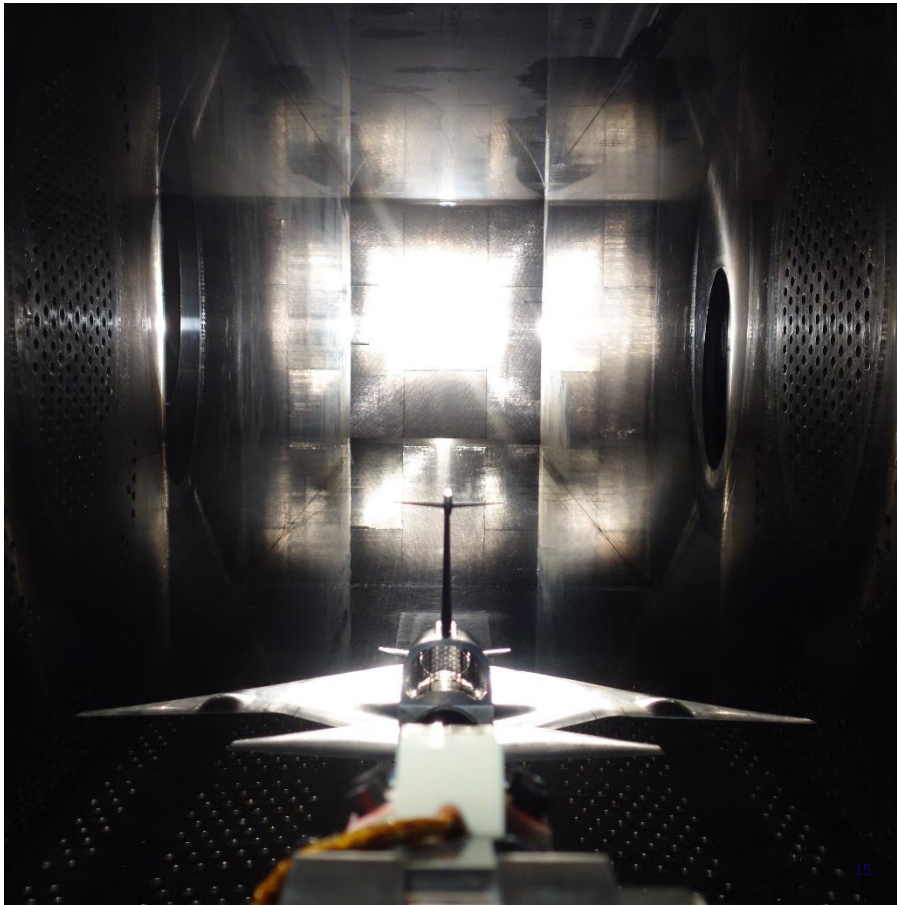
Flexible Walled Nozzle



Hydraulic stations that drive a single wall and the cams that dictate wall movement



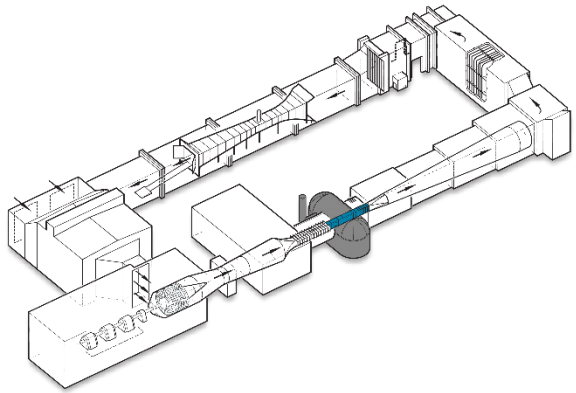
QueSST model installed in 8x6 SWT test section and the flexwall visible upstream



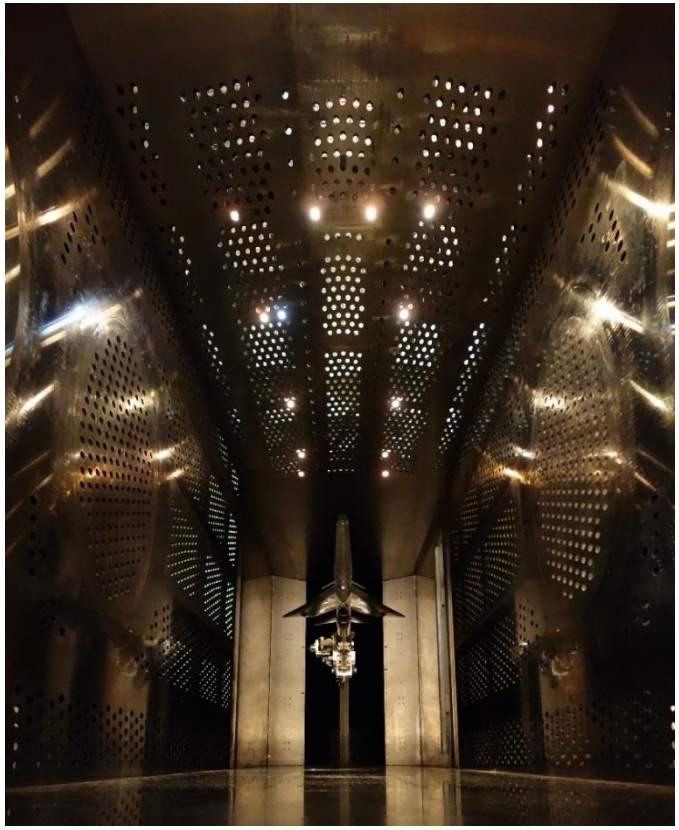
Test Section

C-1956-42930

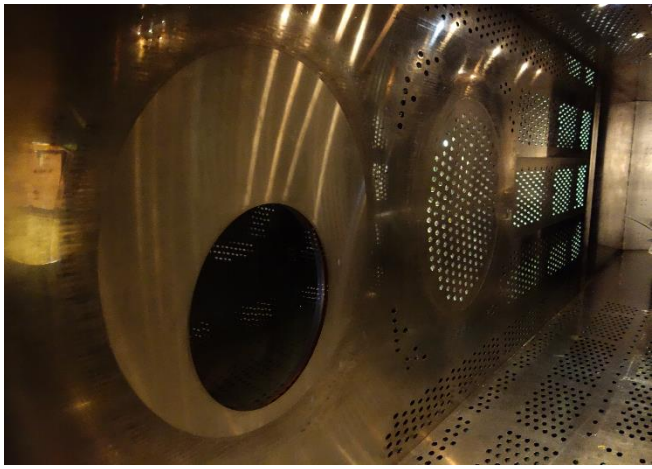
Porosity hole drilling operation in 8x6 SWT, 1956

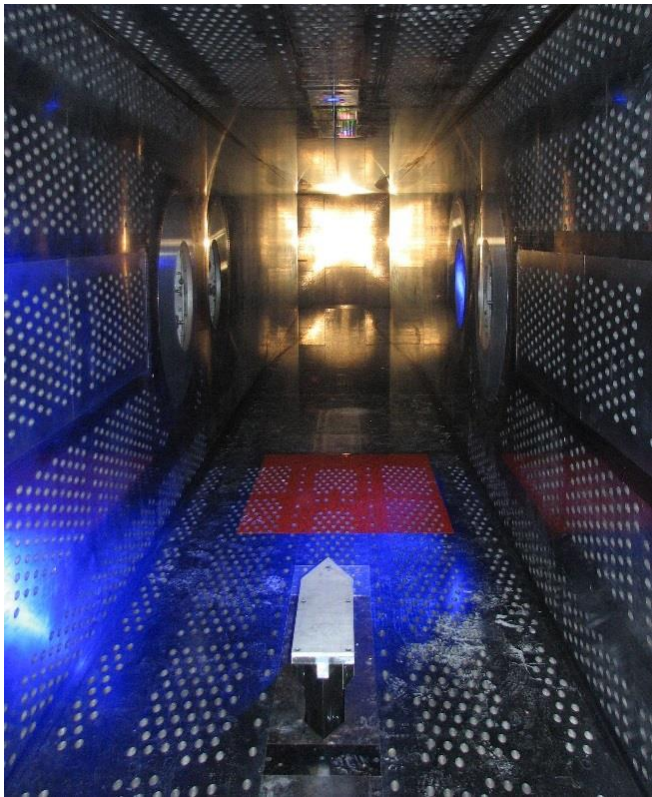


"South wall" of test section showing both smooth and porous sections with both Schlieren windows and porous blanks



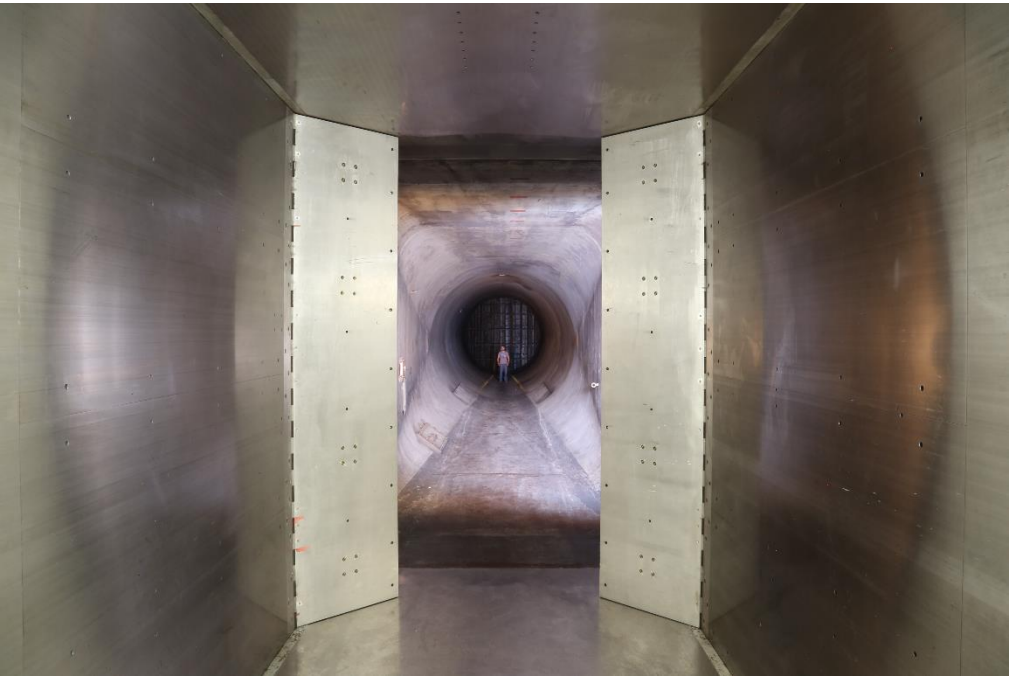
QueSST model installed in 8x6 SWT test section



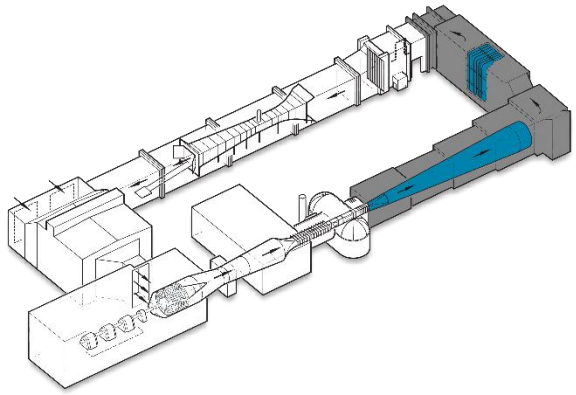


Looking upstream; flow imaging installation and full view of 8x6 SWT test section

Diffuser & Acoustic Muffler



8x6 diffuser as seen from the test section looking downstream; visible person is halfway down

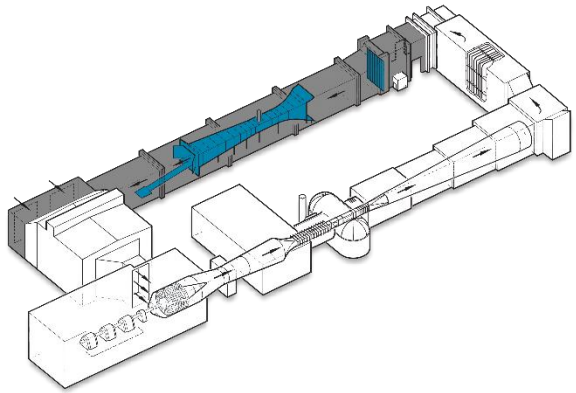


C-1950-26414

End of 8x6 SWT diffuser, into Turn #1, and into triple-storied Acoustic Muffler

Closing the Circuit and the 9x15 LSWT

C-1990-4389
McDonnell Aircraft Company
279-3C STOVL model

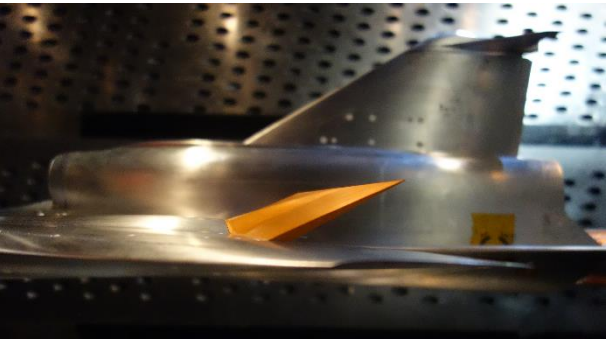


C-1994-01831L
Turbofan model using compressed air as fan drive; installed in legacy 9x15 LSWT

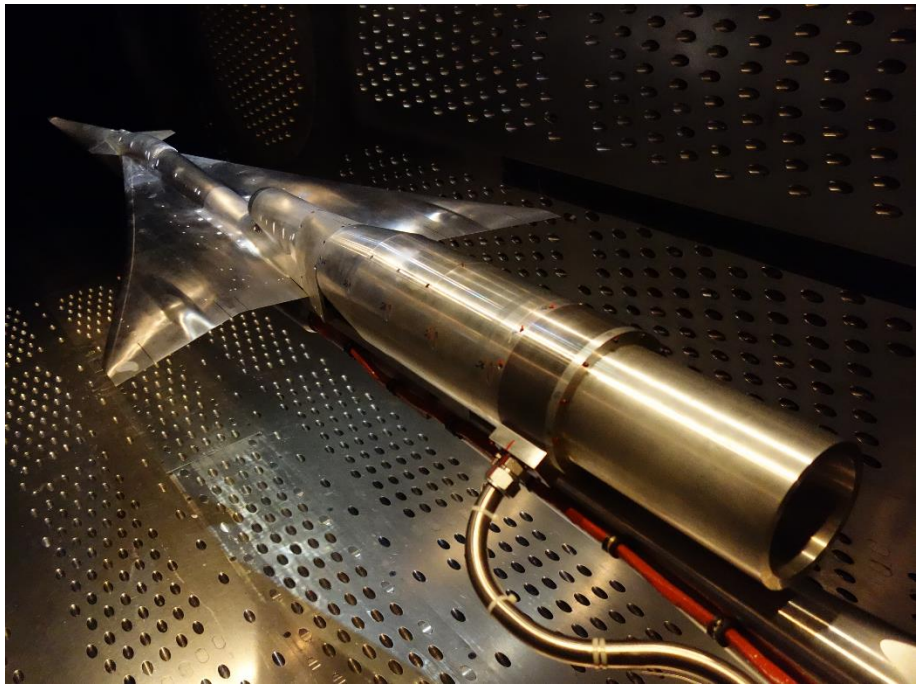
9x15 test section dismantled in preparation for facility upgrades in 2017-2018

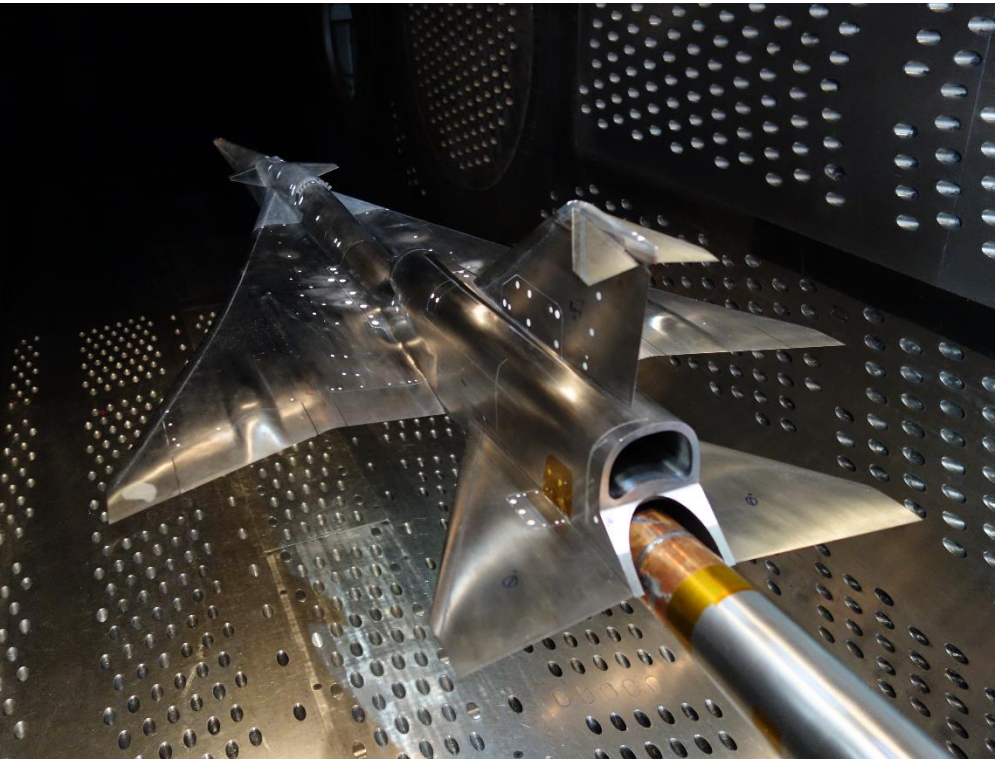
INSTALLATION OF QUESST

QueSST Test Phases

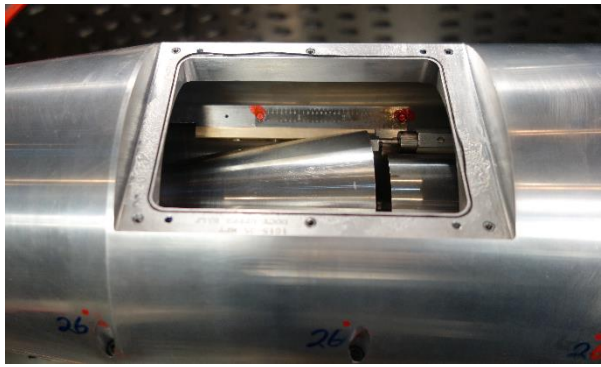


QueSST aerodynamic installation February 2017 – March 2017

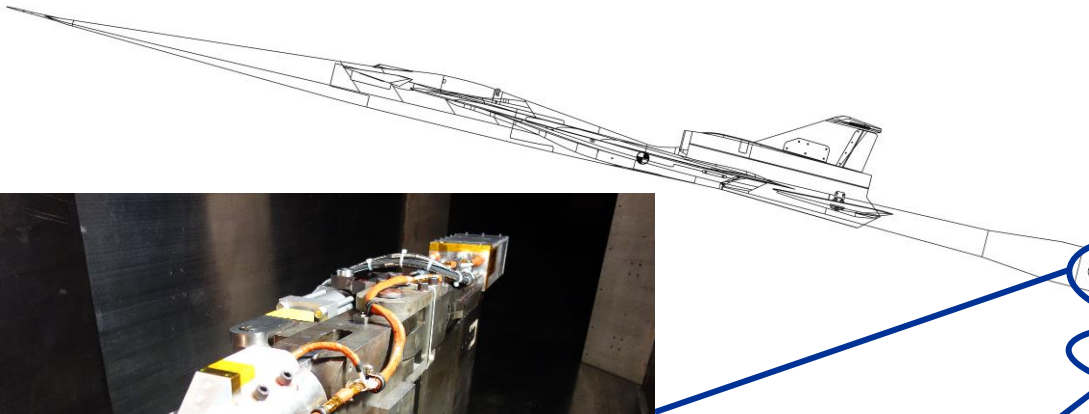


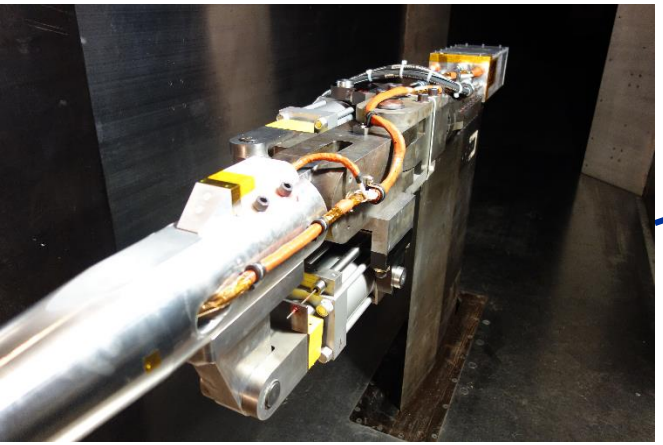


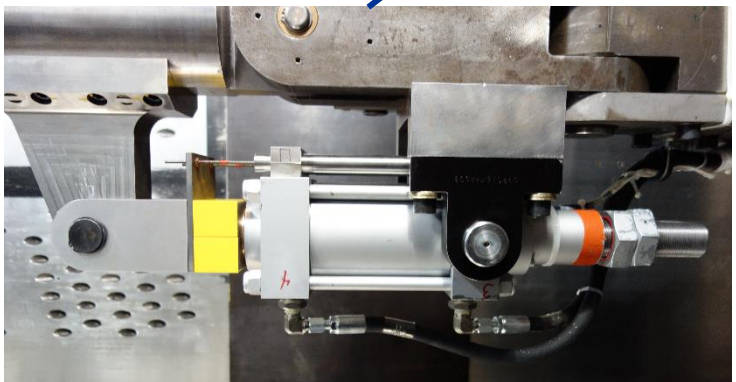
QueSST propulsion installation April 2017 – May 2017

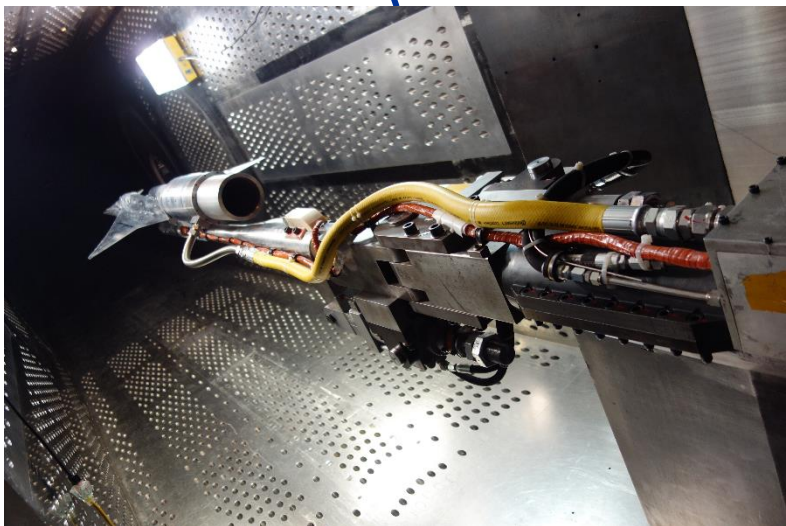


Components of the QueSST Supports

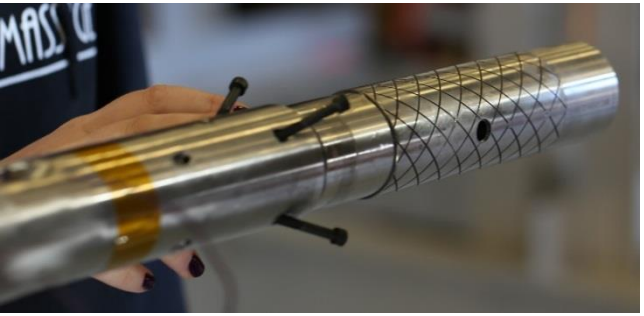








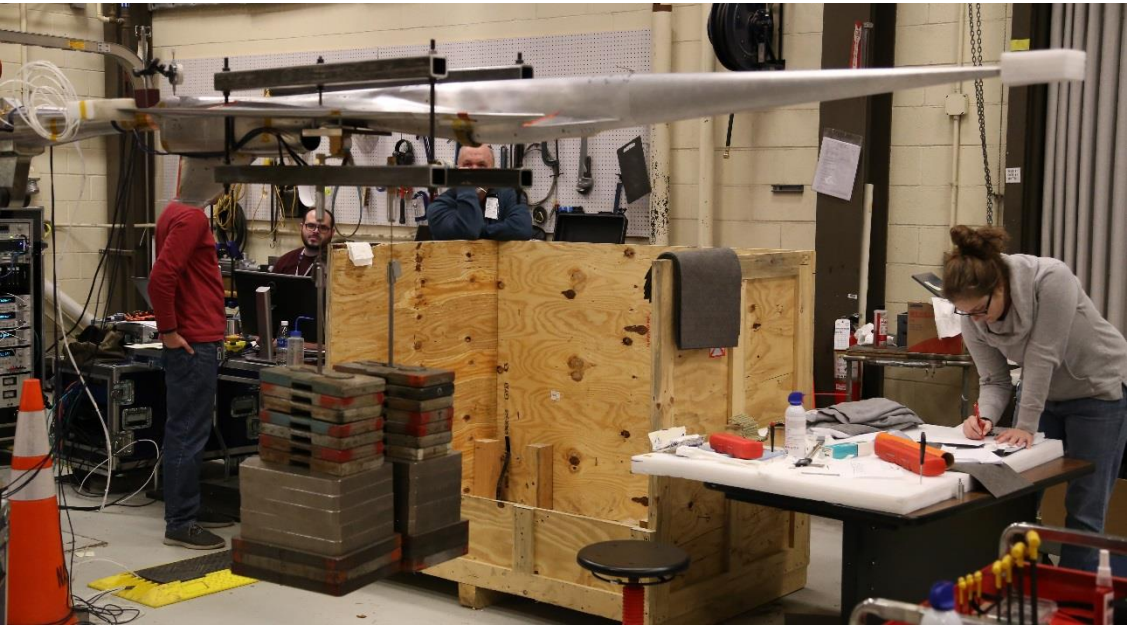
Prep Room Installation & Checkloads



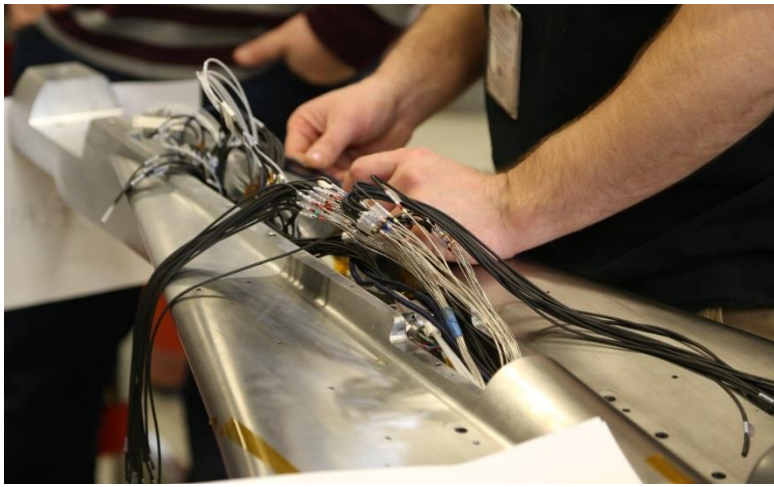
Balance installation in-progress

Model support stack-up installed on model positioning system

1,080-lbs loading in the Normal, or “Lift” component

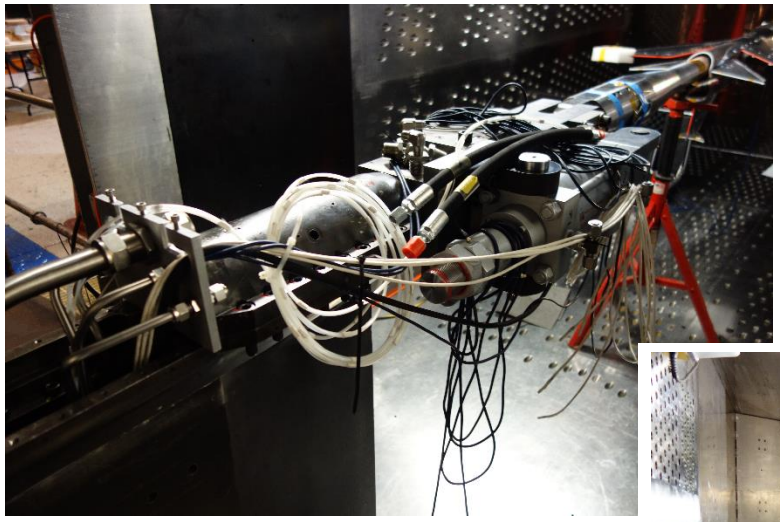


Model instrumentation work in preparation area



Test Section Installation

Lift of QueSST model into tunnel through downstream 16-foot hatch

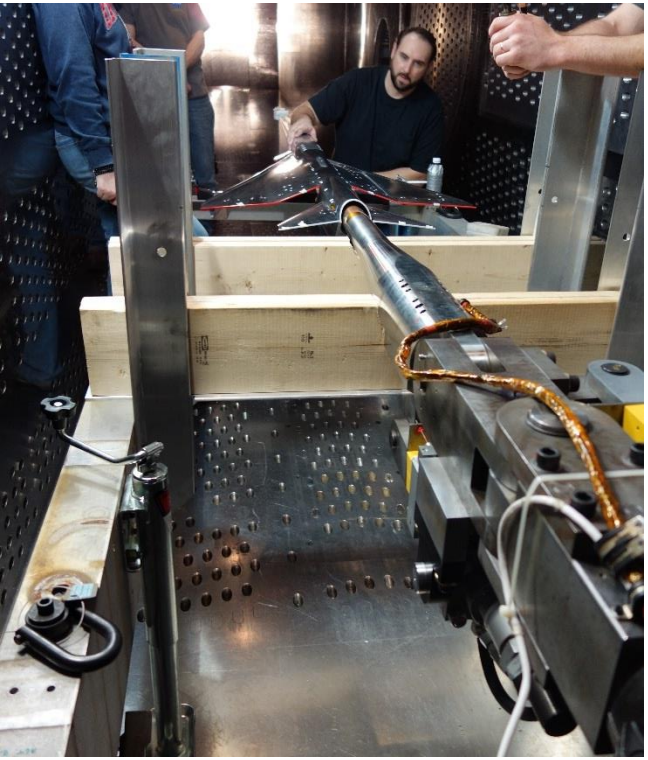


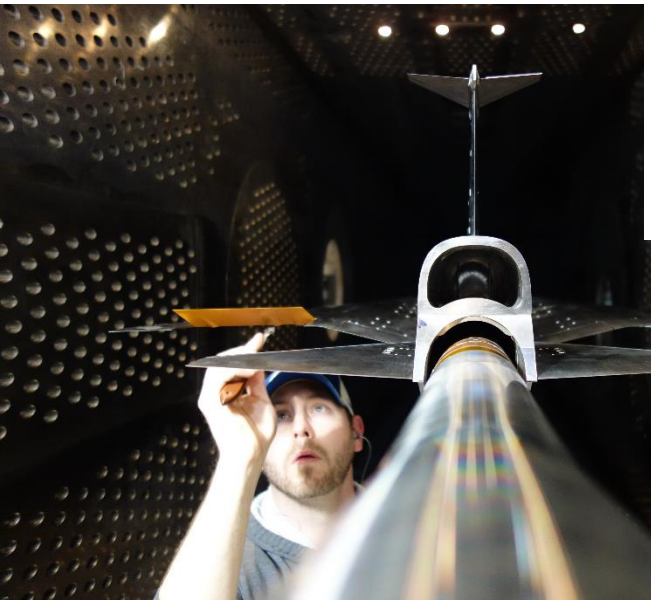
QueSST model installed, lifted off cart, cart pushed forward and disassembled

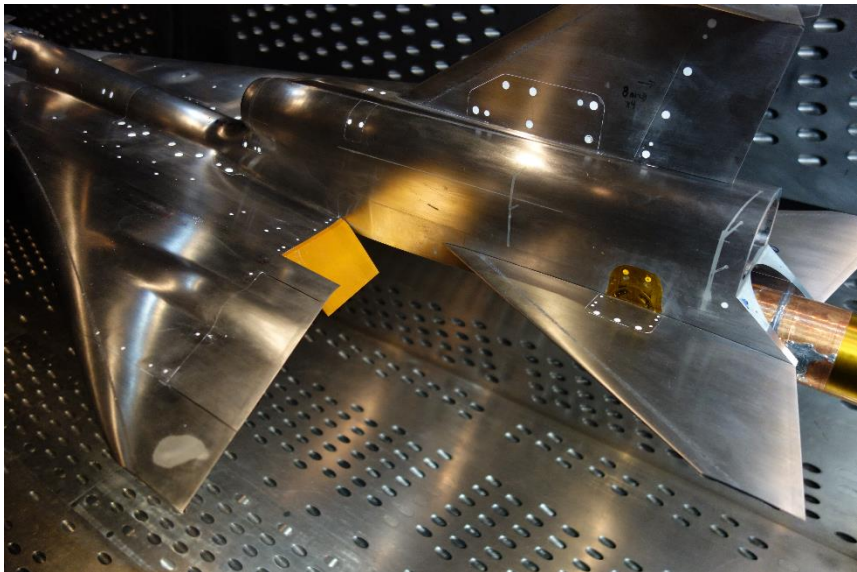
Support structure hydraulics and instrumentation cleaned up for run

QueSST assembly and data system validation checkloads as installed in test section

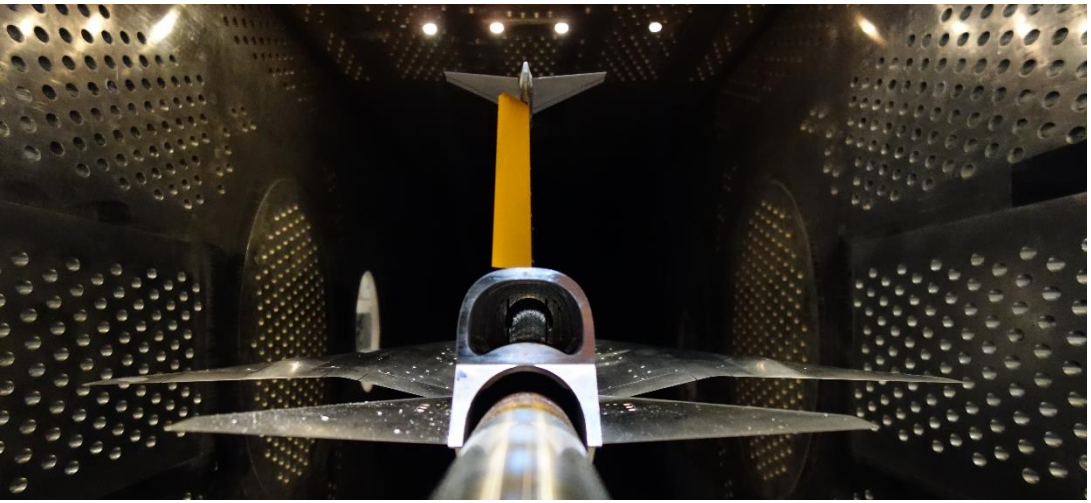
Testing - Aero

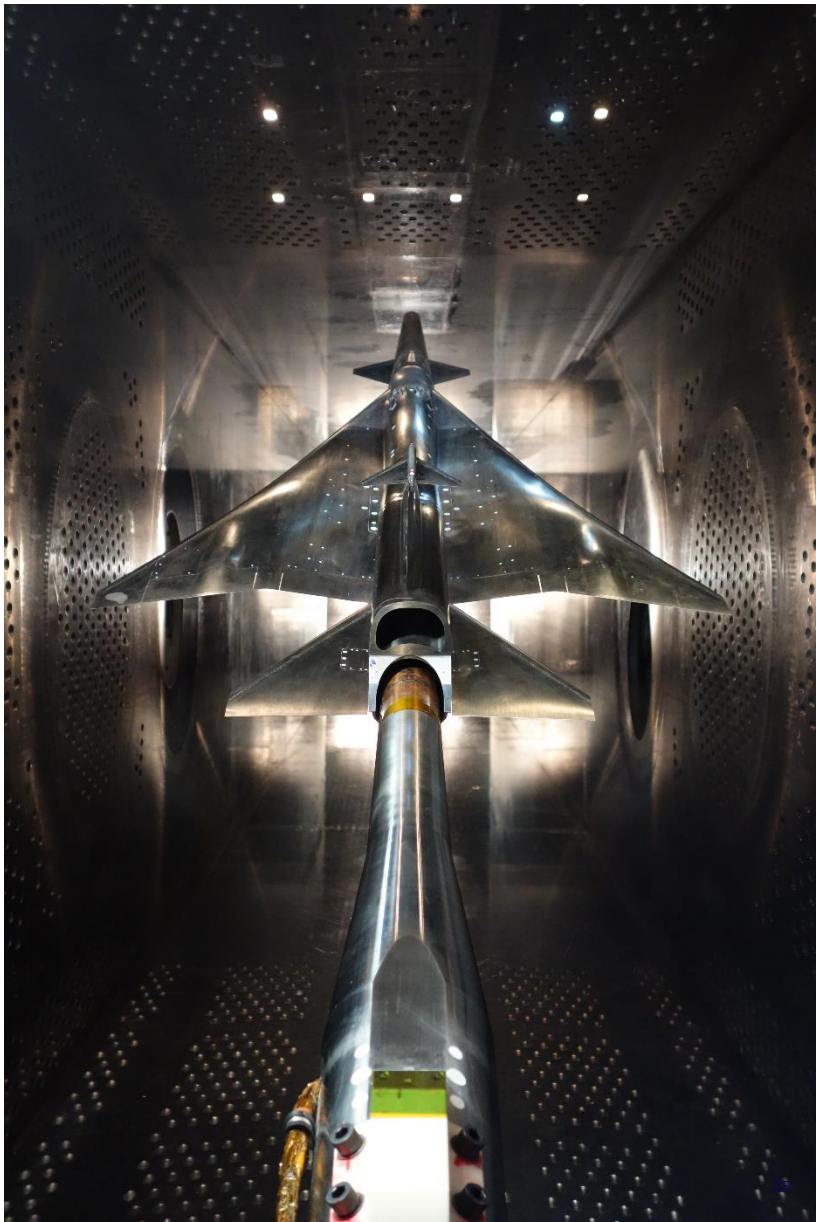




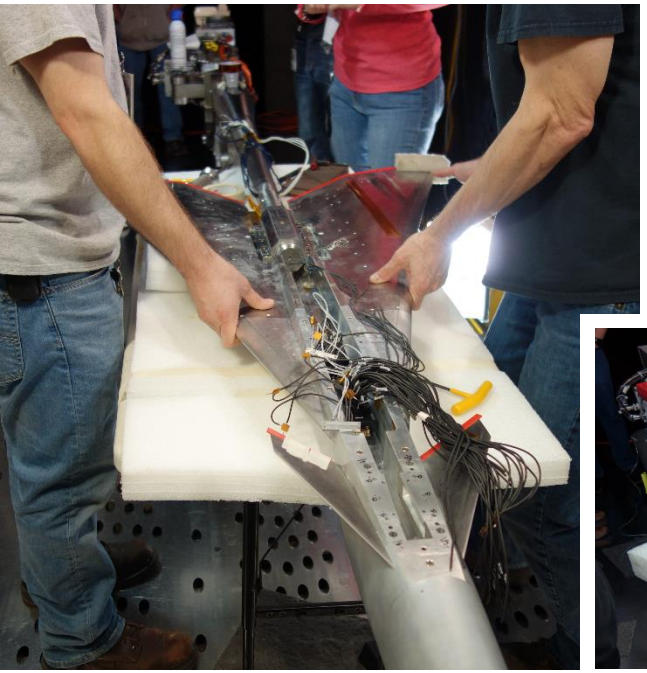


Testing - Aero

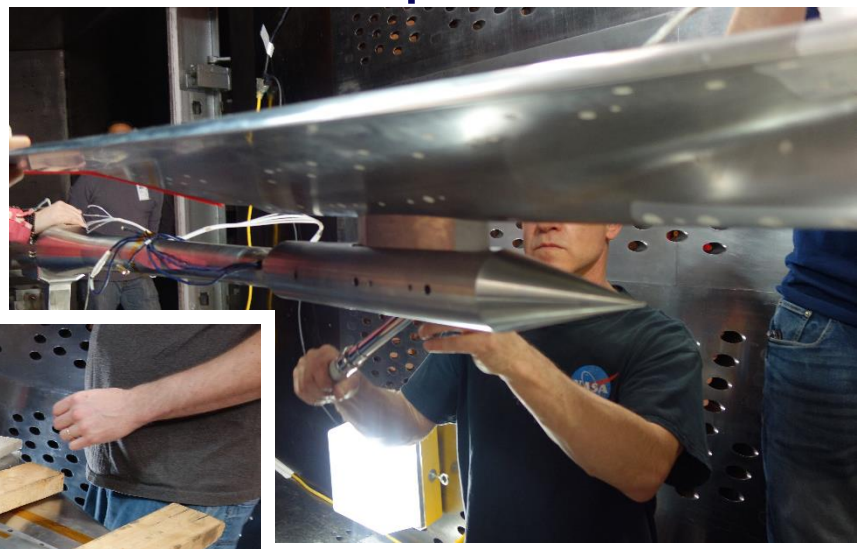


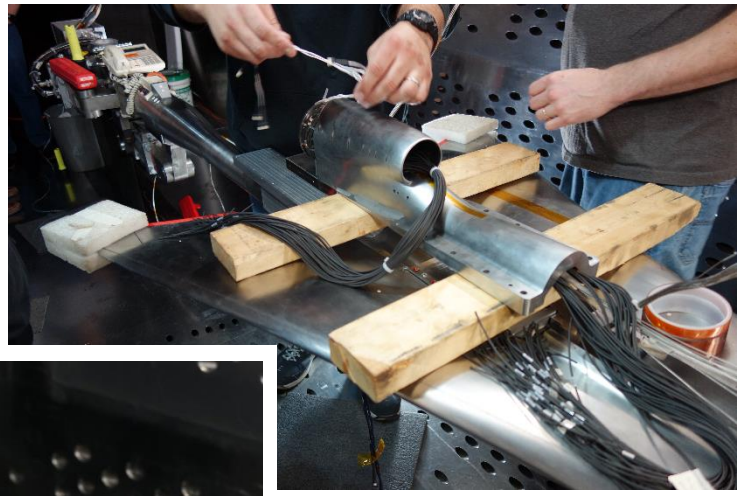


Model Change from Aero to Prop

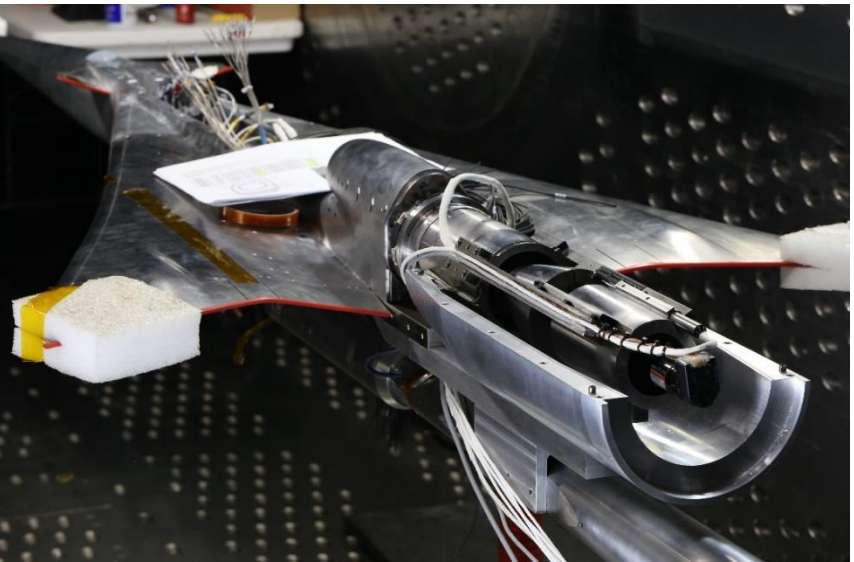


Aero tail geometry, internal balance mounting block, and balance removed; Model re-installed on offset blade to allow for MFP can

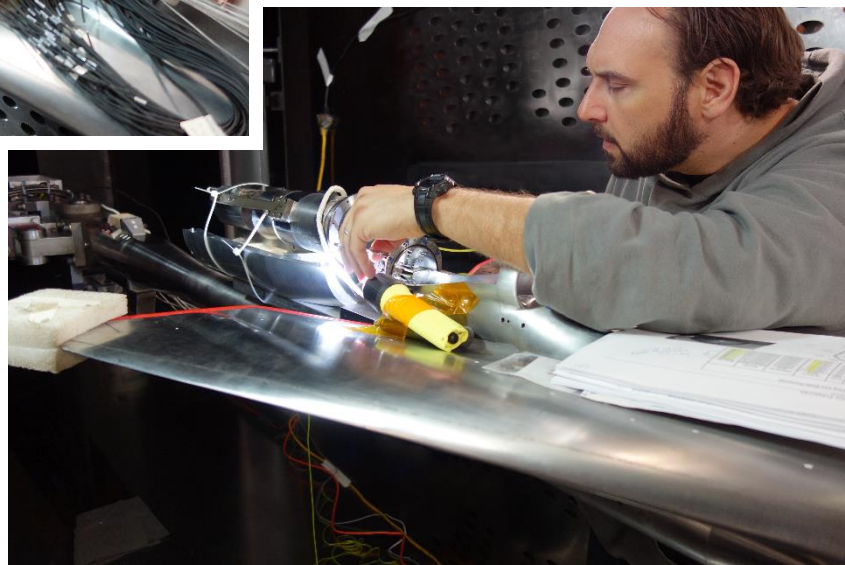




Propulsion geometry, rakes, and instrumentation routed and hooked up

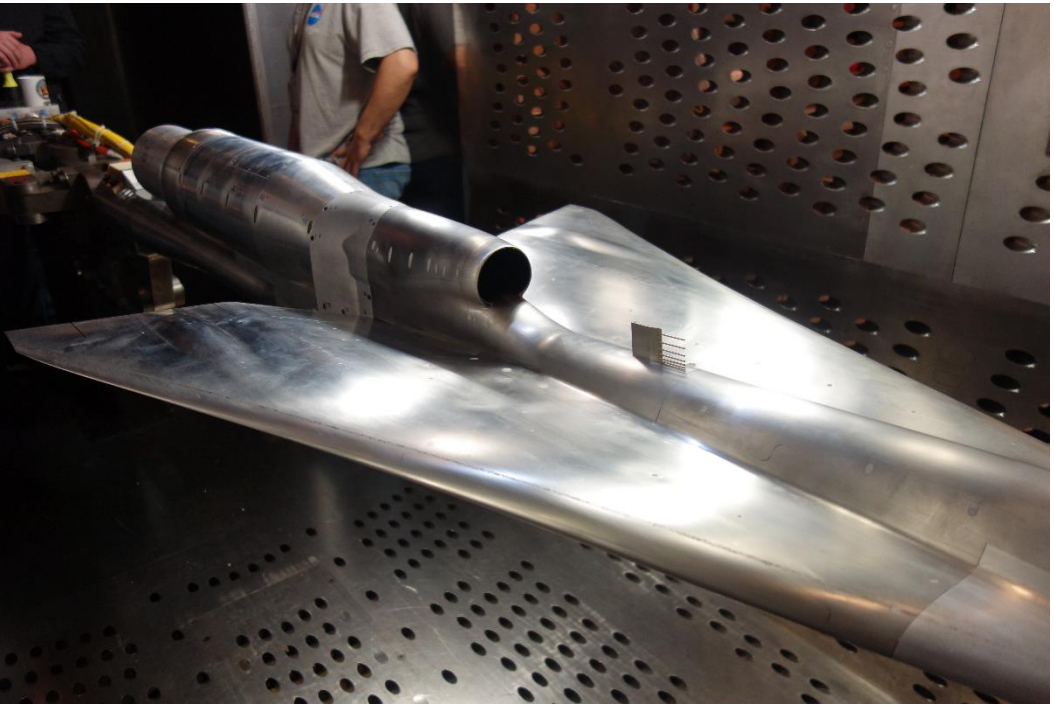


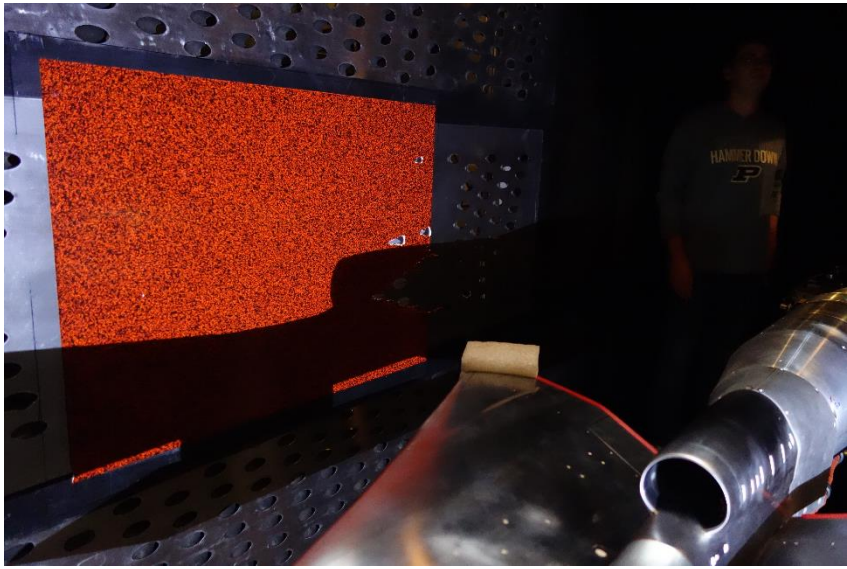
MFP installed and motion checked out



Testing - Propulsion

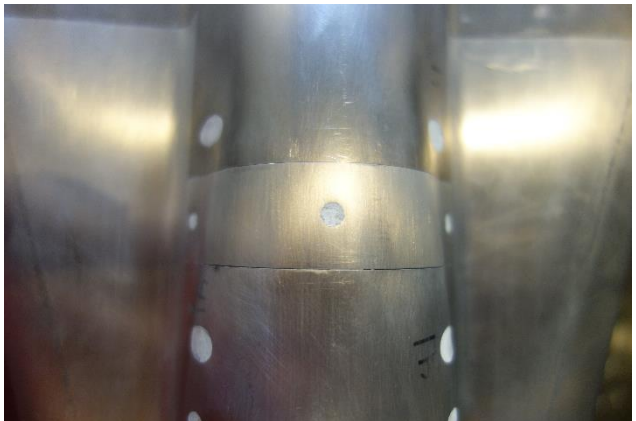
Inlet boundary layer rake installed



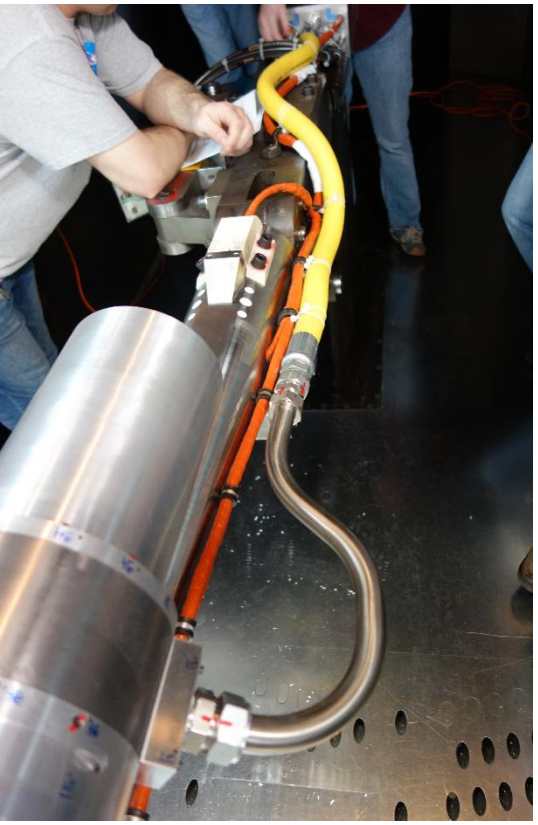


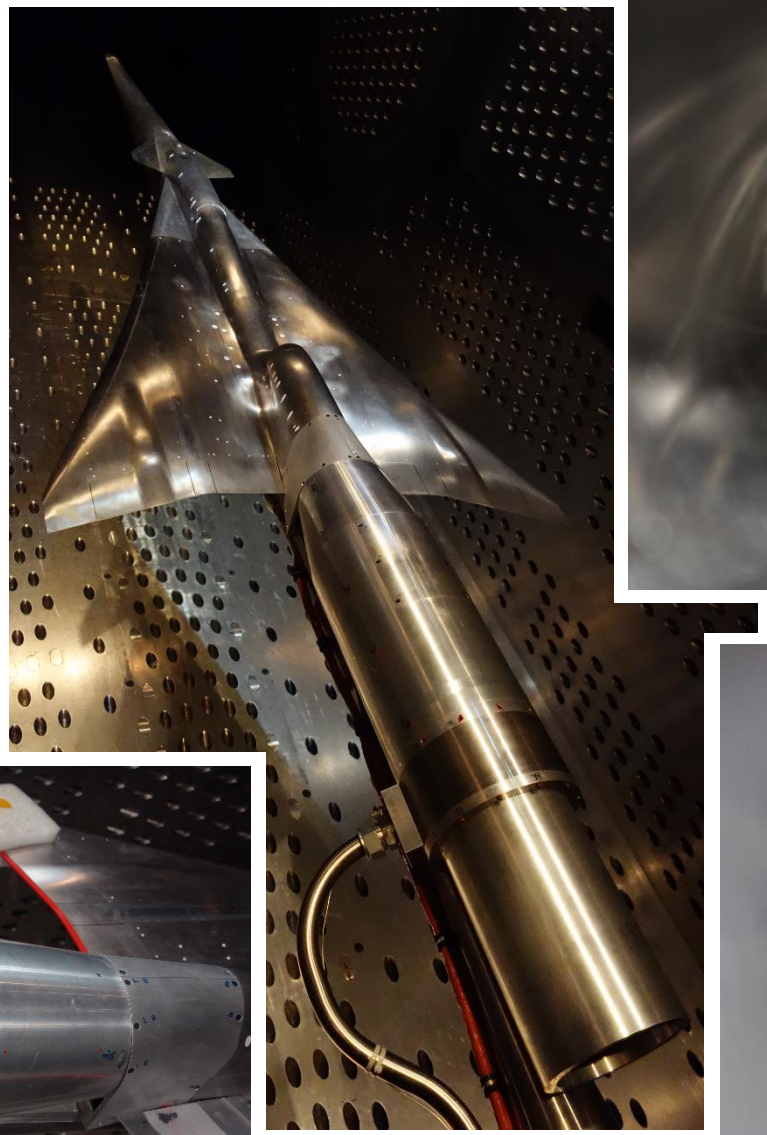
Background Oriented Schlieren (BOS) installed

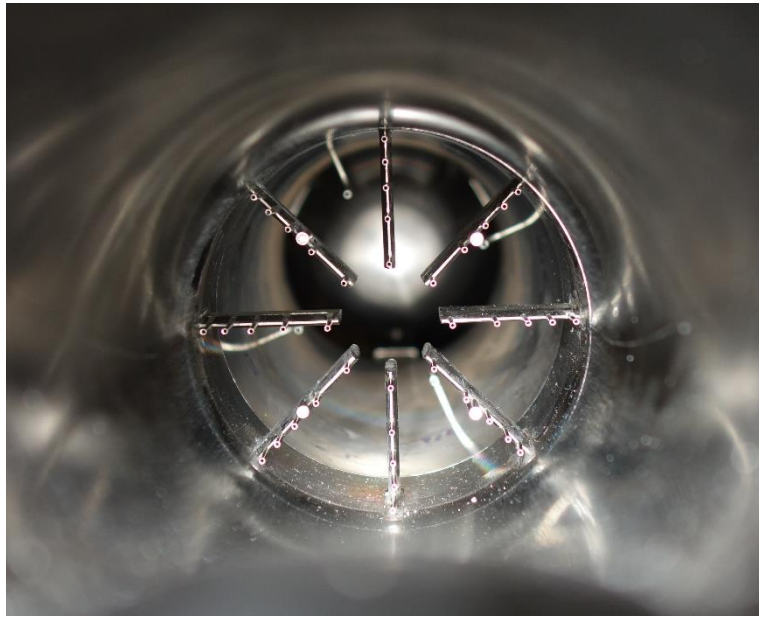
Three different vortex generator (VGs) installed for propulsion inlet testing

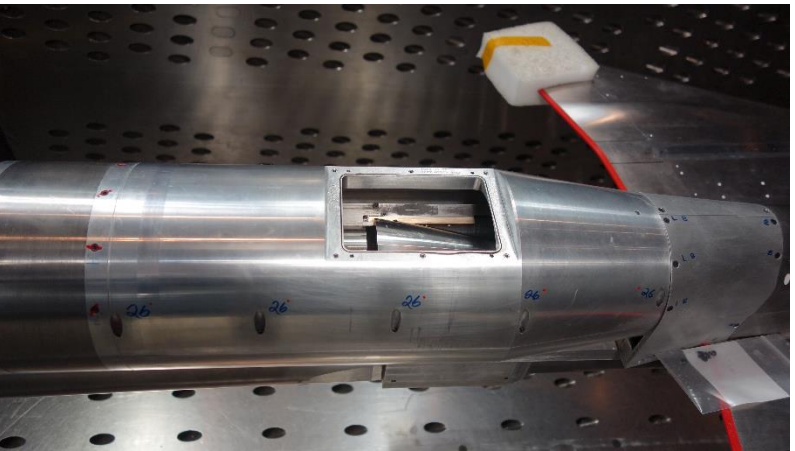


Testing - Propulsion

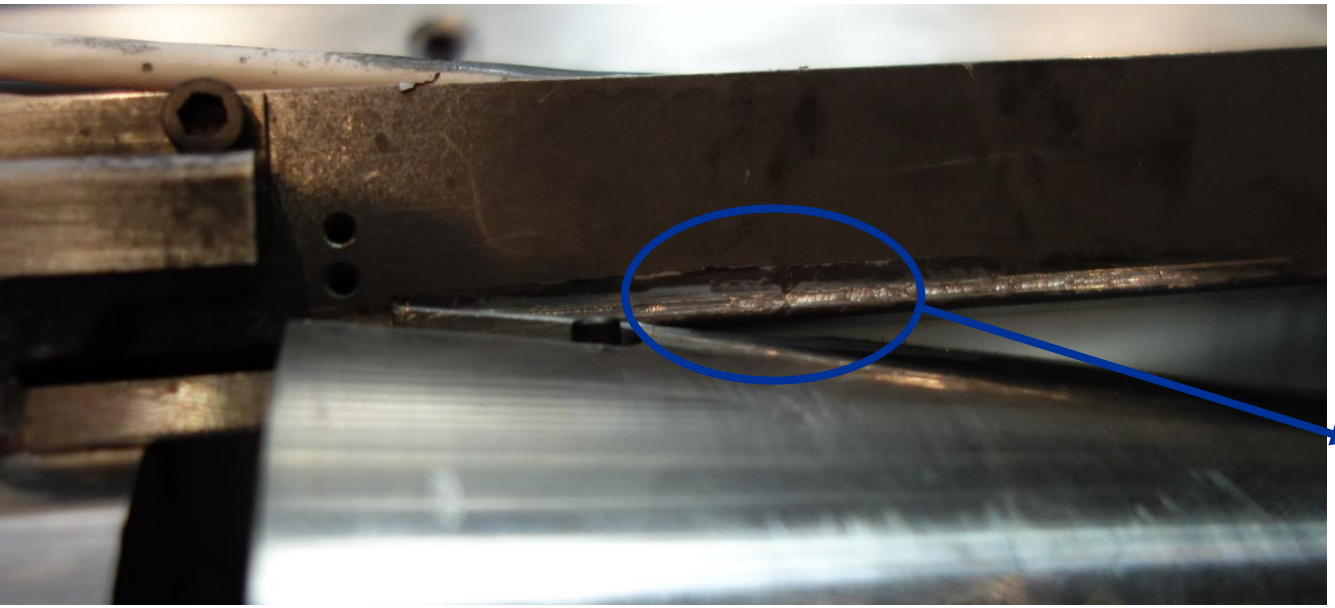






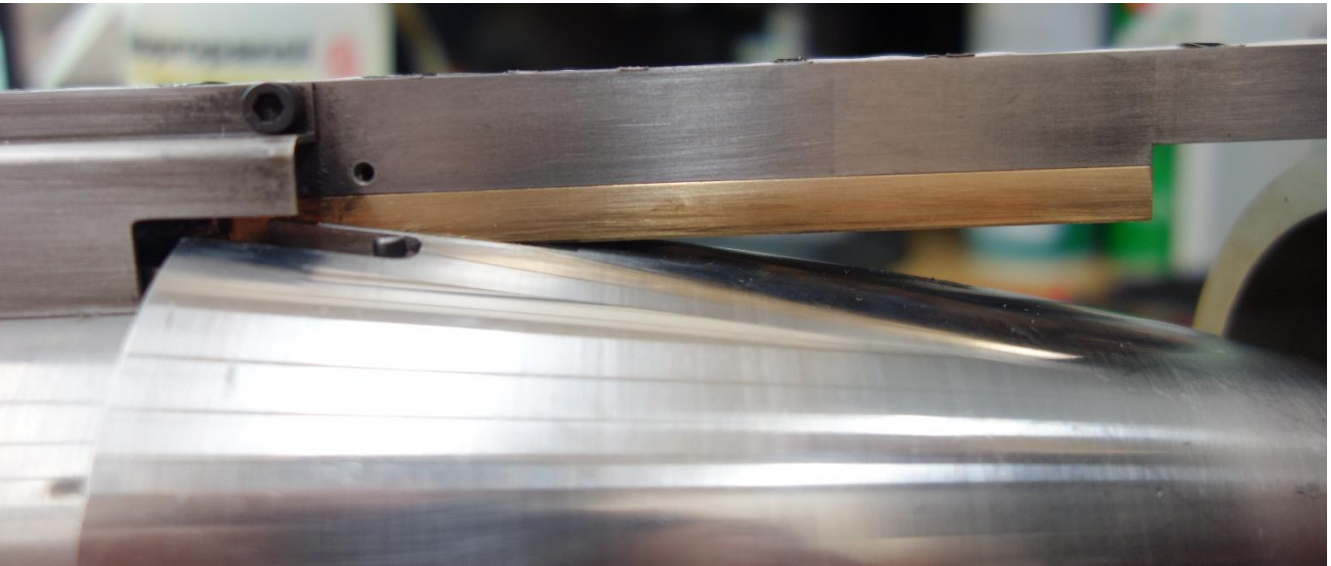


Challenges and Opportunities



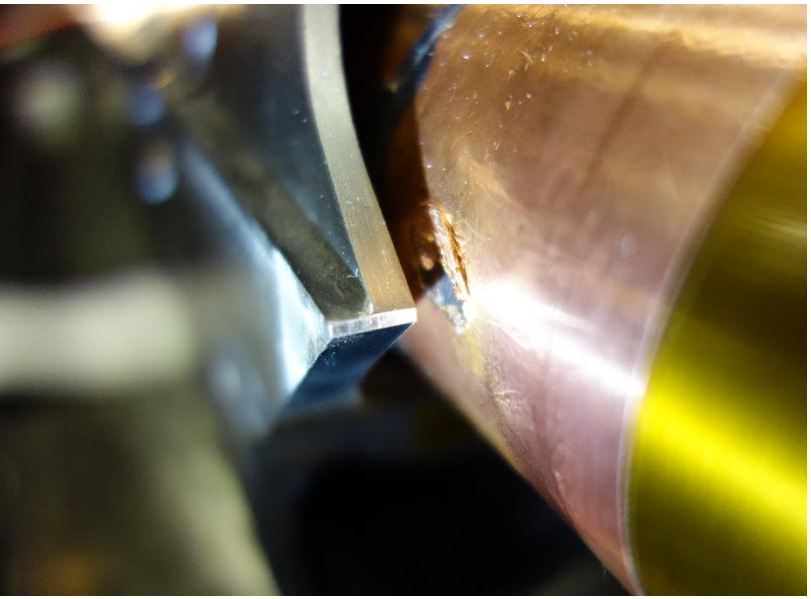
Plug galling on guide rails due to plug rotation

Rail damage left after plug/rail seizure



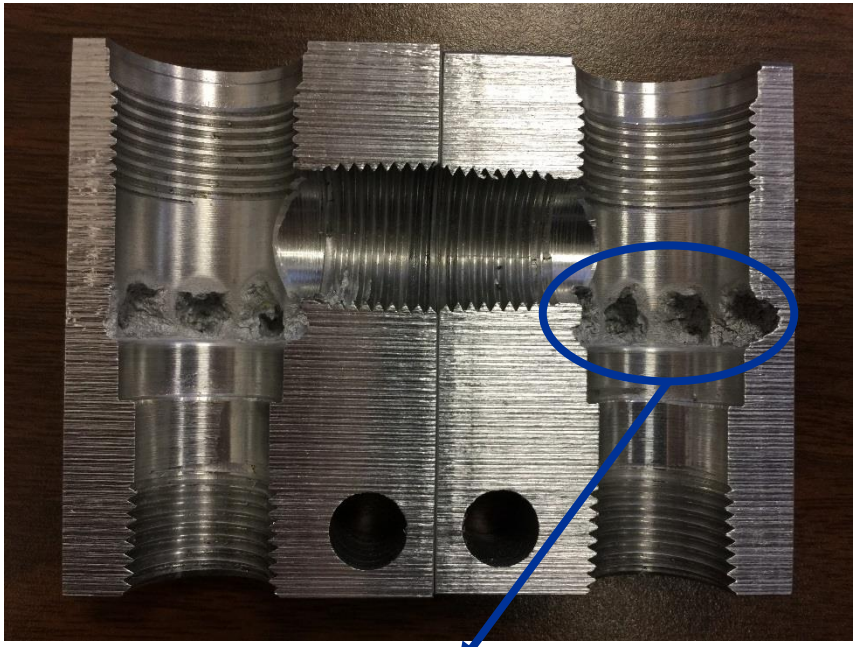
MFP rail modification to bronze sliders

Challenges and Opportunities



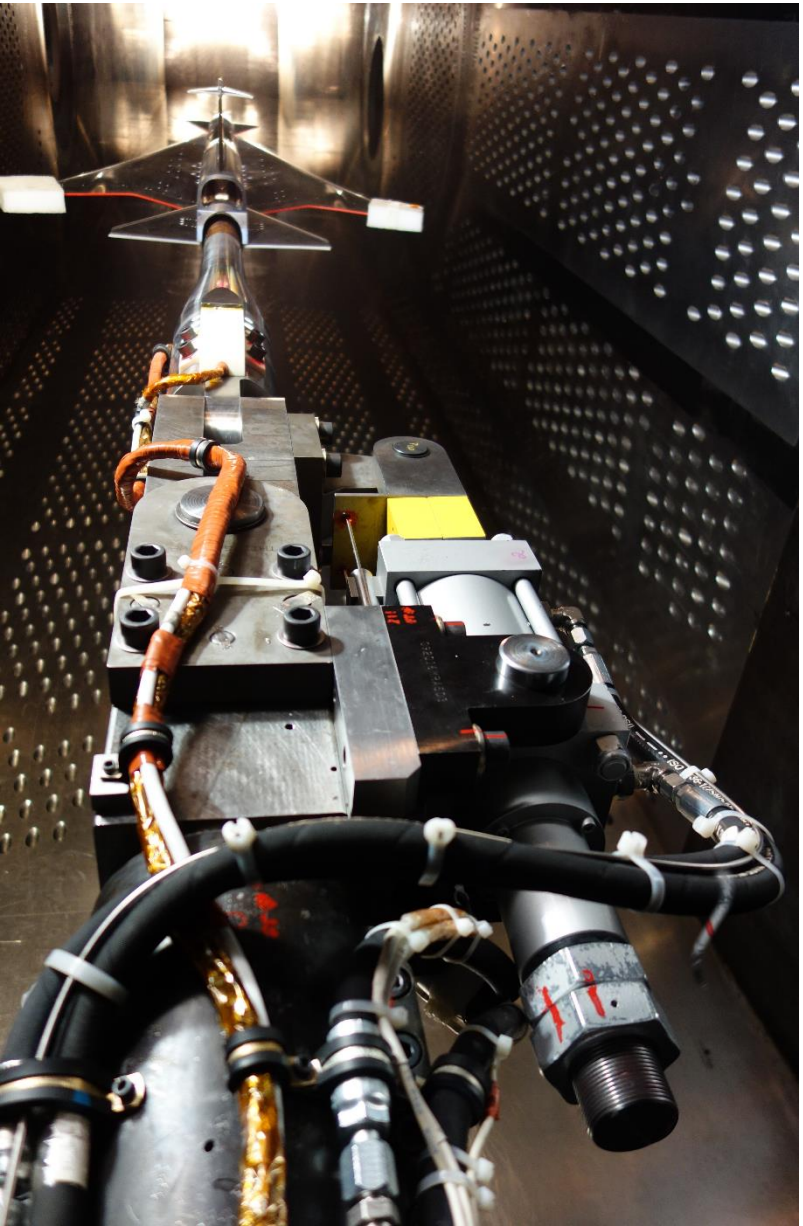
Fouling strip damage on model due to moog spool valve failure

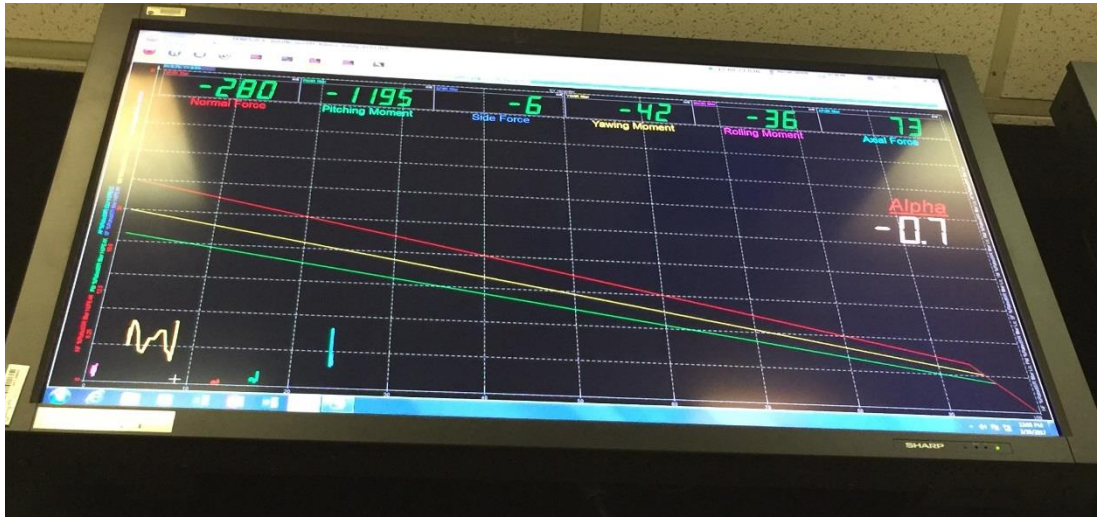
Hydraulic relief manifold “wormholing” due to higher pressure cavitation



Hydraulic servo control valve o-ring failure causing high pressure hydraulic leak

Challenges and Opportunities

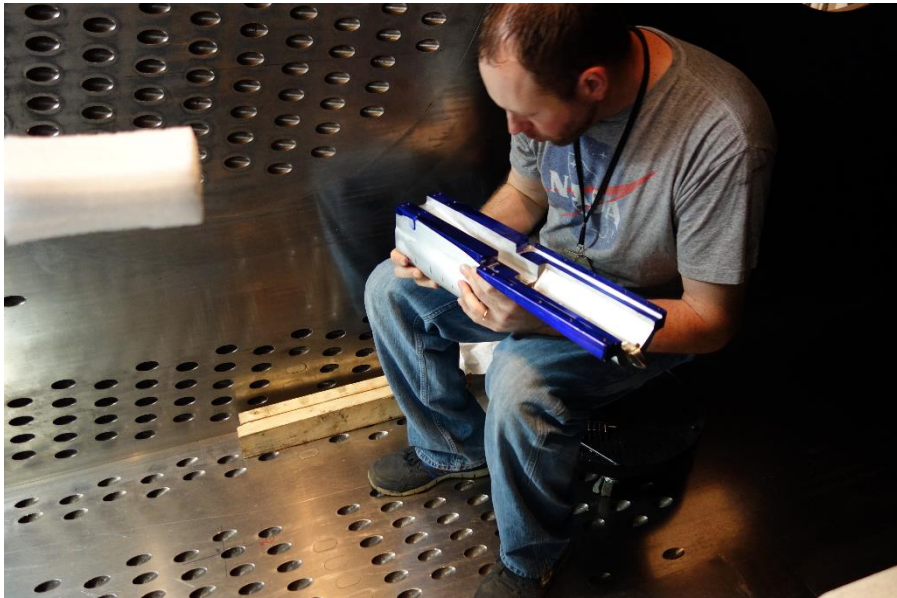


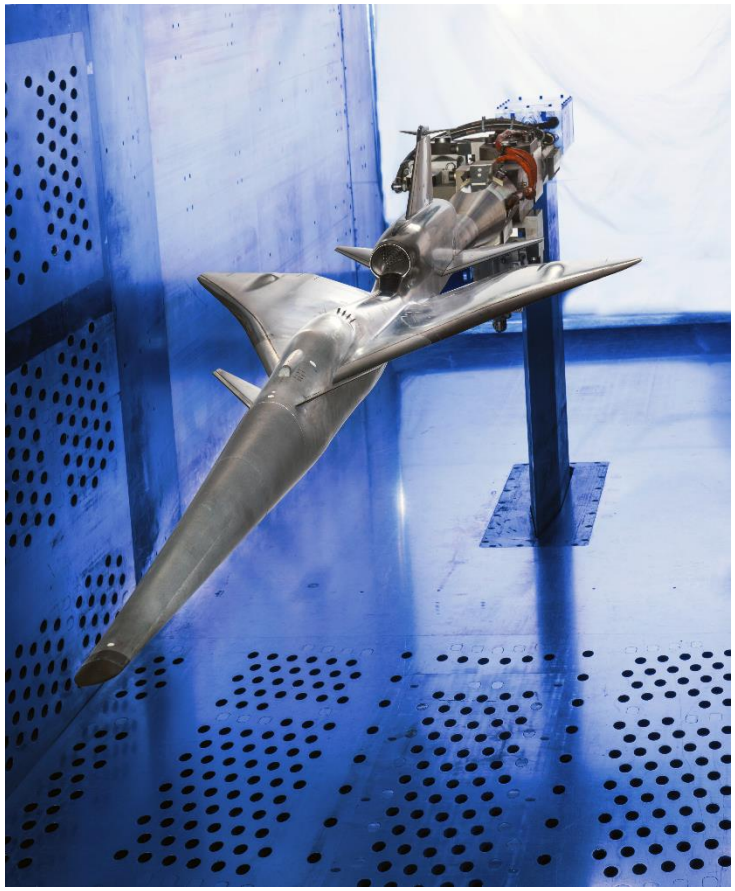


New balance monitoring system

QueSST double-knuckle reinforcement and cylinder sizing to take larger pitching loads

Secondary (new) inlet assembly fit to existing hardware

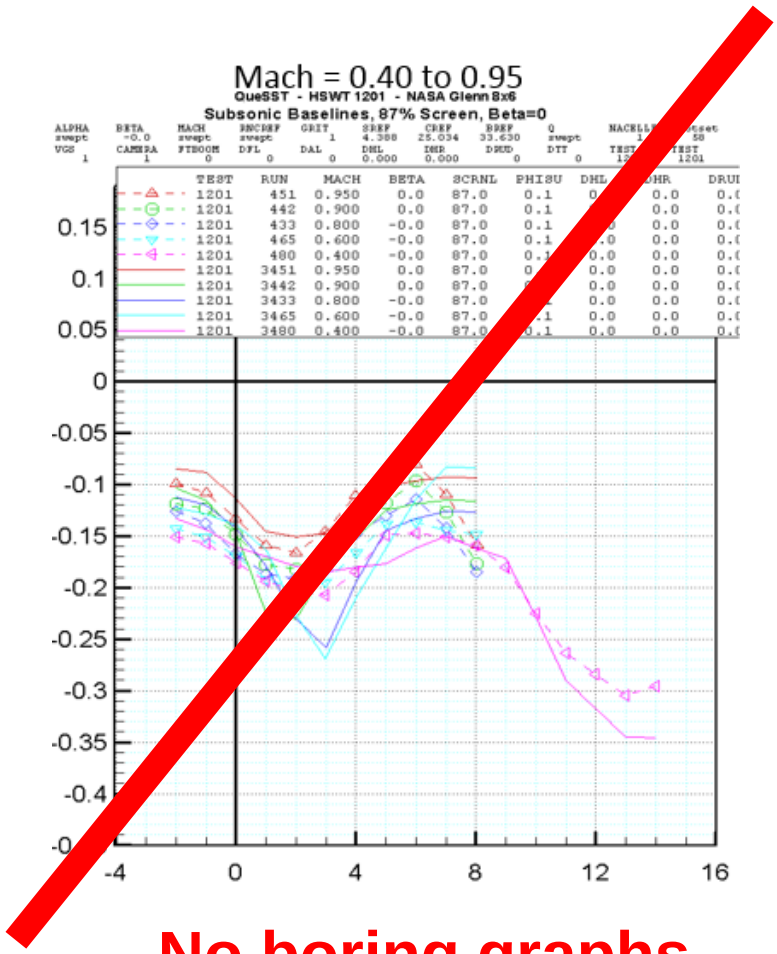




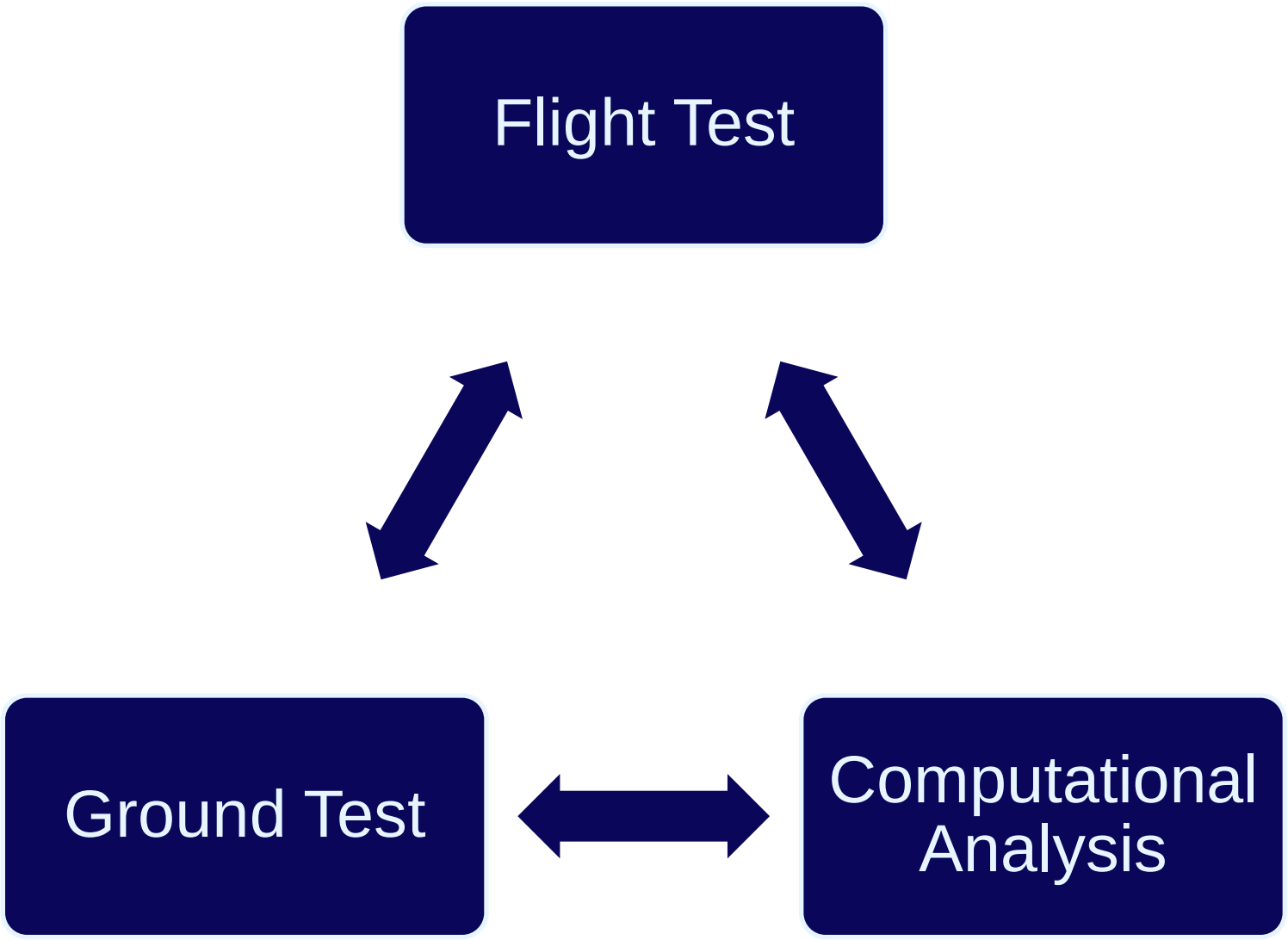
RESULTS:
VEHICLE AERODYNAMICS

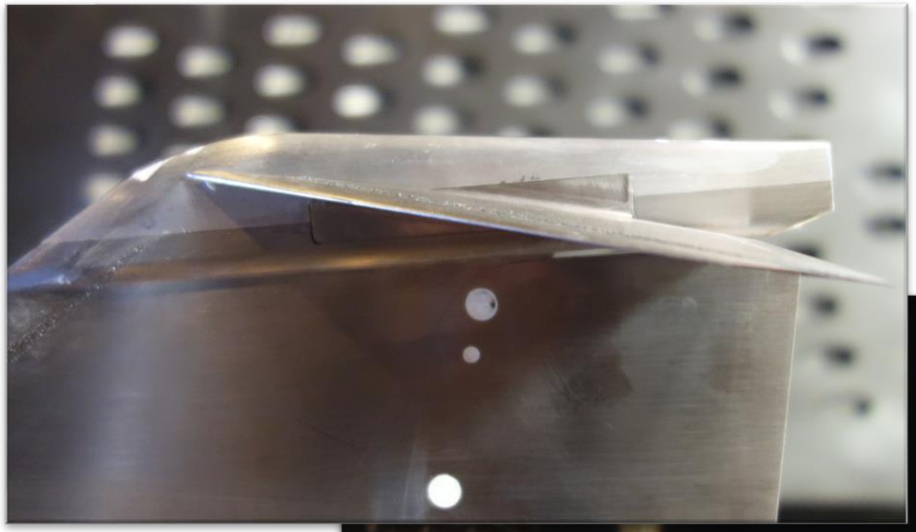
What do engineers want from wind tunnel data?

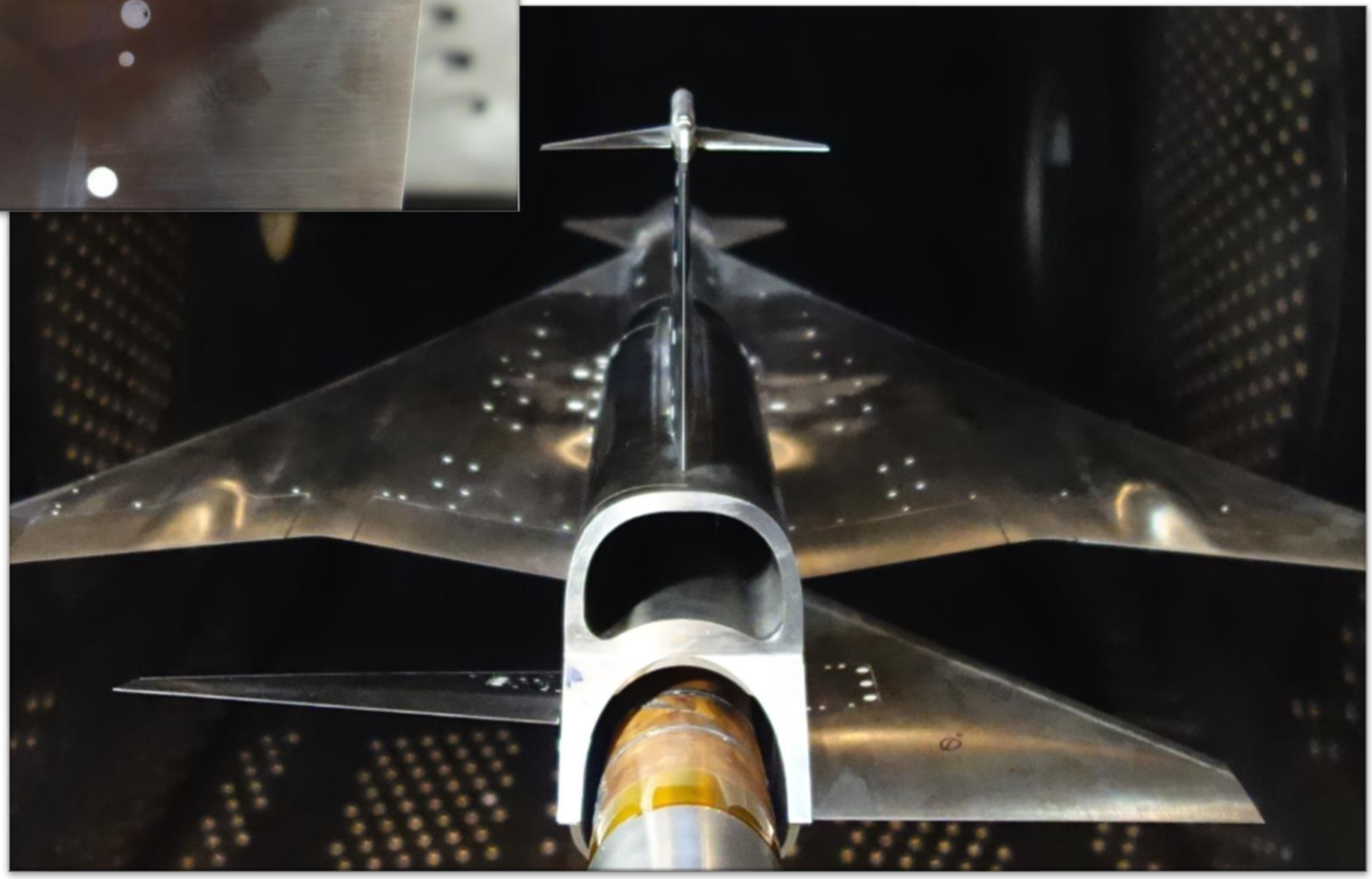
- Compare simulation
- Force measurements
- Surface deflections
- Surface pressure

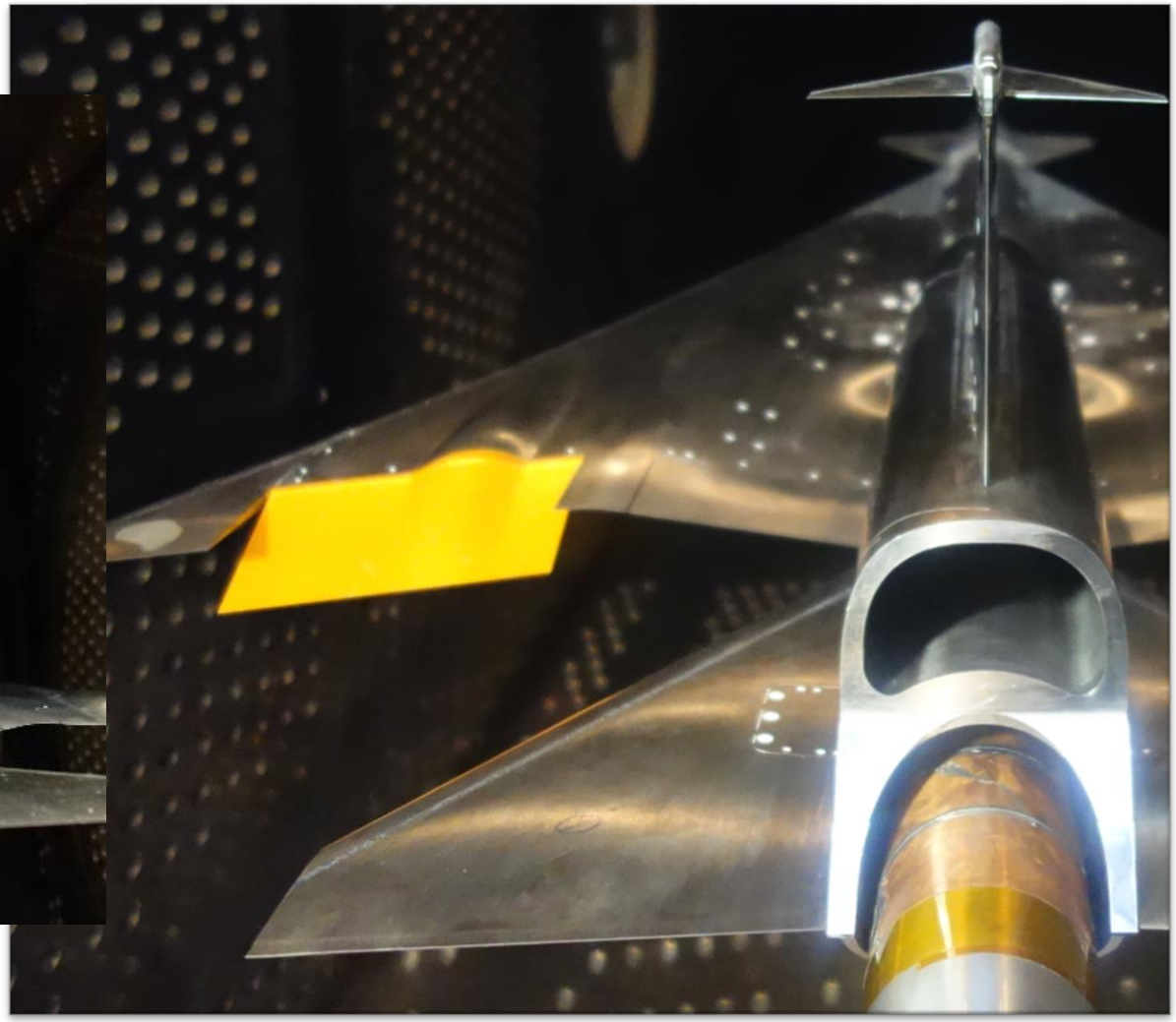


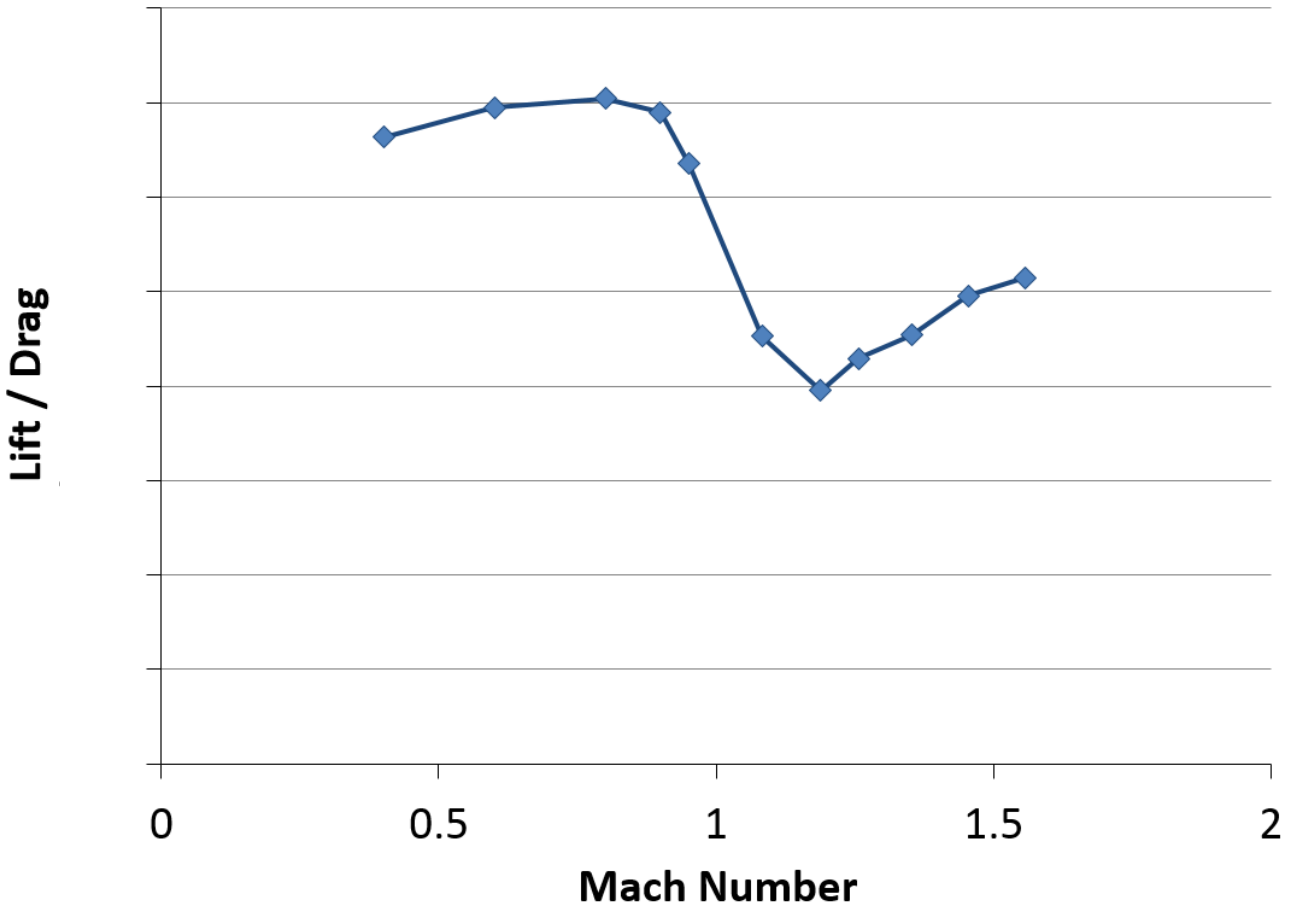
No boring graphs today (maybe 2)

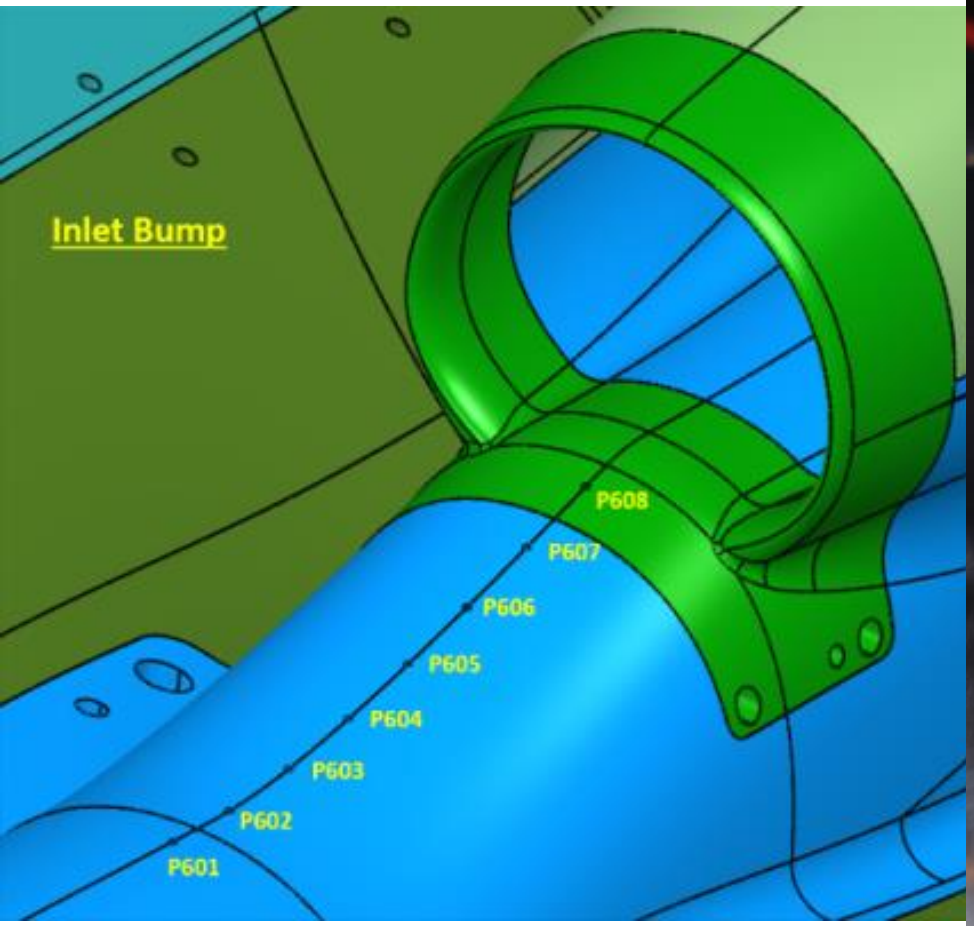

Flight Test
Ground Test
Computational Analysis

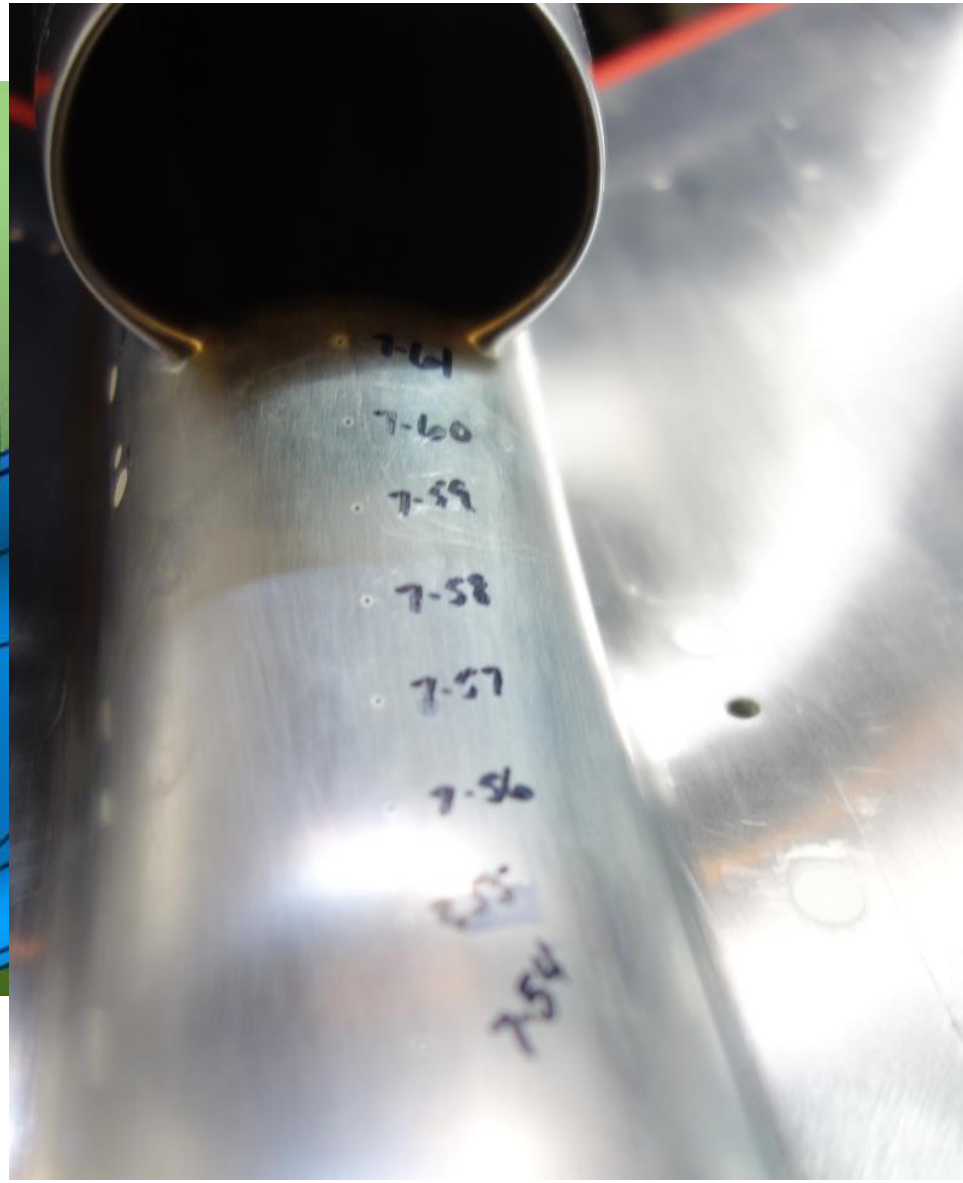


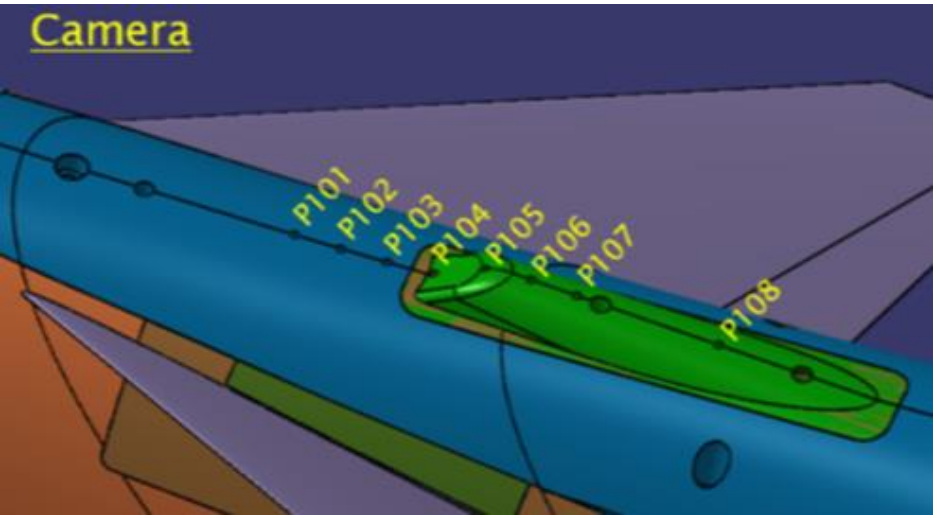


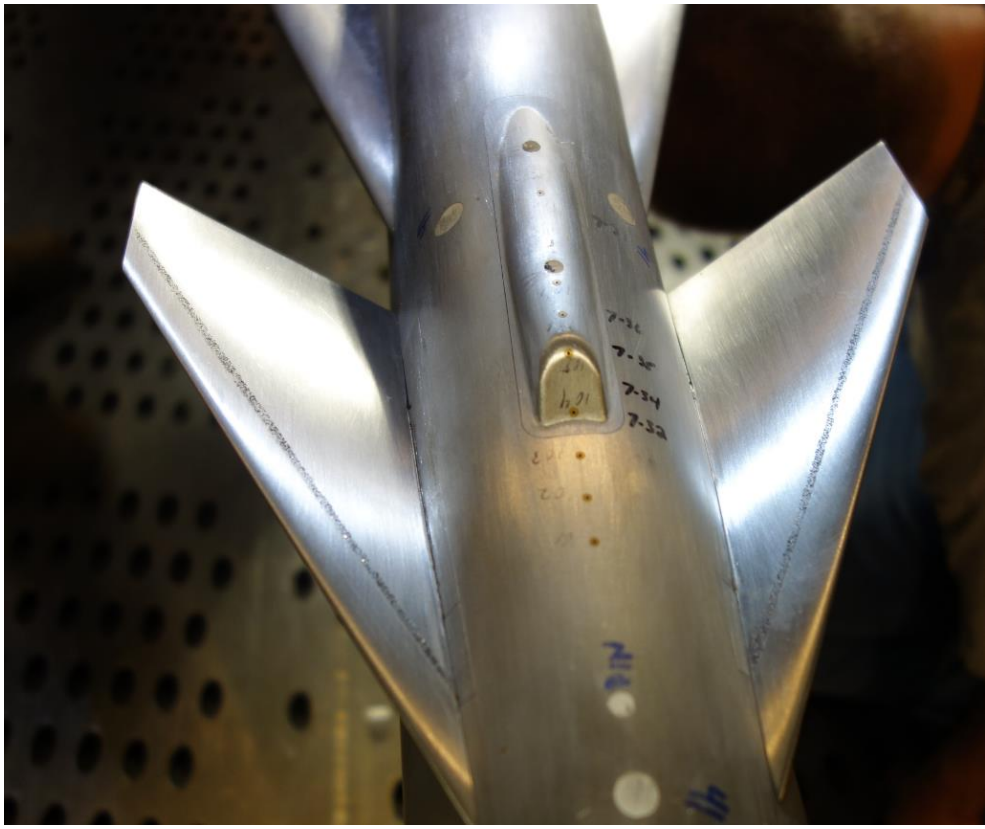


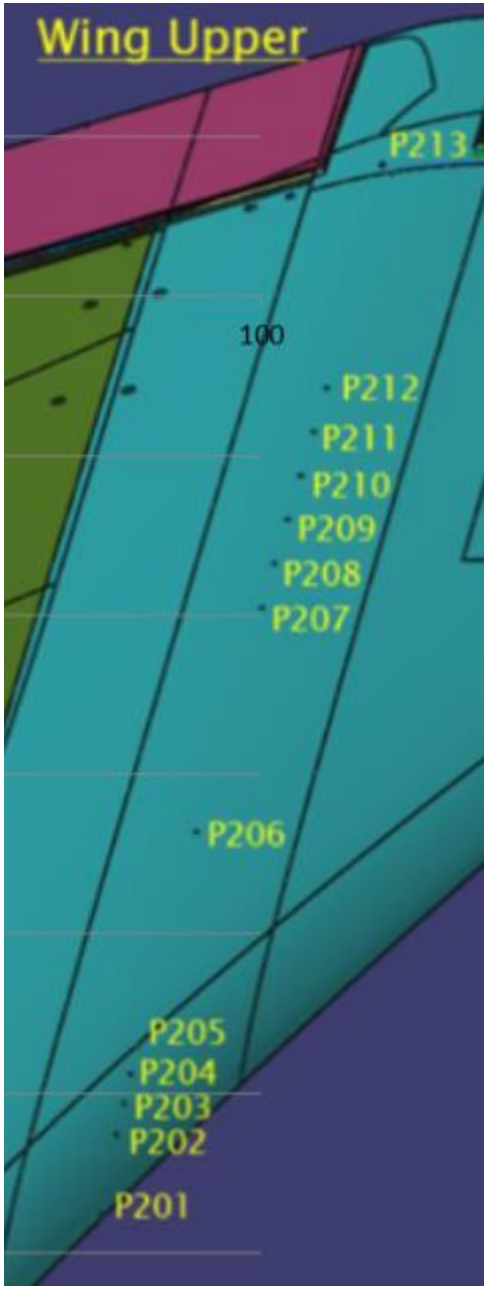

Lift / Drag
0
0.5
1
1.5
2
Mach Number

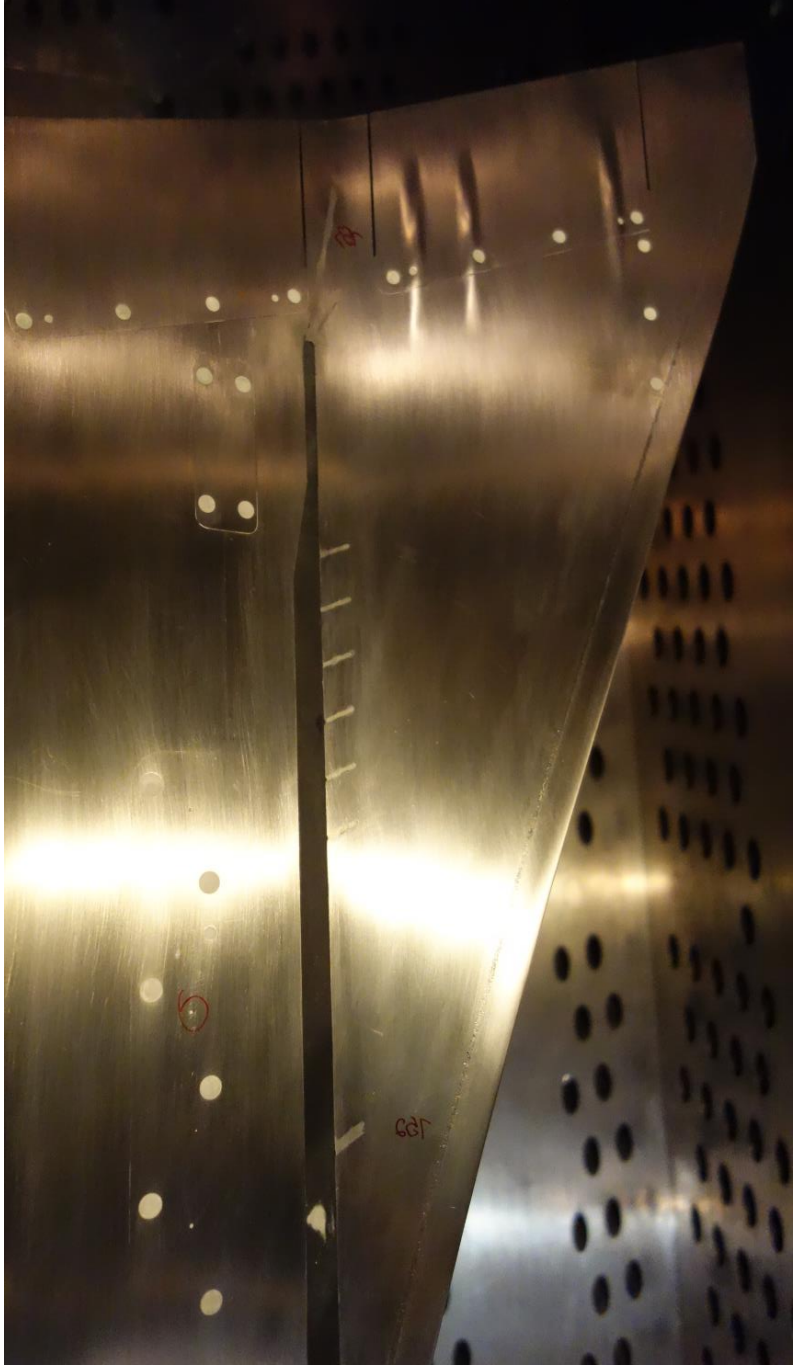

Inlet Bump
P608
P607
P606
P605
P604
P603
P602
P601

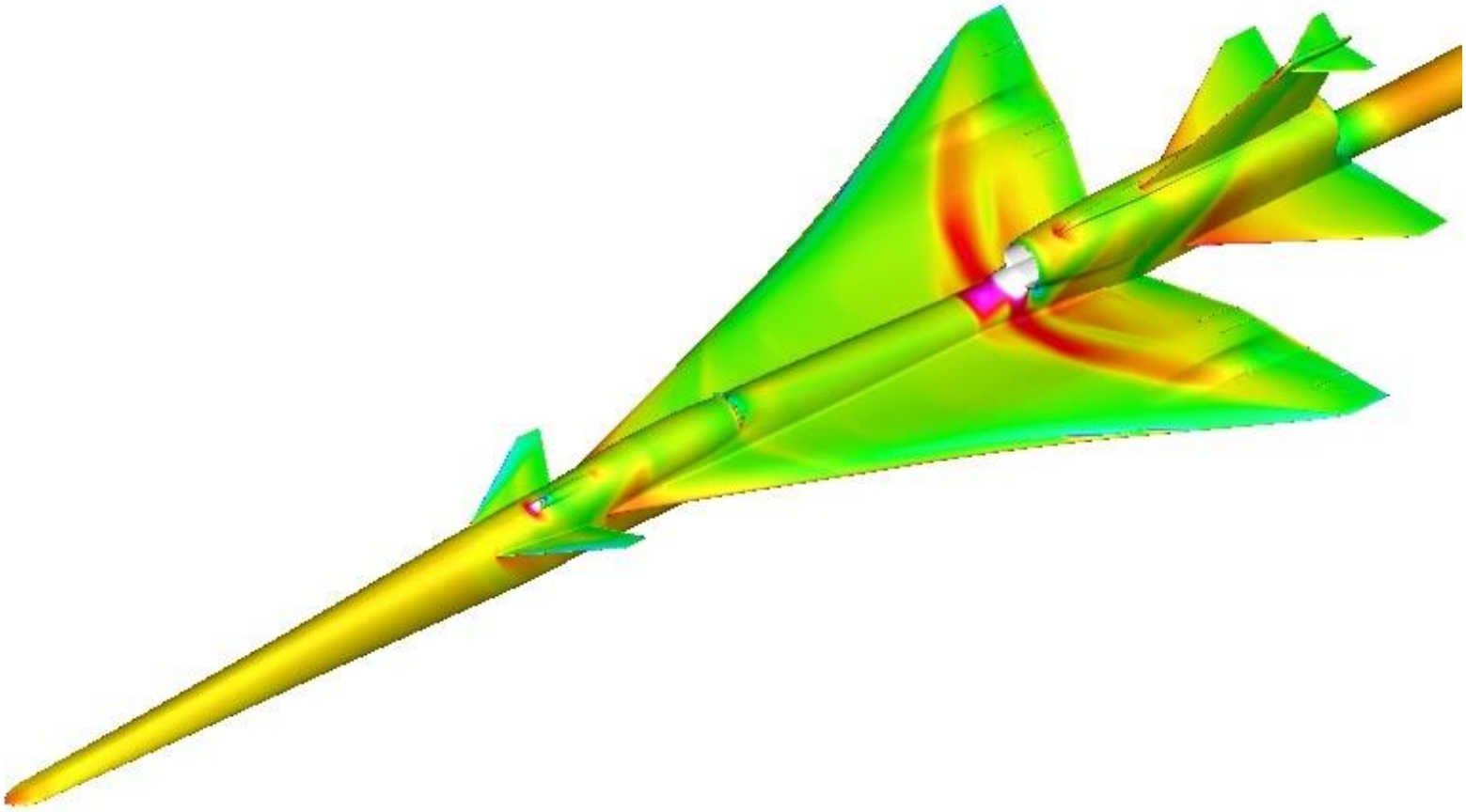

7-61
7-60
7-59
7-58
7-57
7-56
7-54

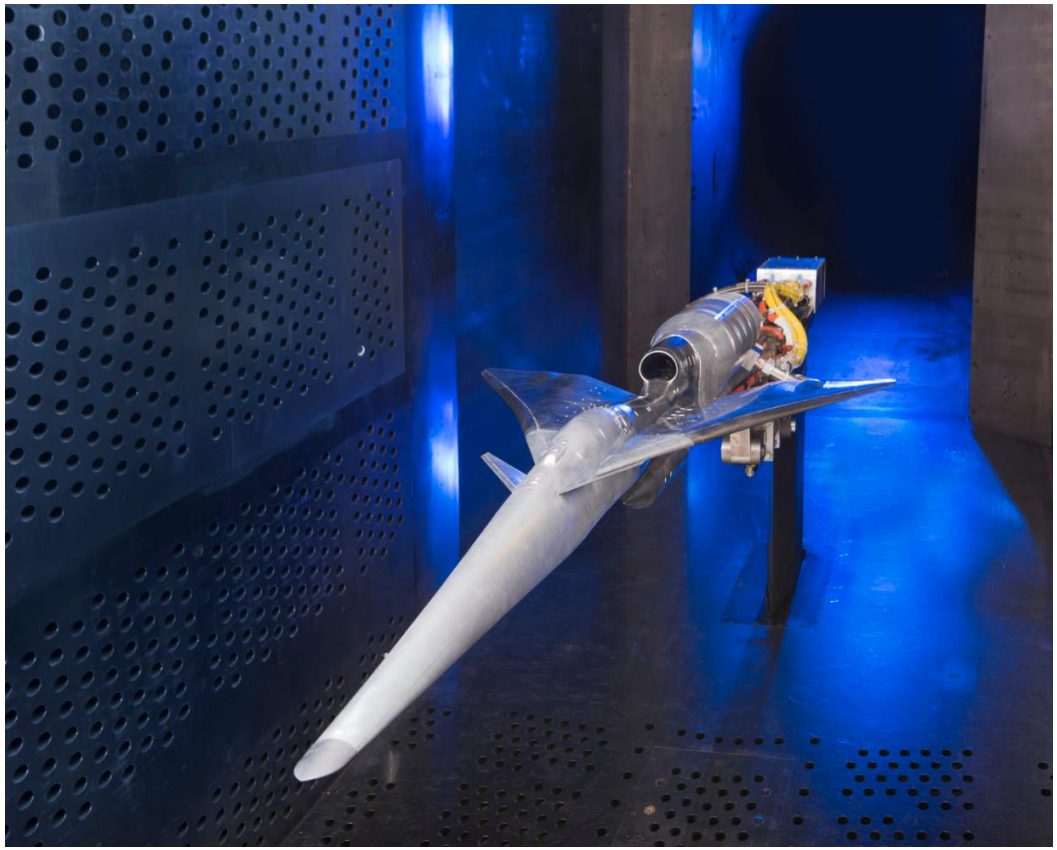

Camera
P101
P102
P103
P104
P105
P106
P107
P108



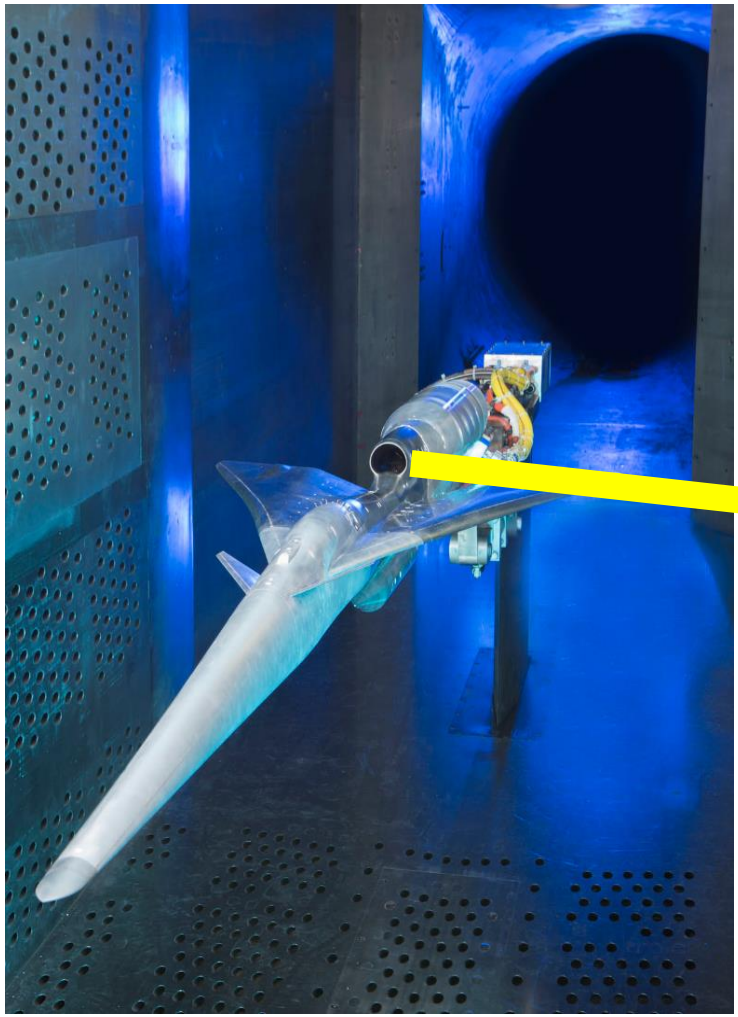

Wing Upper
P213
100
P212
P211
P210
P209
P208
P207
P206
P205
P204
P203
P202
P201

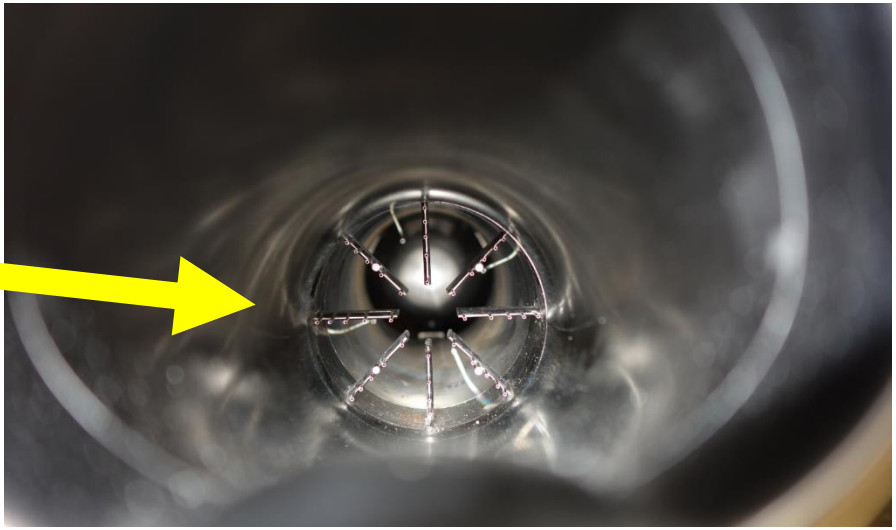


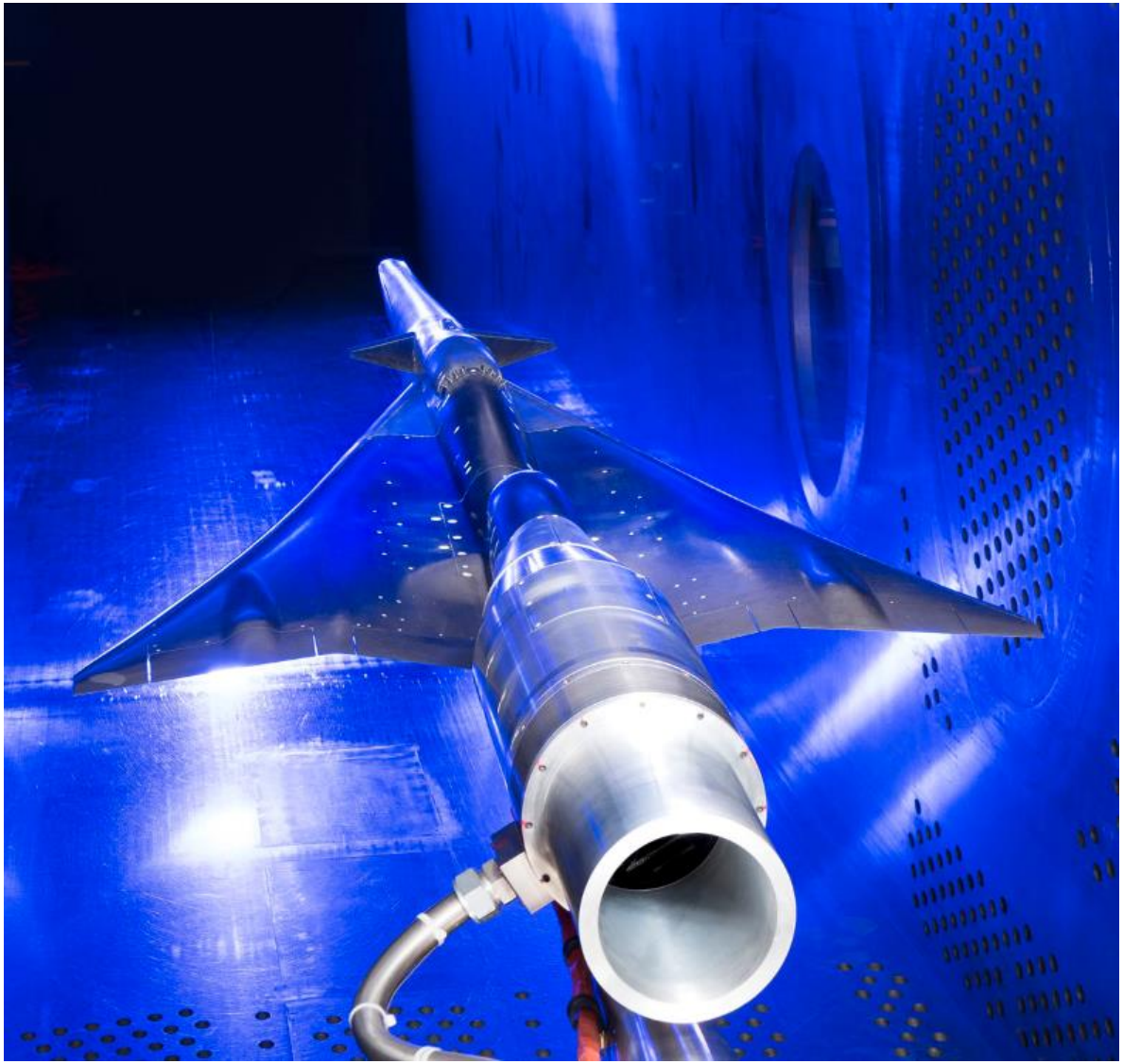


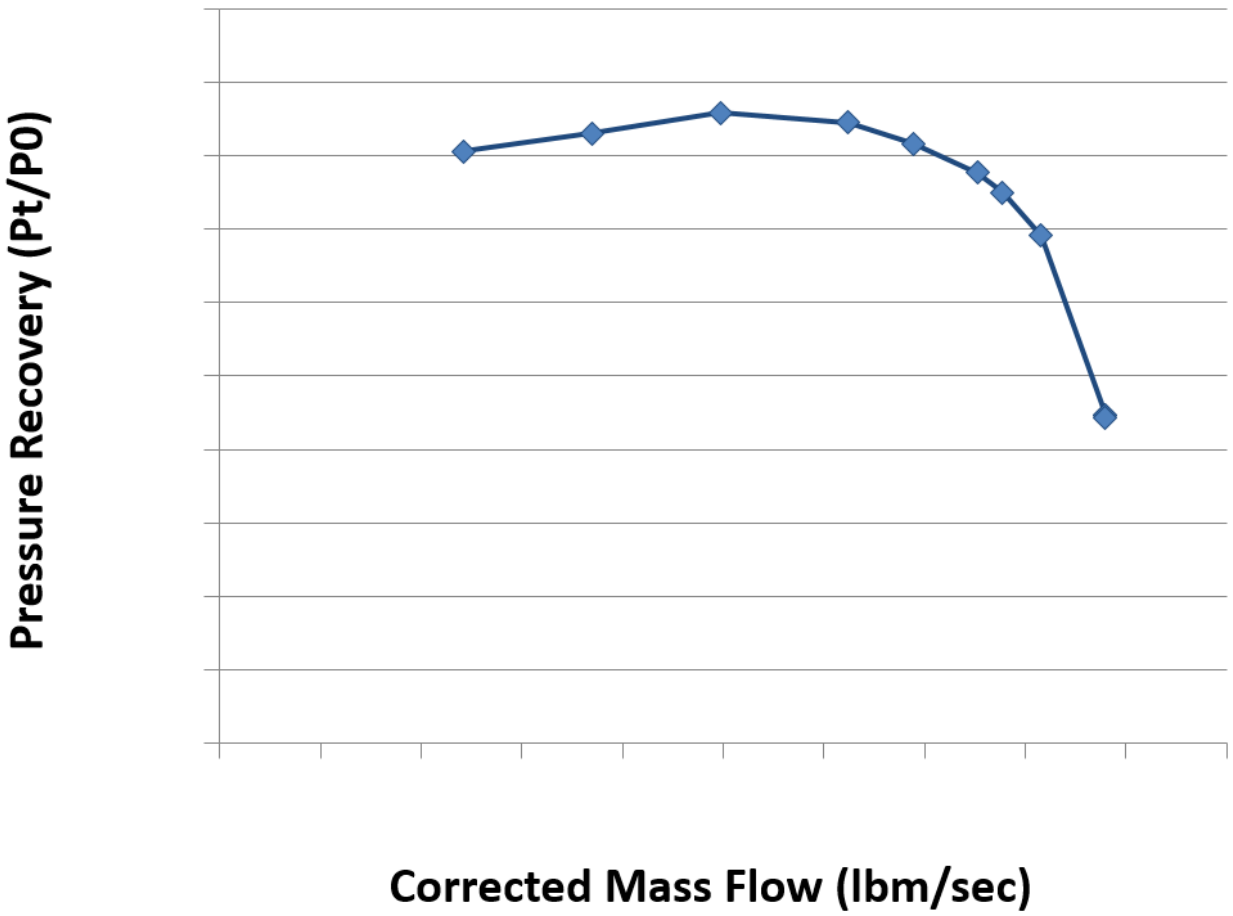


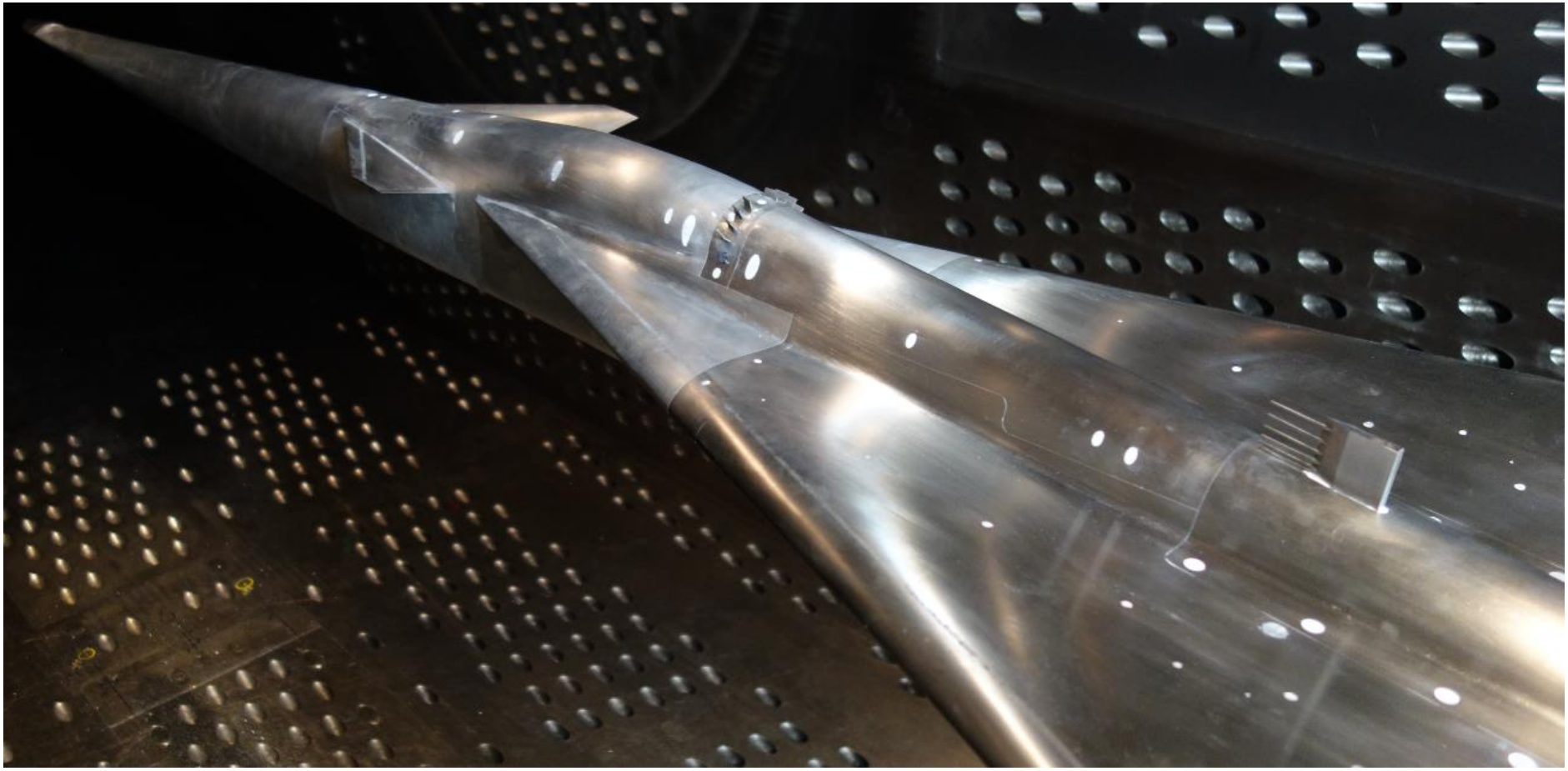
RESULTS: PROPULSION

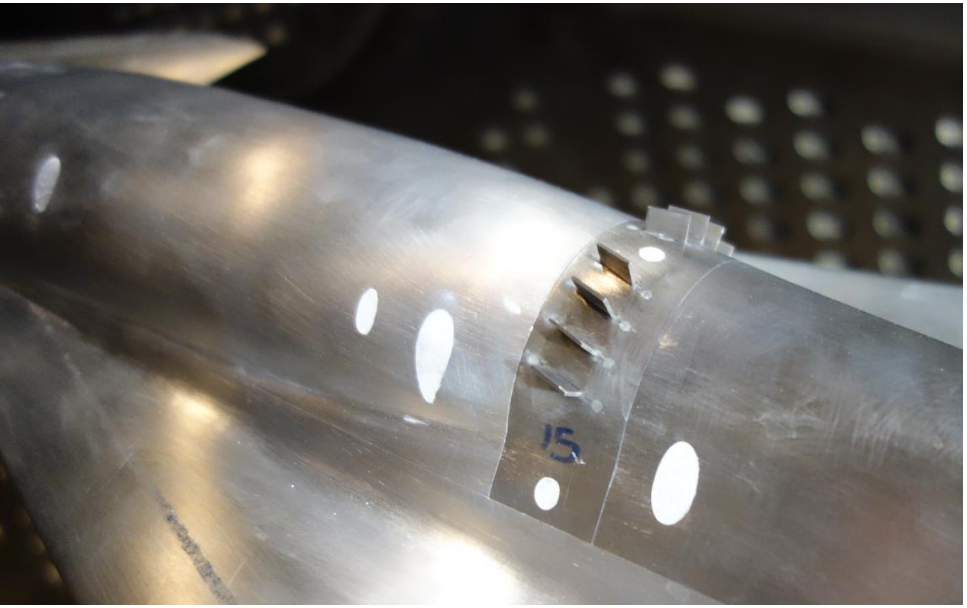


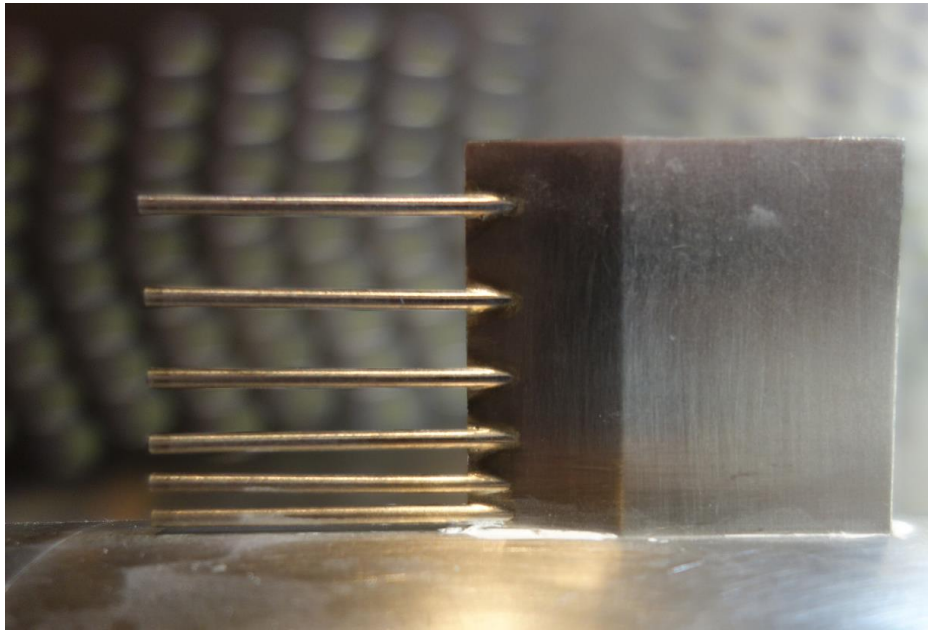


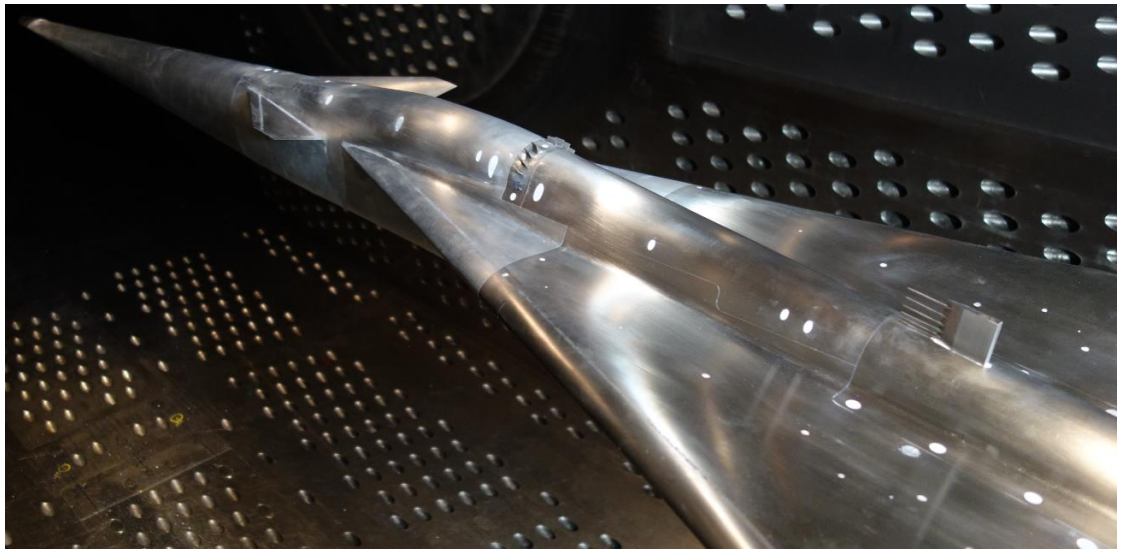


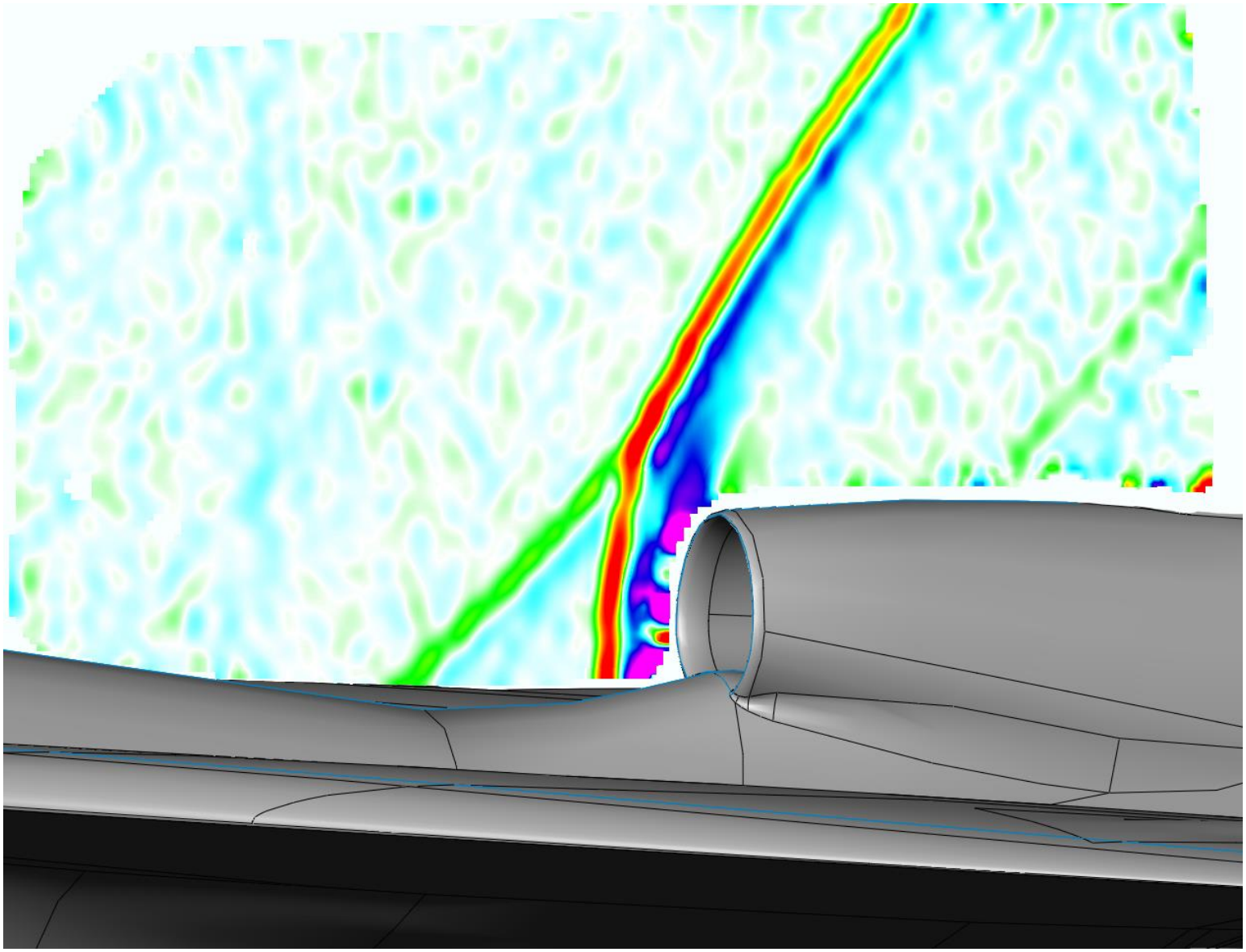

Pressure Recovery (Pt/P0)
Corrected Mass Flow (lbm/sec)

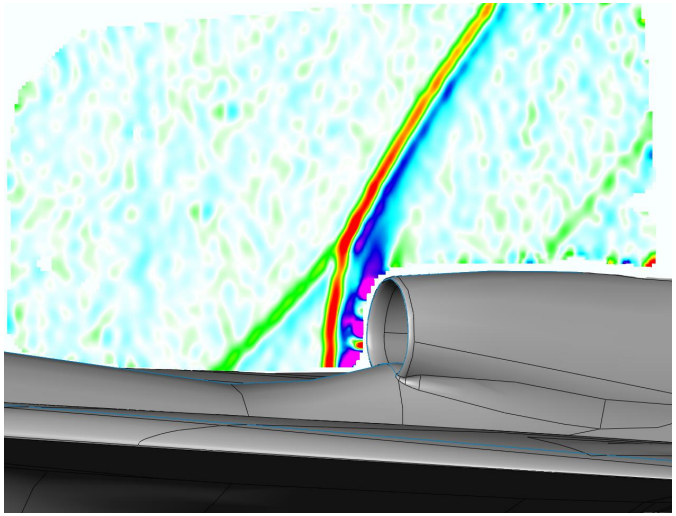


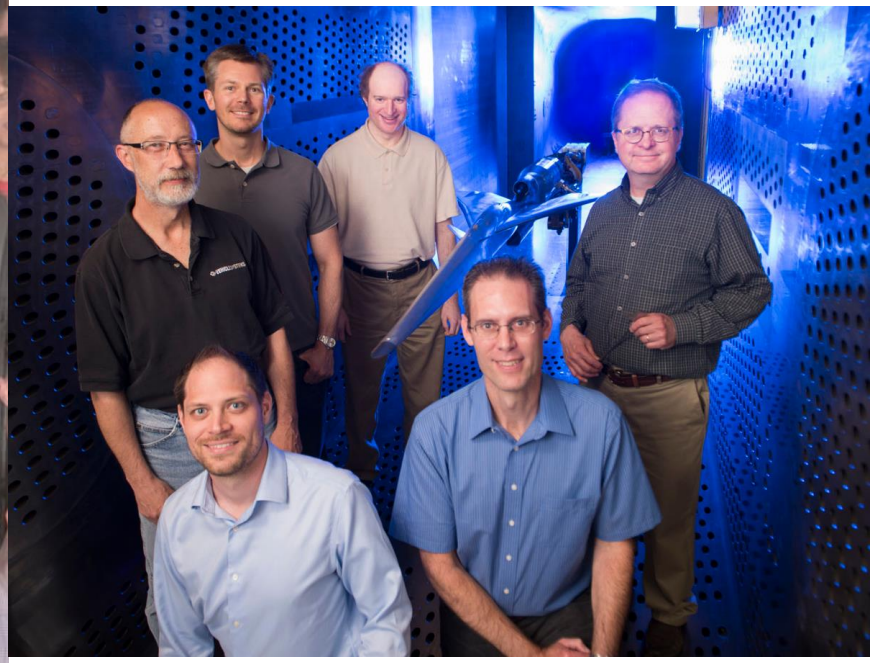

15





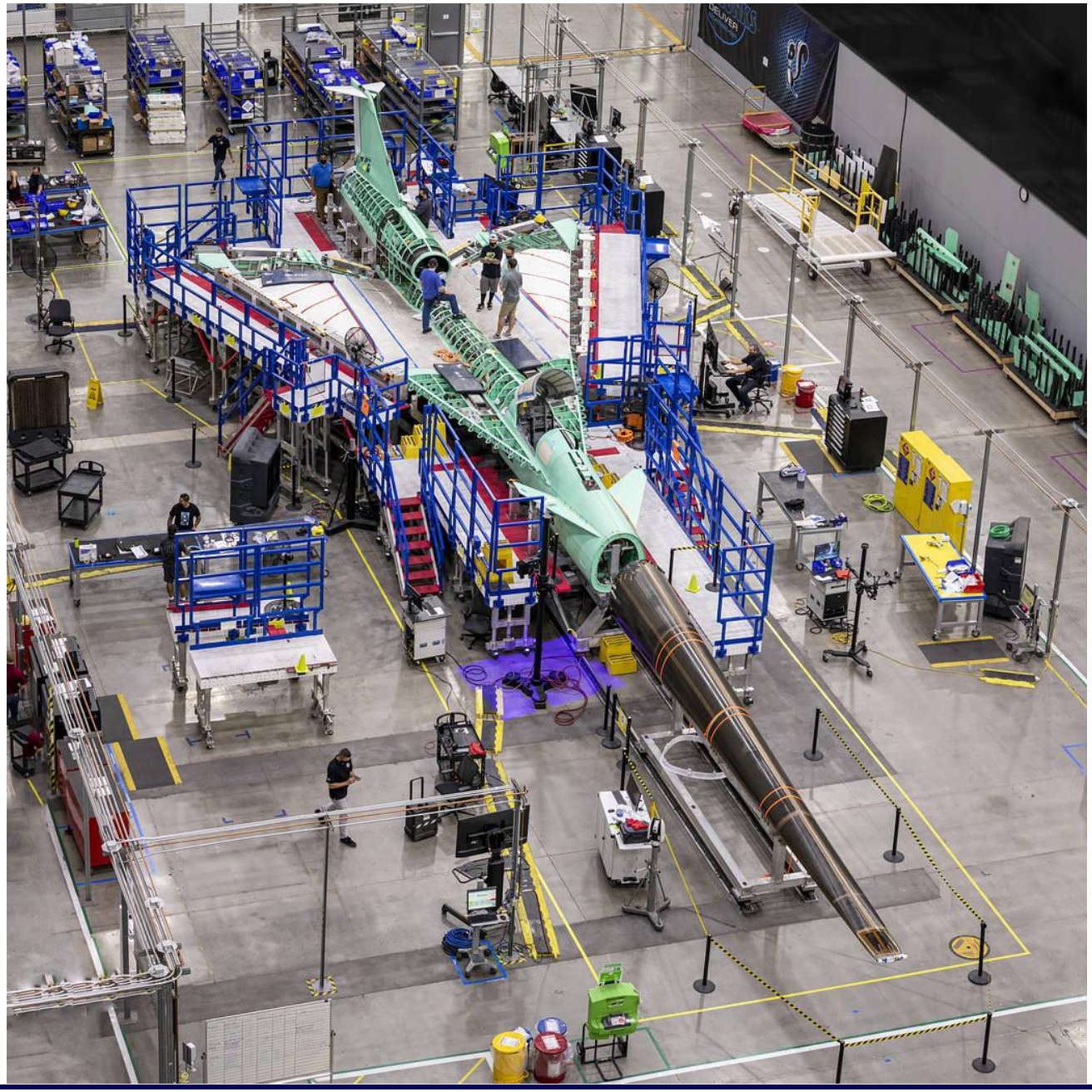


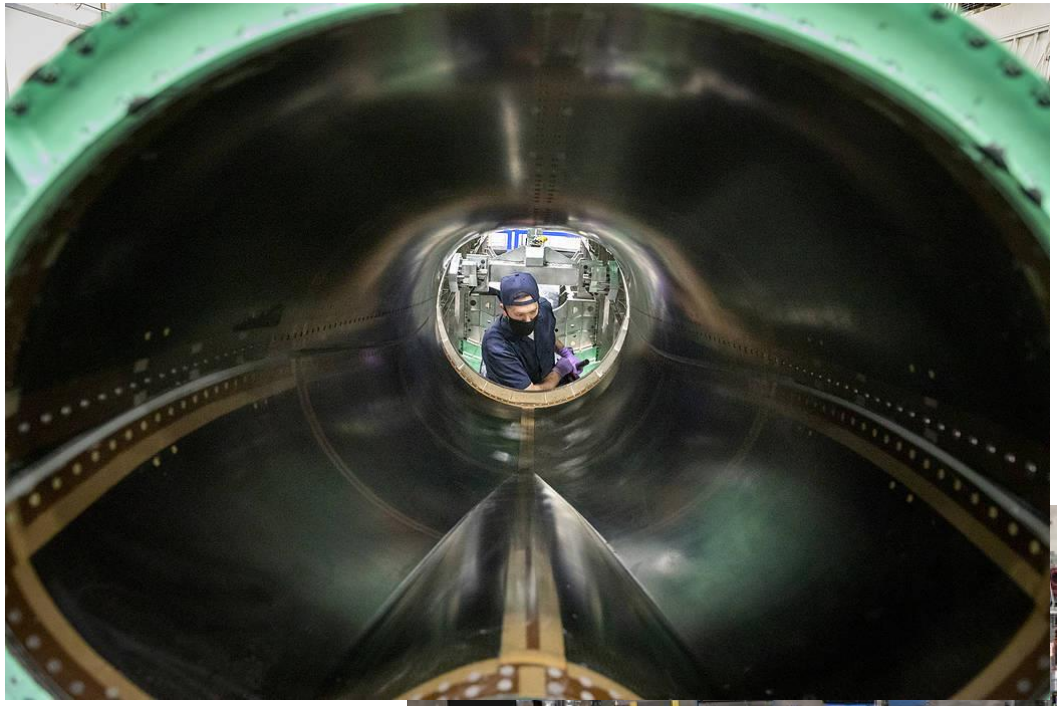




Update

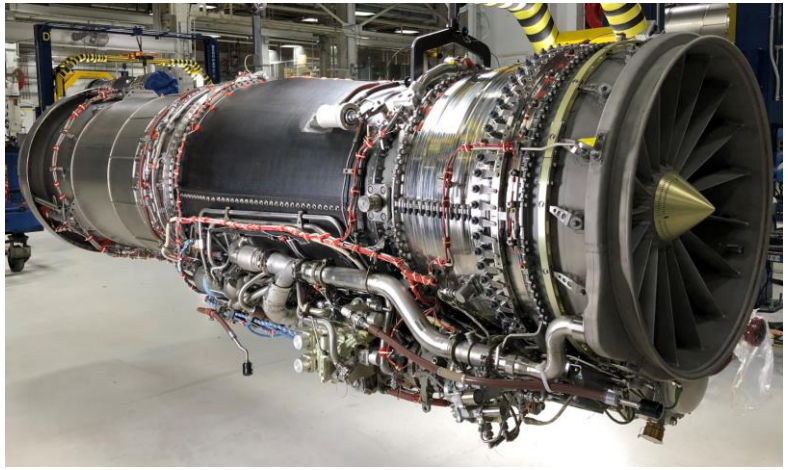
- 2022 is a big year for LBFD
  - Final Assembly of the Vehicle
  - **Ship to Ft. Worth for Loads Test**
  - Air Data Probe 8x6 Wind Tunnel Test
  - Deliveries of NASA systems complete
  - Subsystem Check Outs (SCOs), Proof & Cal Tests, Ground Vibration Test
  - Engine Installation
  - Flight Readiness Review (FRR)





Engines Delivered August 2020

- Two F414-GE-100 engines
- Shipped from GE Lynn MA to AFRC



LBFD Propulsion Team Activities 2021

- Propulsion CFD: plume/aft-deck interaction, hydrazine exhaust
- Engine Field Service Instructions (SiC nozzle flaps)
- Engine flight test instrumentation checkouts
- Propulsion control room preparations/training
- Propulsion cockpit simulator integration
- Engine fit check in the aircraft
- Engine installation and system checkouts
- Flight Readiness Review
- Engine ground testing (in vehicle)
- First flight

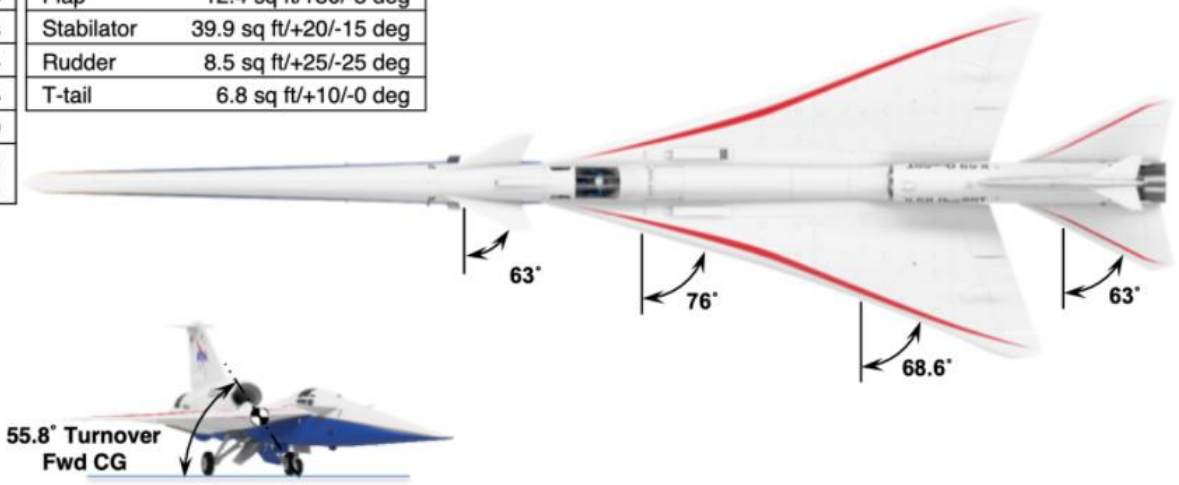
AFRC Flight Control Room

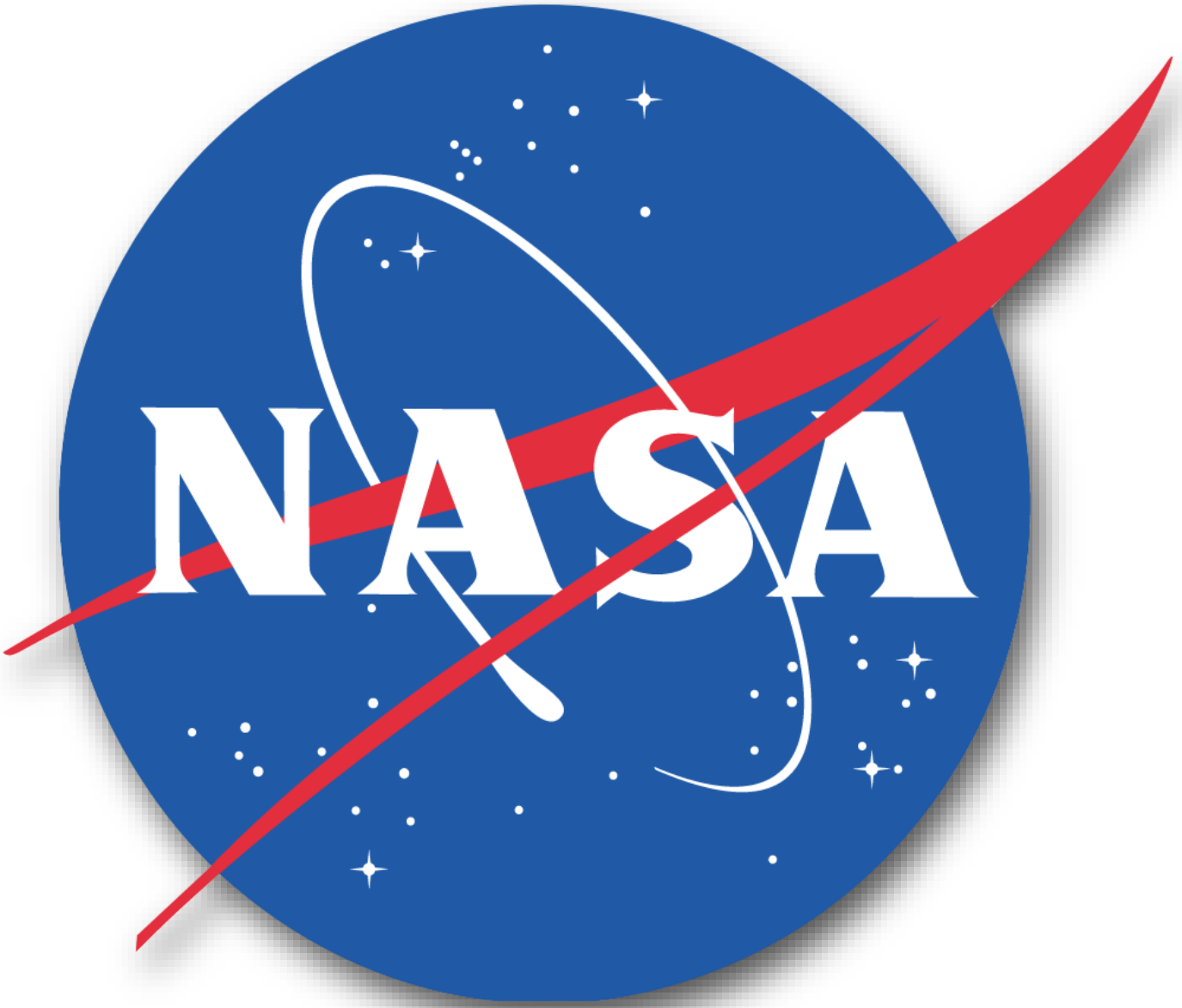
AFRC Cockpit Simulator

Tie-down ground testing example

Configuration C612	
MDGW	25,000 lbs
Fuel (Max)	8,700 lbs
Payload	600 lbs
Design Mach	1.4
Loudness	<75 PLdB
Engine	1xF414-GE-100
Landing Gear	F-16 Blk25 NLG F-16 Blk25 MLG

Control Surfaces	
Aileron	12.9 sq ft/+35/-25 deg
Flap	12.4 sq ft/+30/-3 deg
Stabilator	39.9 sq ft/+20/-15 deg
Rudder	8.5 sq ft/+25/-25 deg
T-tail	6.8 sq ft/+10/-0 deg




NASA