

TRANSONIC DYNAMICS TUNNEL

Overview of Features and Capabilities



National Aeronautics and
Space Administration

Transonic Dynamics Tunnel
NASA Langley Research Center



TRANSONIC DYNAMICS TUNNEL

TDT is ...

A unique national facility

The best suited facility in the world to flutter test large, aeroelastically-scaled, full-span models at transonic speeds

TDT is ...

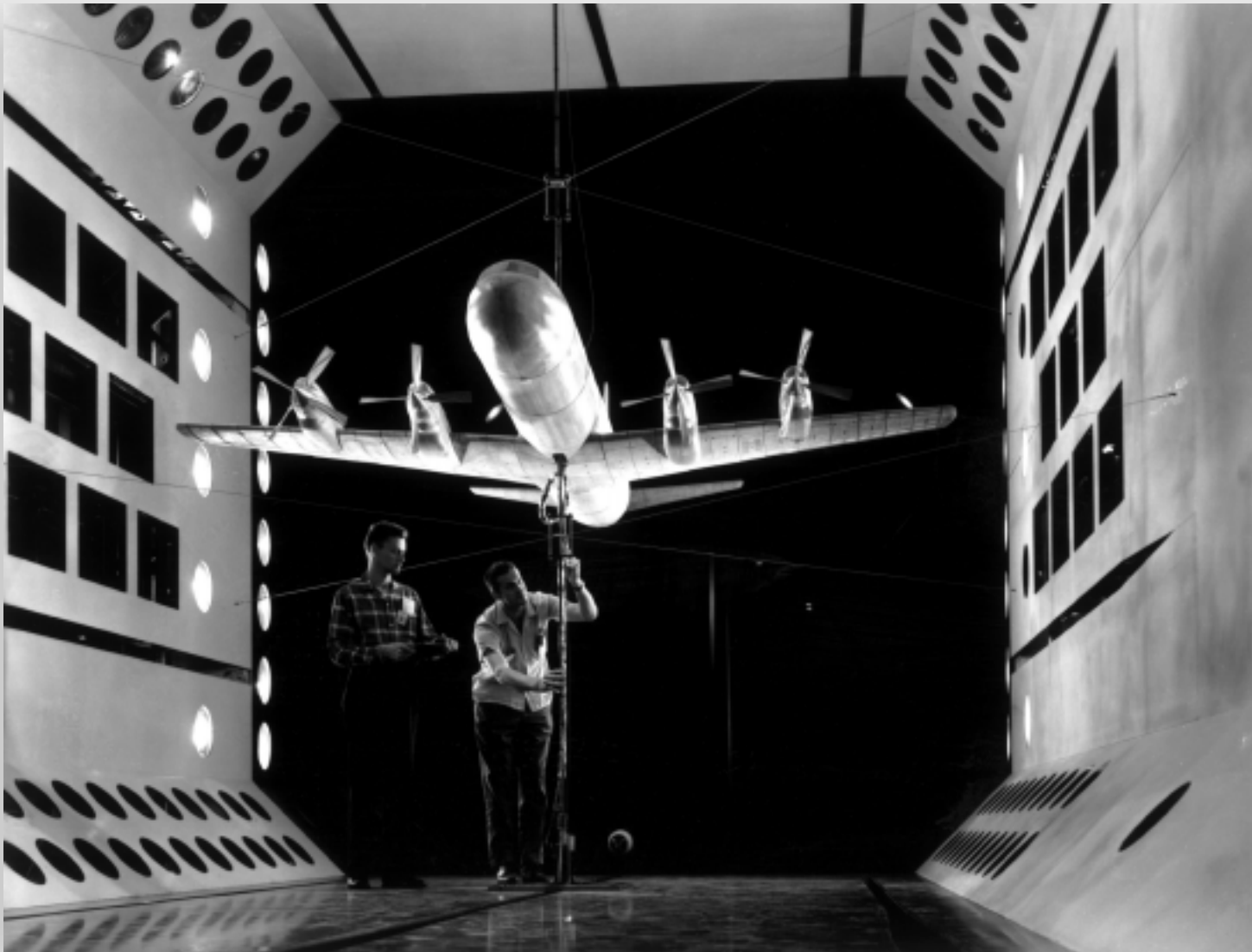
Dedicated to identifying, understanding, and solving relevant aeroelastic problems

- Flutter/Divergence/Buffer
- Active Controls (Aeroservoelasticity)
- Gust Response
- Rotorcraft Dynamics/Aeroelasticity
- Ground Wind Loads
- Unsteady Aerodynamics
- “Novel” Phenomena

TDT supports ...

U.S. Department of Defense, U.S. Industry, U.S. University, and NASA Programs

LOCKHEED ELECTRA IN TDT



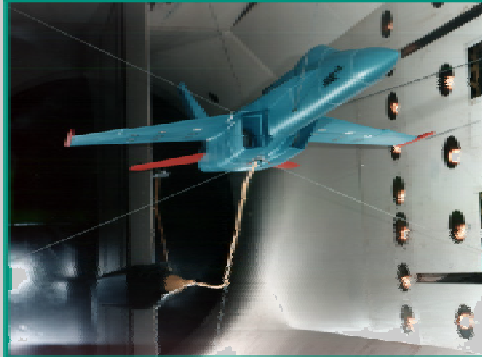
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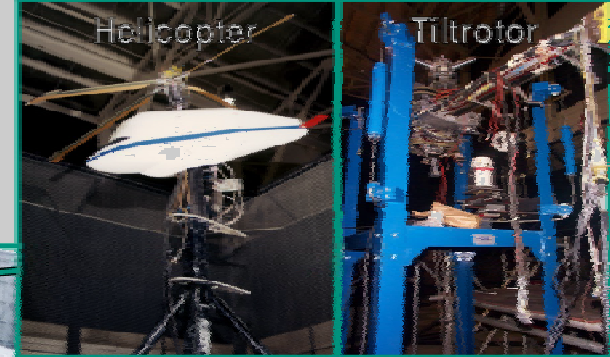


TRANSONIC DYNAMICS TUNNEL COMPLEX

TDT Test Section



Rotorcraft Hover Test Facility

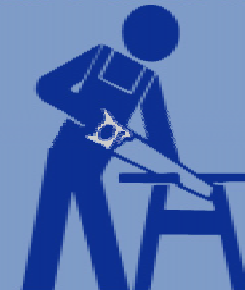


Model Preparation Area #1



Model Preparation Area #2

UNDER CONSTRUCTION



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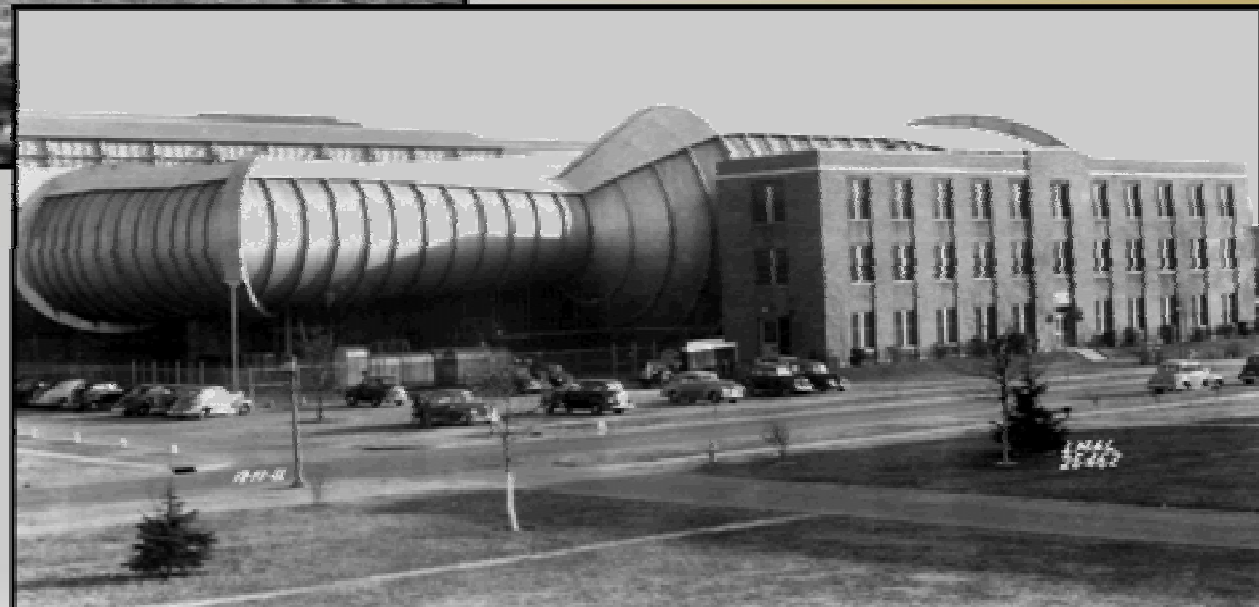
EVOLUTION OF THE TDT

From the 19-Foot Pressure Tunnel...



PHOTO BY
19' PRESSURE TUNNEL
APRIL 16, 1937.

1937



1941

1976

EVOLUTION OF THE TDT ...To the Transonic Dynamic Tunnel

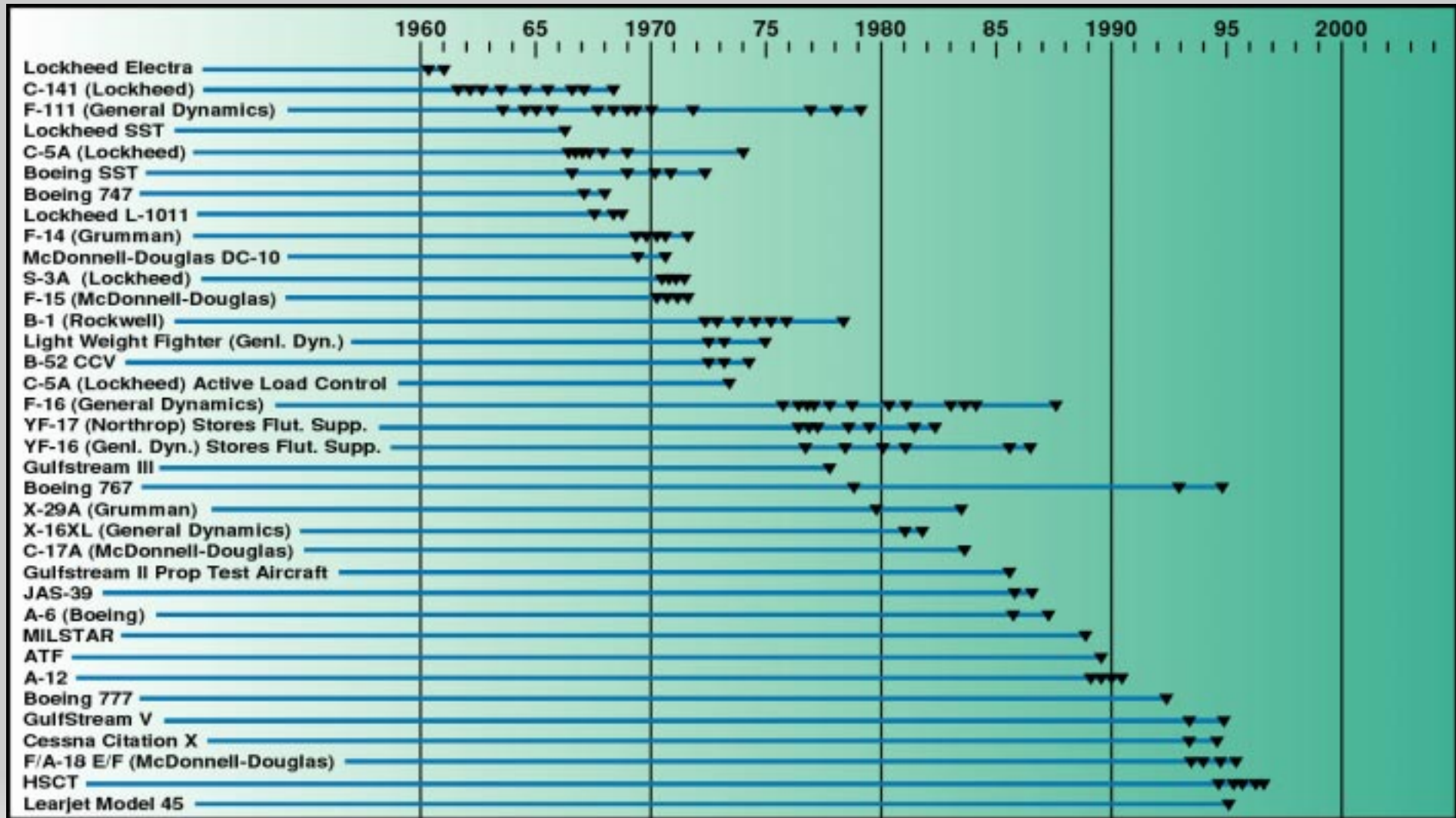


1960

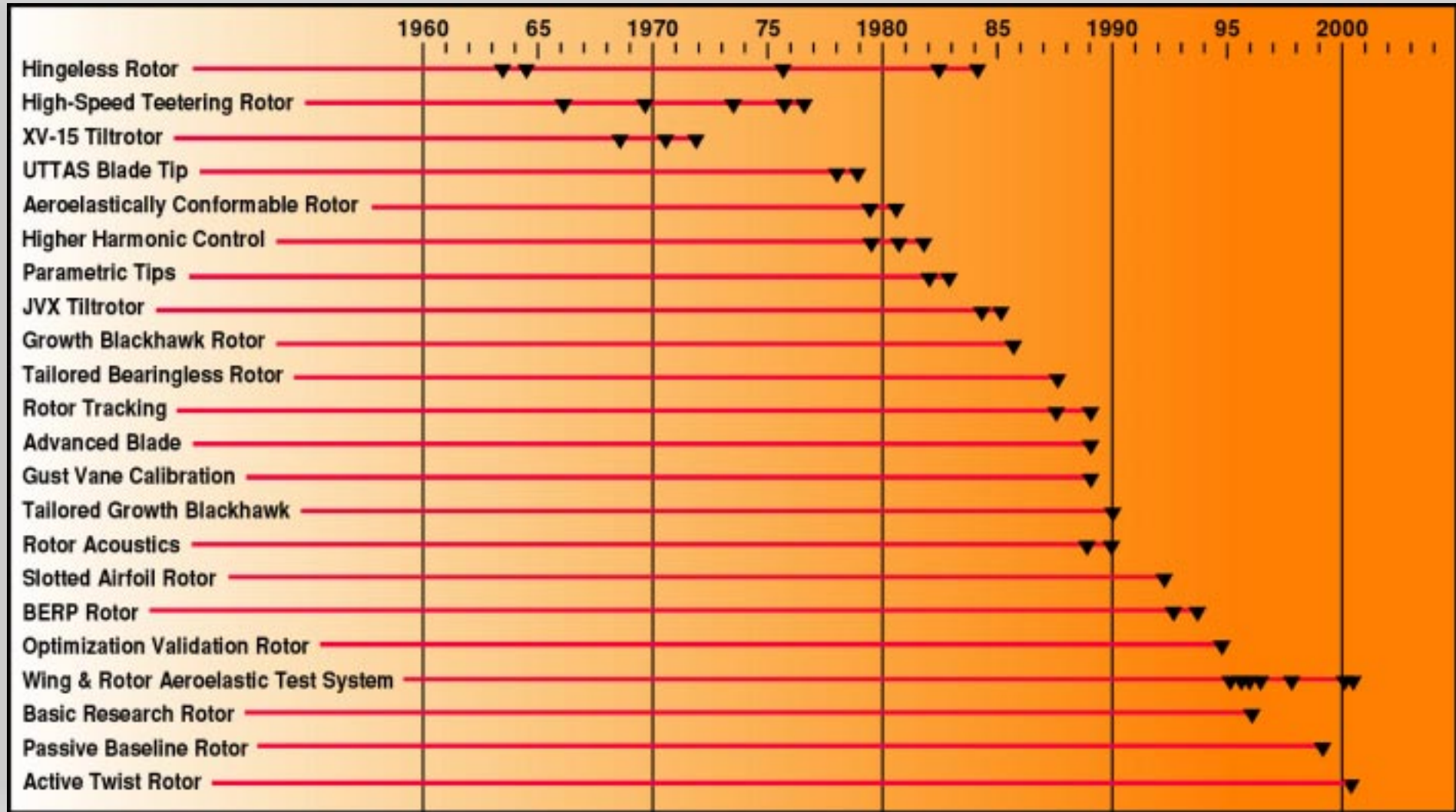


2000

MAJOR AIRPLANE FLUTTER INVESTIGATIONS



MAJOR ROTORCRAFT INVESTIGATIONS

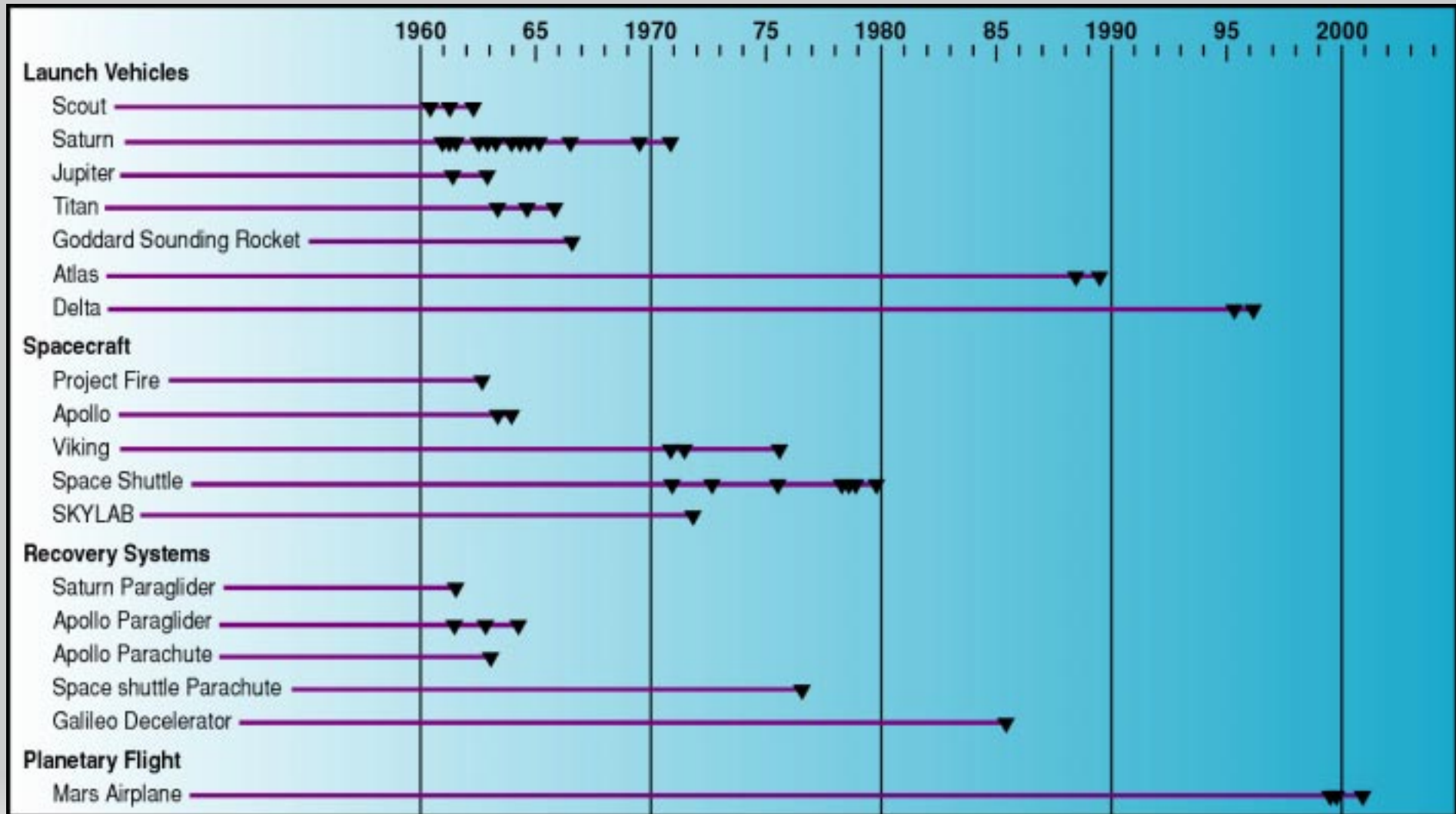


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MAJOR SPACE-RELATED INVESTIGATIONS



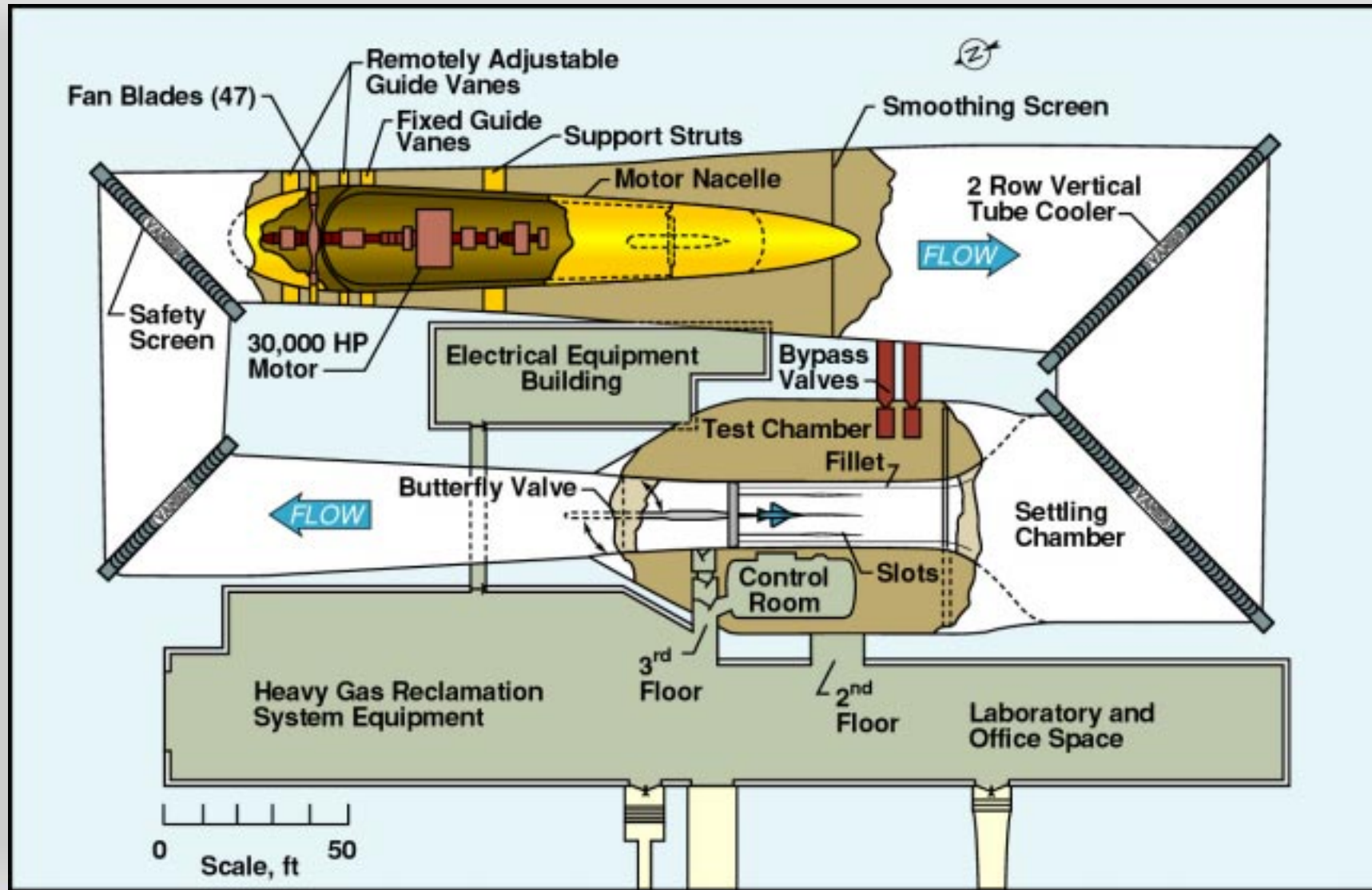
TDT CHARACTERISTICS

Wind tunnel	Large, closed-circuit, continuous-flow, single return
Test section	16 feet x 16 feet
Test medium	R-134a or Air
Main drive power	30,000 HP, two speed ranges
Mach number range	0 to 1.2, continuous
Total pressure range	0.01 to 1.0 atmosphere, continuous
Reynolds number (max)	9.6 x 10 ⁶ per foot (R-134a) 3.0 x 10 ⁶ per foot (Air)
Dynamic pressure (max)	550 psf (R-134a) 320 psf (Air)

TDT FEATURES

- Excellent model visibility from control room
- Rapid tunnel shutdown for model safety
- Safety screens for fan protection
- Several model support (mount) systems
- Airstream oscillator (gust generating) system
- R-134a reclamation / purification system
- Test section / plenum isolation valves

TDT PLAN VIEW

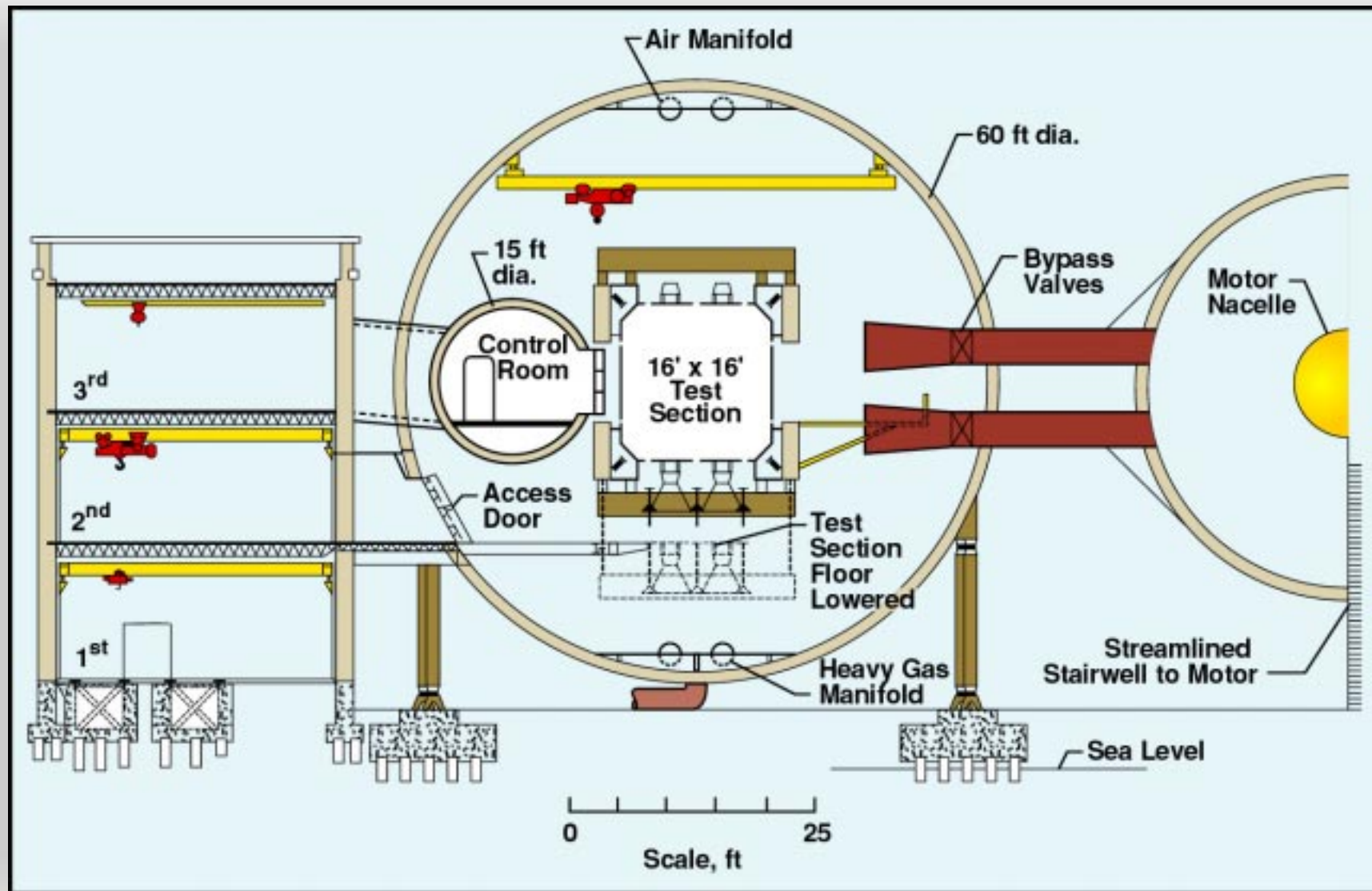


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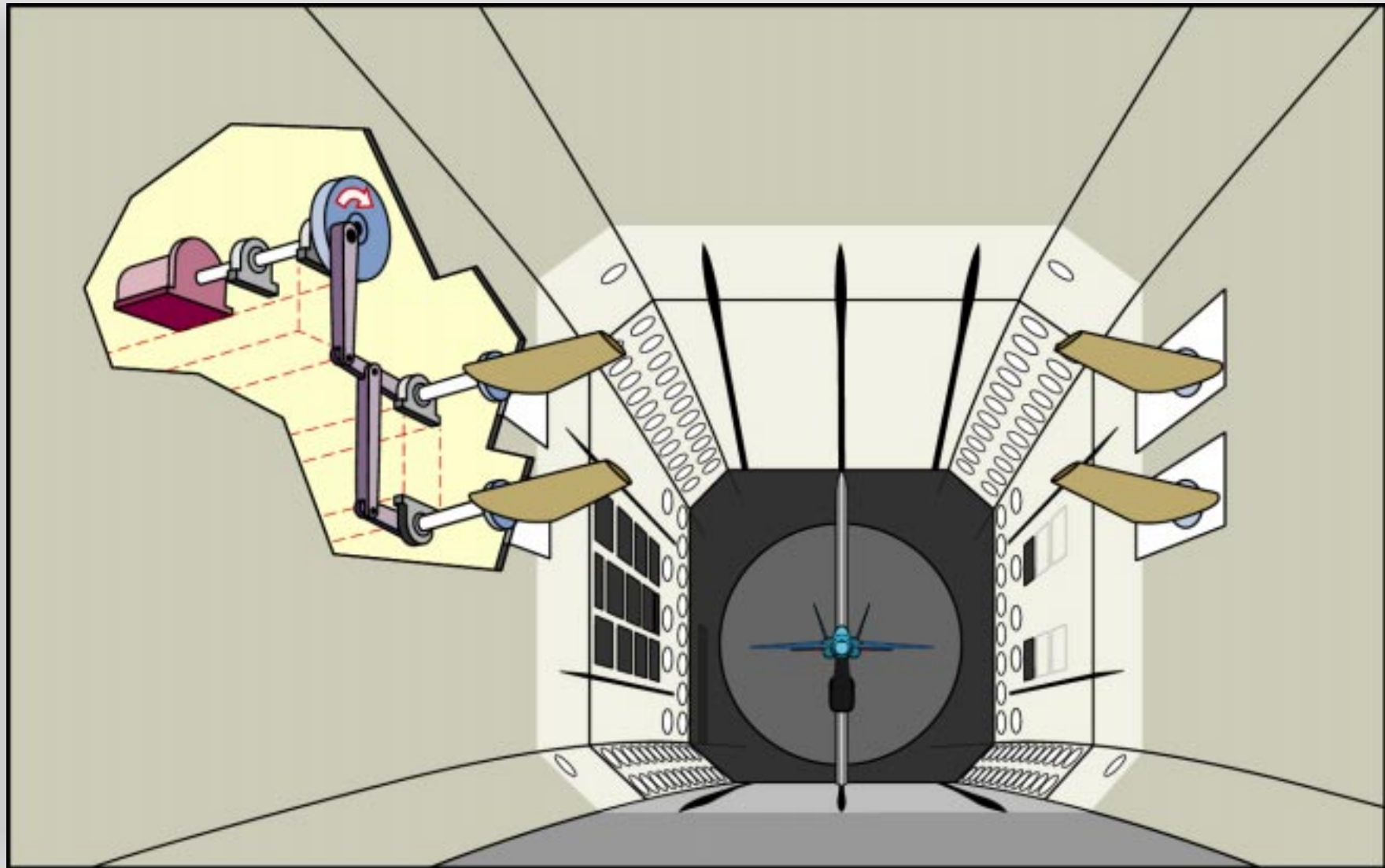
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TDT CROSS SECTION



TDT AIRSTREAM OSCILLATOR SYSTEM



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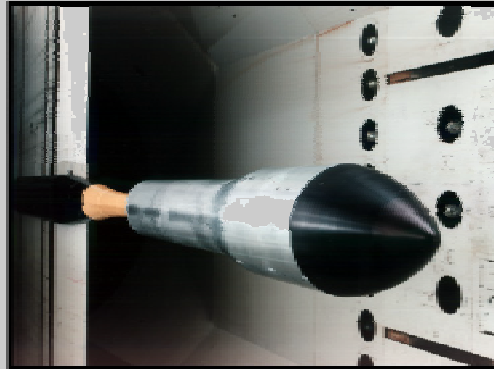
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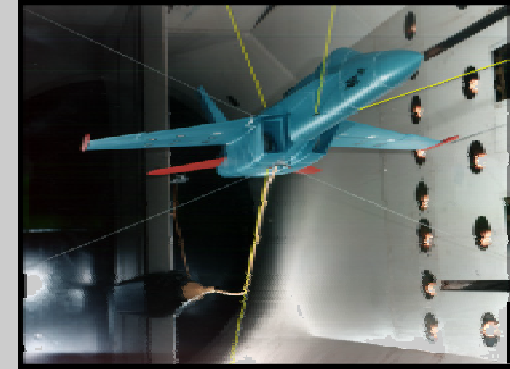
MODEL MOUNTING SYSTEMS FOR THE TDT



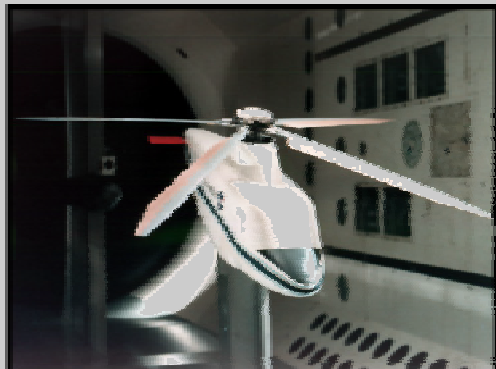
Sidewall Turntable



Sting



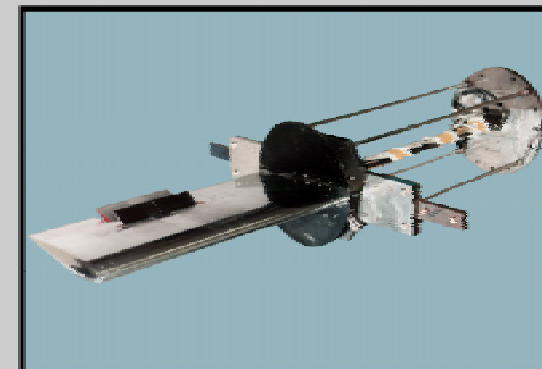
Two-Cable System



Rotor Testbed



Floor Turntable

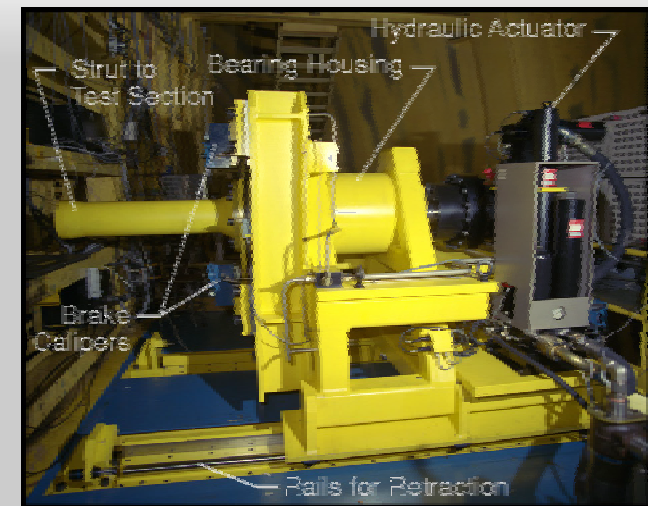


Pitch and Plunge Apparatus

TDT OSCILLATING TURNTABLE

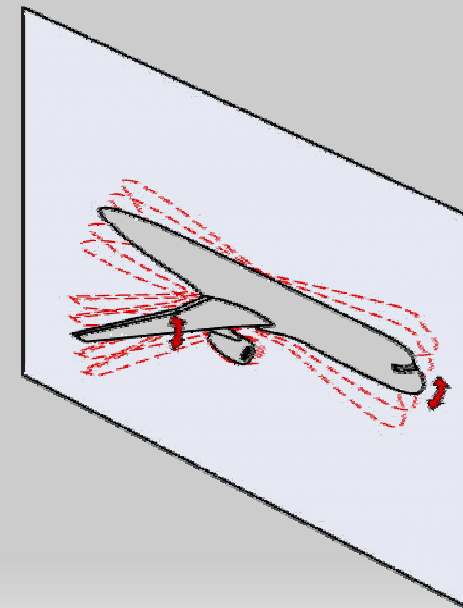
OTT Features

- Capable of oscillating large, semi-span models in pitch at transonic speeds
 - Frequencies up to 40 Hz
 - Amplitudes vary with frequency
- Static pitch electric drive system for tests which do not require oscillations (not shown)
- Retraction system allows positioning models within the test section



OTT as a Research Tool

- Provides the ability to acquire high-quality unsteady pressure and loads data due to precisely controlled pitch oscillations for correlation with unsteady CFD codes
 - For code validation and enhancement
 - Enhanced codes will lead to improved flutter-predictions and other aeroelastic-analysis benefits



WHY TEST IN A HEAVY GAS TEST MEDIUM?

Preliminaries

Assumptions

- Airplane design point remains the same
 - Flight conditions -- Mach number & altitude
 - Vehicle configuration -- Size & weight
- Model design point remains the same
 - Tunnel conditions -- Mach number & dynamic pressure
 - Model configuration -- Size

Heavy Gas Test Medium vs. Air Test Medium

- Density of R-134a $\cong 3.5 \times$ Density of air
- Viscosity of R-134a $\cong \frac{2}{3} \times$ Viscosity of air
- Speed of sound in R-134a $\cong \frac{1}{2} \times$ Speed of sound in air

WHY TEST IN A HEAVY GAS TEST MEDIUM?

Advantages over Testing in Air

Quantity	Scales as*	Normalized Value of Quantity** in-	
		Air	R-134a
Model Mass	$(\rho_{R-134a} / \rho_{Air})$	1.0	3.58
Model Structural Frequencies	(a_{R-134a} / a_{Air})	1.0	0.467
Froude Number	(a_{R-134a} / a_{Air})	1.0	0.467
Reynolds Number	$(a_{R-134a} / a_{Air})^{-1} \times (\mu_{R-134a} / \mu_{Air})^{-1}$	1.0	3.25
Fan Horsepower	$(\rho_{R-134a} / \rho_{Air}) \times (a_{R-134a} / a_{Air})^3$	1.0	0.365

* Based on previous assumptions
100°F

** Quiescent conditions, P = 2200 psf, T =



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VACUUM BLOWERS PHOTOGRAPH



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RECOVERY COMPRESSOR PHOTOGRAPH

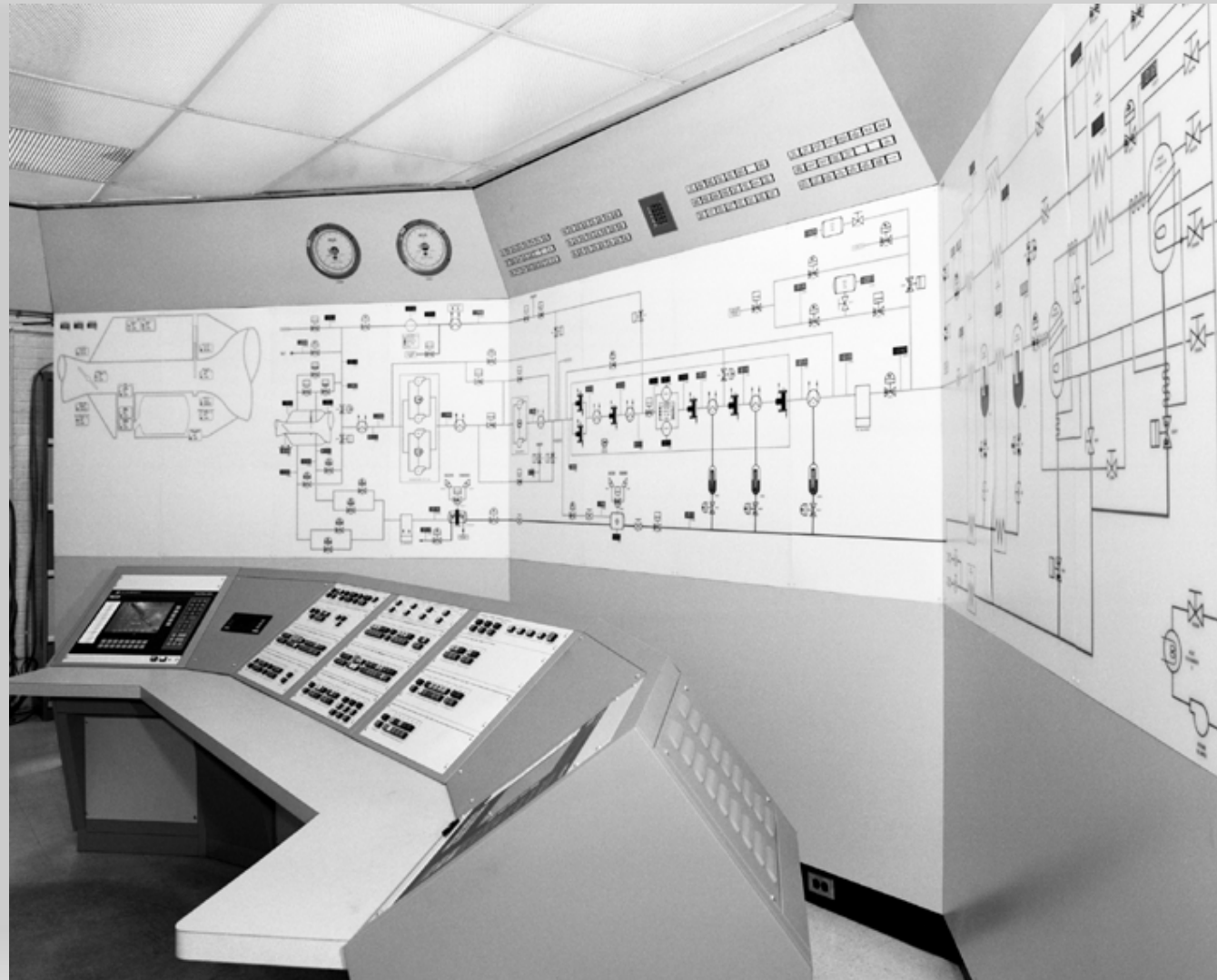


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HEAVY GAS RECLAMATION SYSTEM CONTROL ROOM

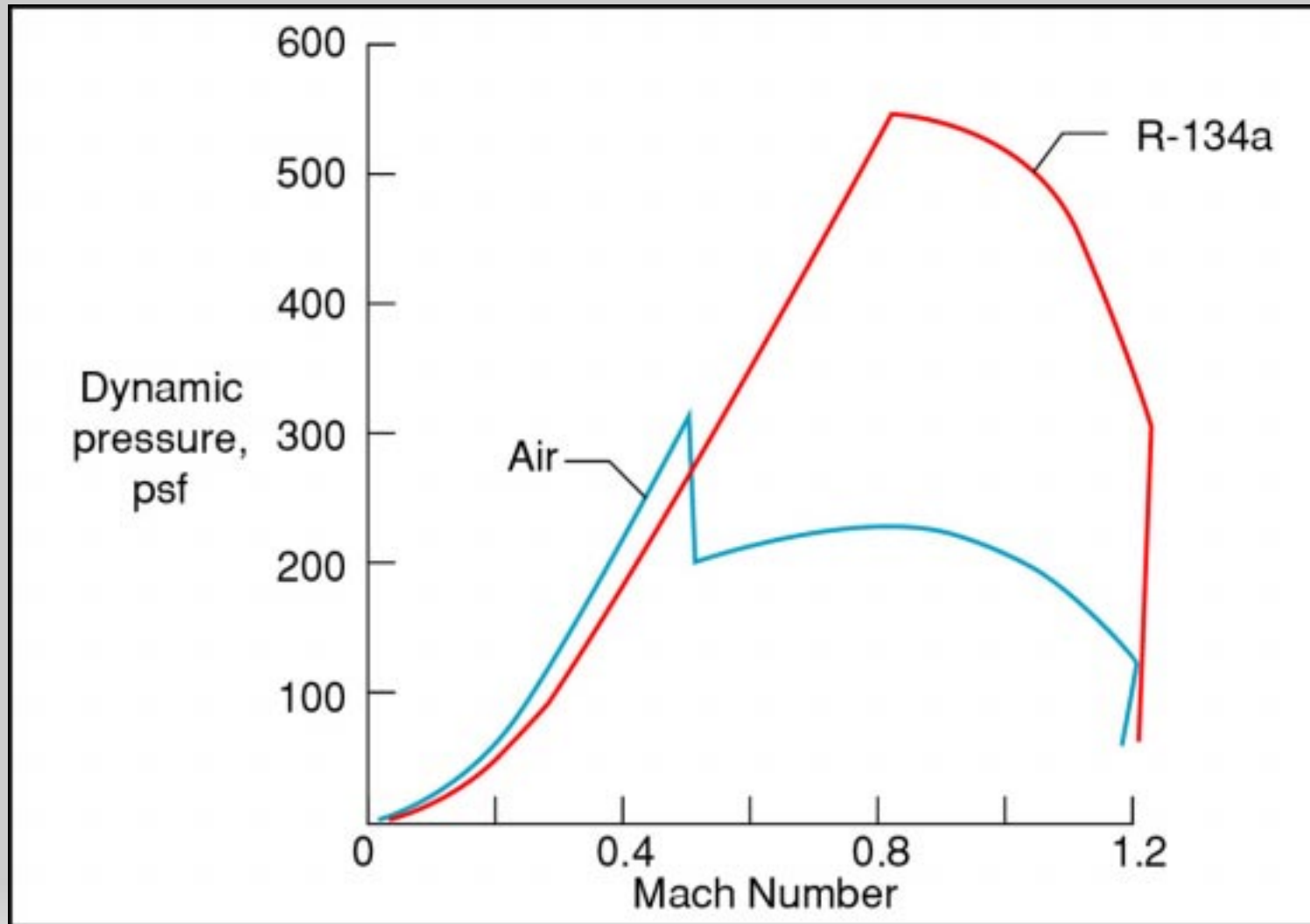


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TDT OPERATIONAL ENVELOPES



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TDT UPGRADES AND IMPROVEMENTS

- New model preparation area (B647) -- winter '01
- Productivity improvements -- spring / summer '01
- Automated facility controls -- summer / fall '02
- Development, testing, and transition to next-generation dynamic data acquisition system (D-DAS)
 - Development of primary software components -- summer '01
 - Parallel testing of primary software components -- fall '01
 - Integration of hardware/software -- winter '02
 - Transition to next-generation D-DAS -- summer '02

SUMMARY

TDT has ... A rich history of making relevant contributions to the field of aeroelasticity

TDT is ... A unique national facility that –

- is the best suited in the world to flutter test large, aeroelastically-scaled, full-span models at transonic speeds**
- supports DoD, Industry, and University programs**
- is critical to achieving NASA's mission**
(... To research, develop, verify, and transfer advanced aeronautics and space technologies)
- is environmentally responsible**