X-33, STEPPING STONE TO LOW COST ACCESS TO SPACE
United States
United States
Chris Naftel
NASA X-33 Technical Assistant
(661) 572-5381
chris.naftel@msfc.nasa.gov

Outline

- Background
- Program Objectives
- X-33 Configuration
- X-33 Assembly and Test Status
- VentureStar™

Access to Space Study

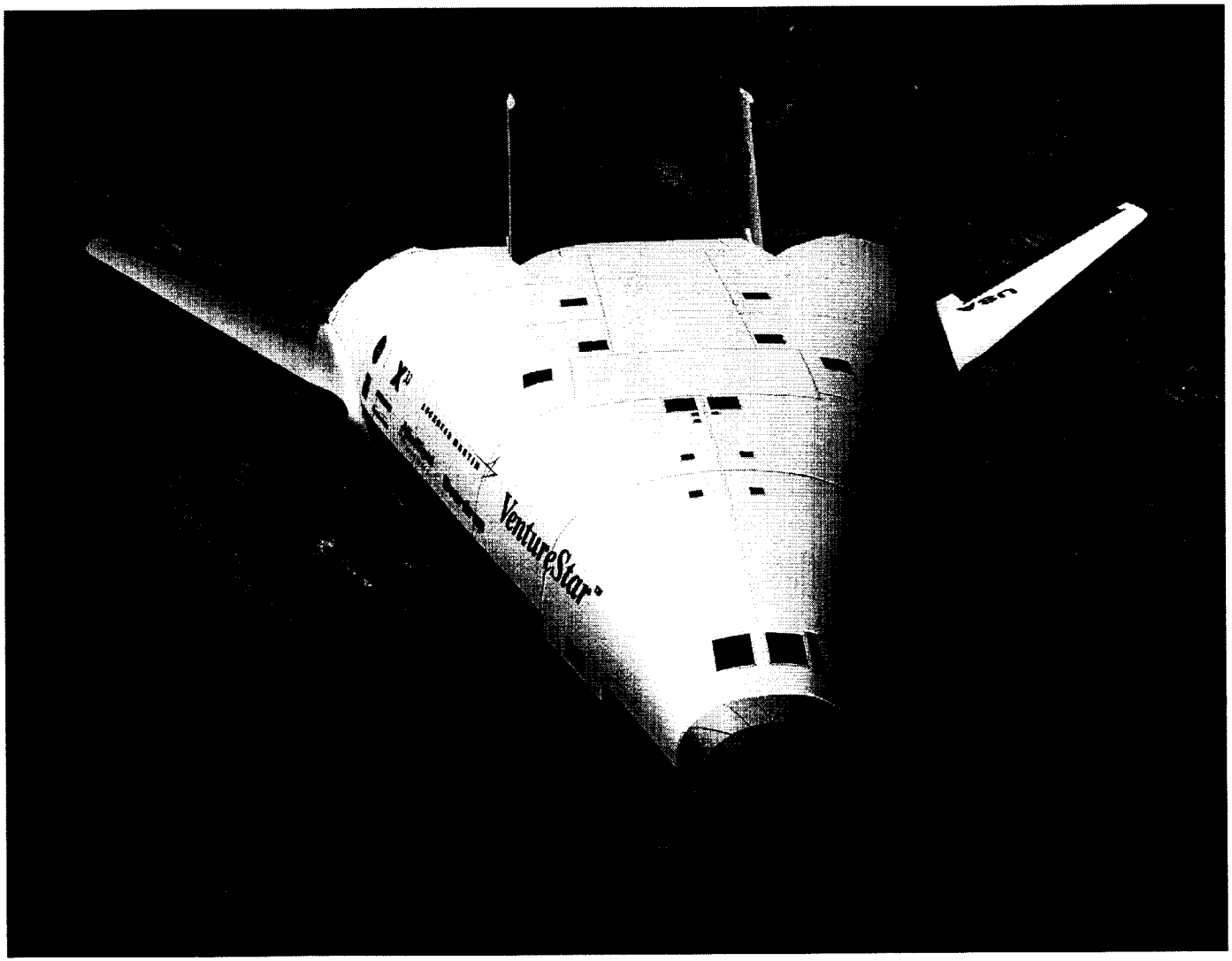
- Conducted in 1993 Through Office of Space Systems Development, NASA Headquarters
  - FY 93 Appropriations Bill to "... Assess National Launch Requirements, Potential Alternatives and Strategies to Address Such Needs ..."

- Space Transportation Systems Needs to Improve
  - Safety of Flight Crews
  - Reliability
  - Cost

- Three Major Architectures Studied:
  - Retain and Upgrade STS & ELV's
  - Develop New ELV's Using Current Technologies
  - Develop RLV Using Advanced Technologies

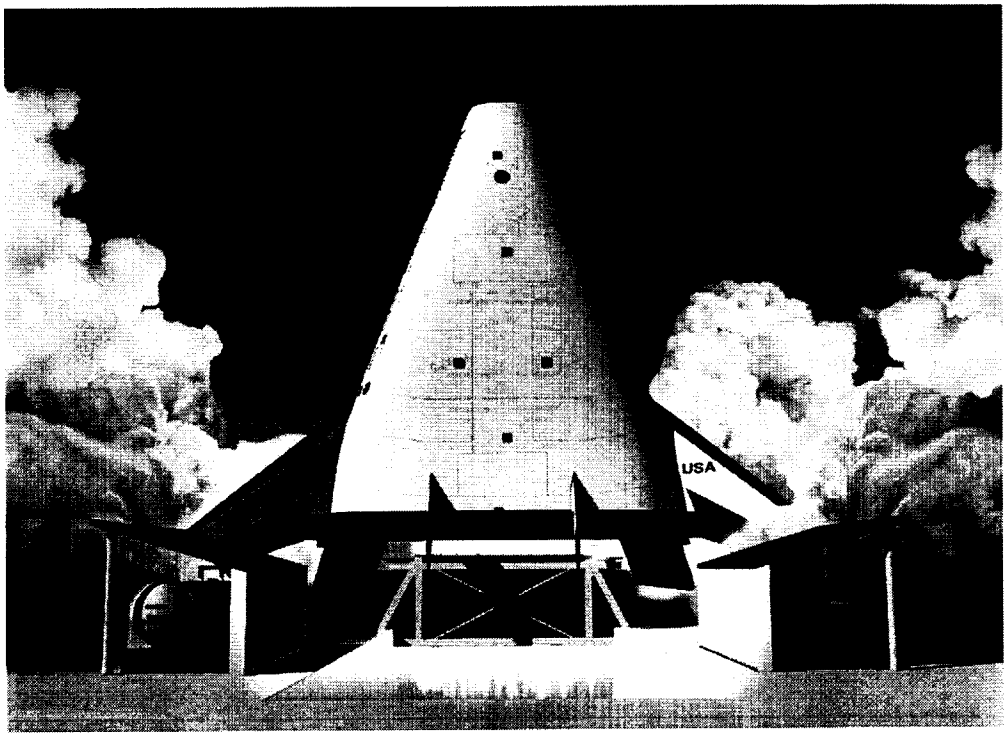
- Advanced Technology RLV Selected for Demonstration

NASA X-33
Advanced Technology Demonstrator



Low-Cost Access to Space

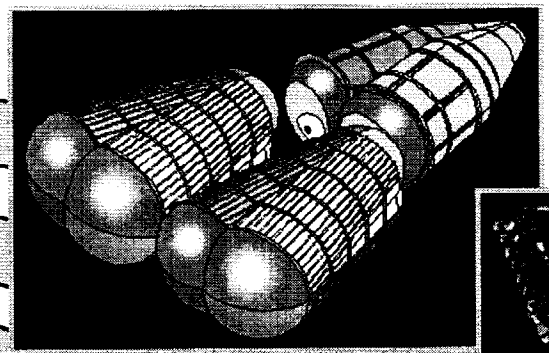
- **Objectives**
  - –Build & test a 53-percent scale prototype of an operational RLV
    - •Realistic flight environment
  - –Demonstrate technologies
    - •Reusable cryogenic tankage
    - •Composite structures
    - •Durable TPS
    - •Advanced avionics
    - •Reliable propulsion systems
    - •Aircraft-like operations



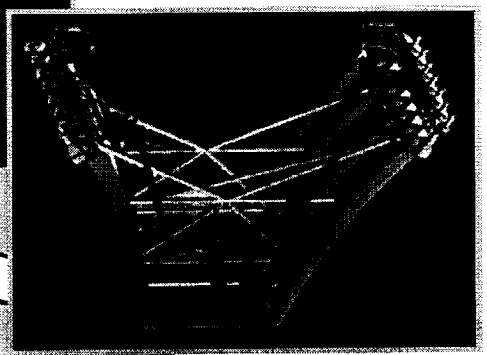
- **Long-term goal**
  - –Reduce payload cost to low Earth orbit by factor of 10 within 10 years ($10,000 to $1,000)

X-33

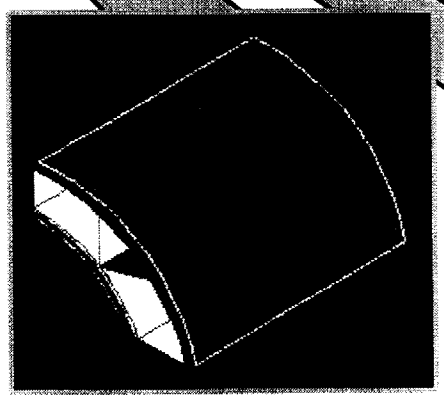
VentureStar™ Technologies



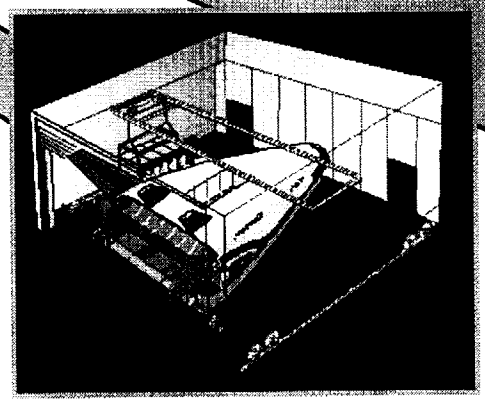
Lightweight Tanks and Structure



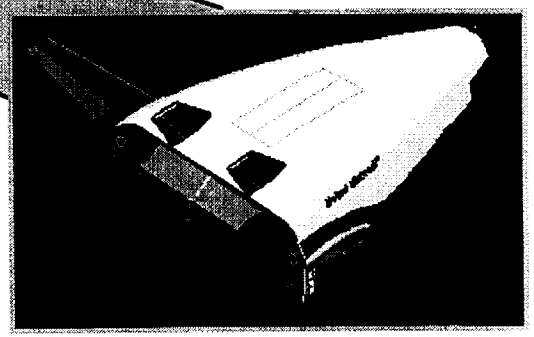
Linear Aerospike Engine



Robust Metallic TPS



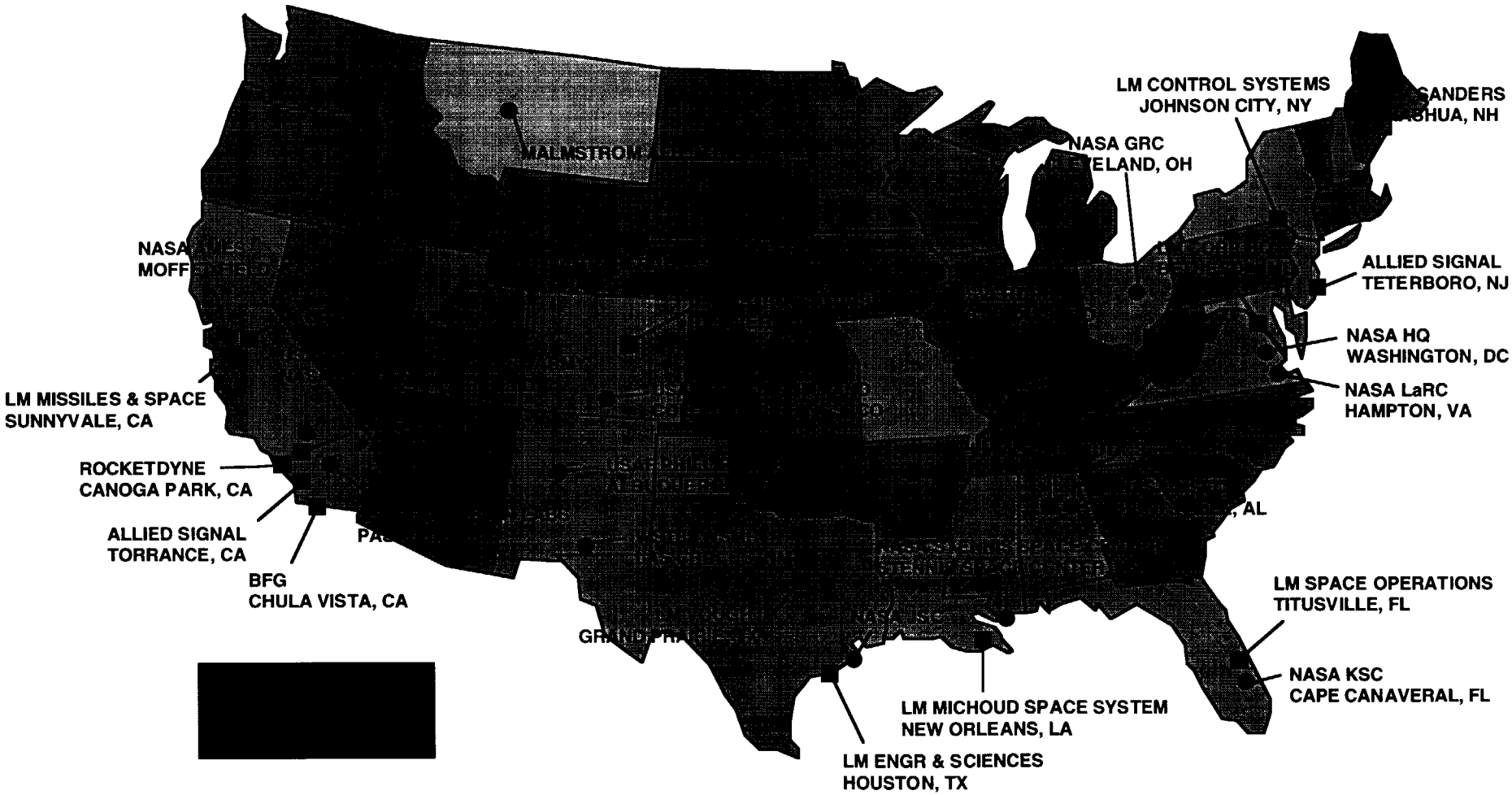
Automated Operations



Lifting Body

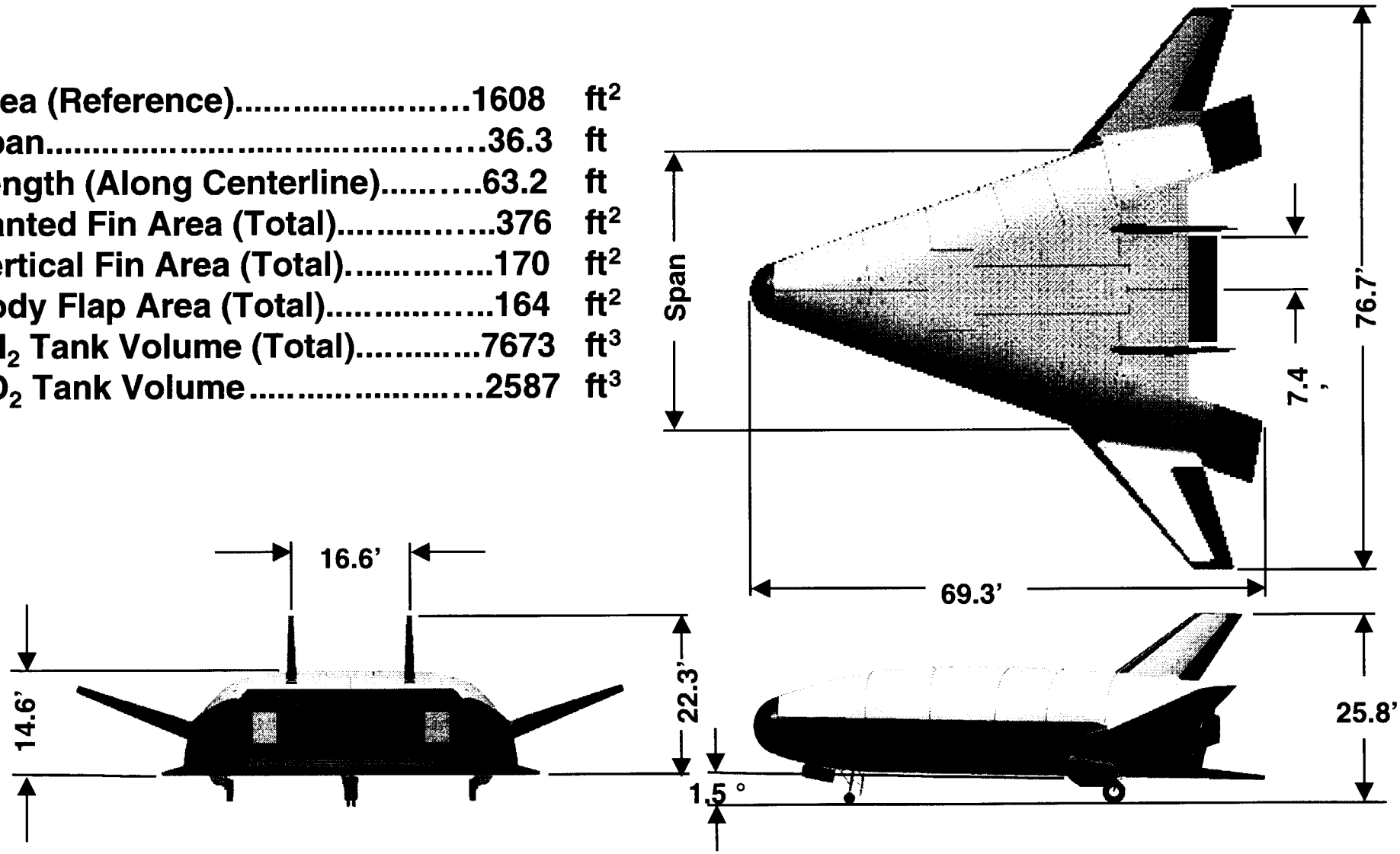
X-33

SSTO / RLV: PARTNERSHIPS FOR SPACE LAUNCH LEADERSHIP



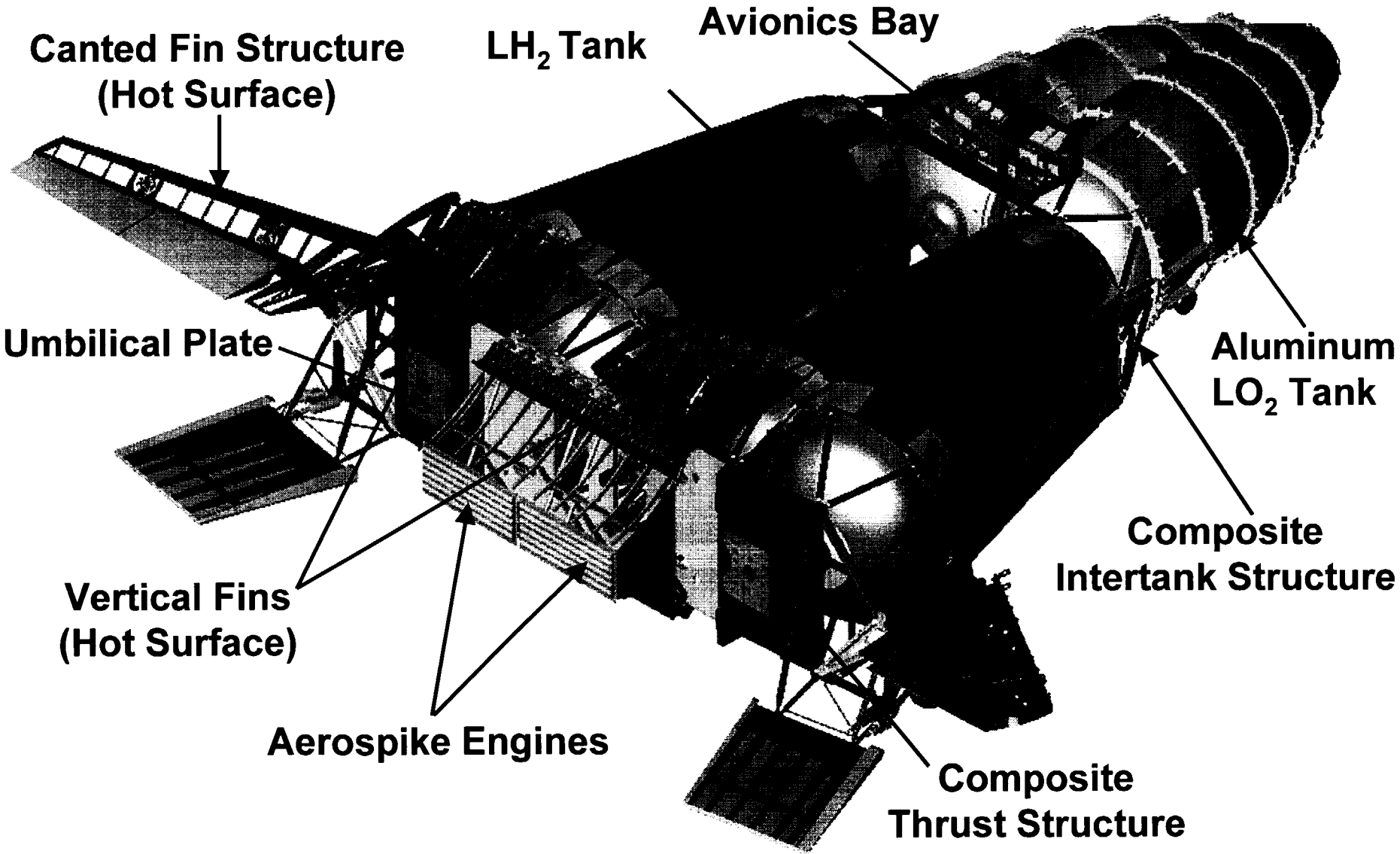
X-33 Configuration

Area (Reference)	1608	ft^2
Span	36.3	ft
Length (Along Centerline)	63.2	ft
Canted Fin Area (Total)	376	ft^2
Vertical Fin Area (Total)	170	ft^2
Body Flap Area (Total)	164	ft^2
LH_2 Tank Volume (Total)	7673	ft^3
LO_2 Tank Volume	2587	ft^3

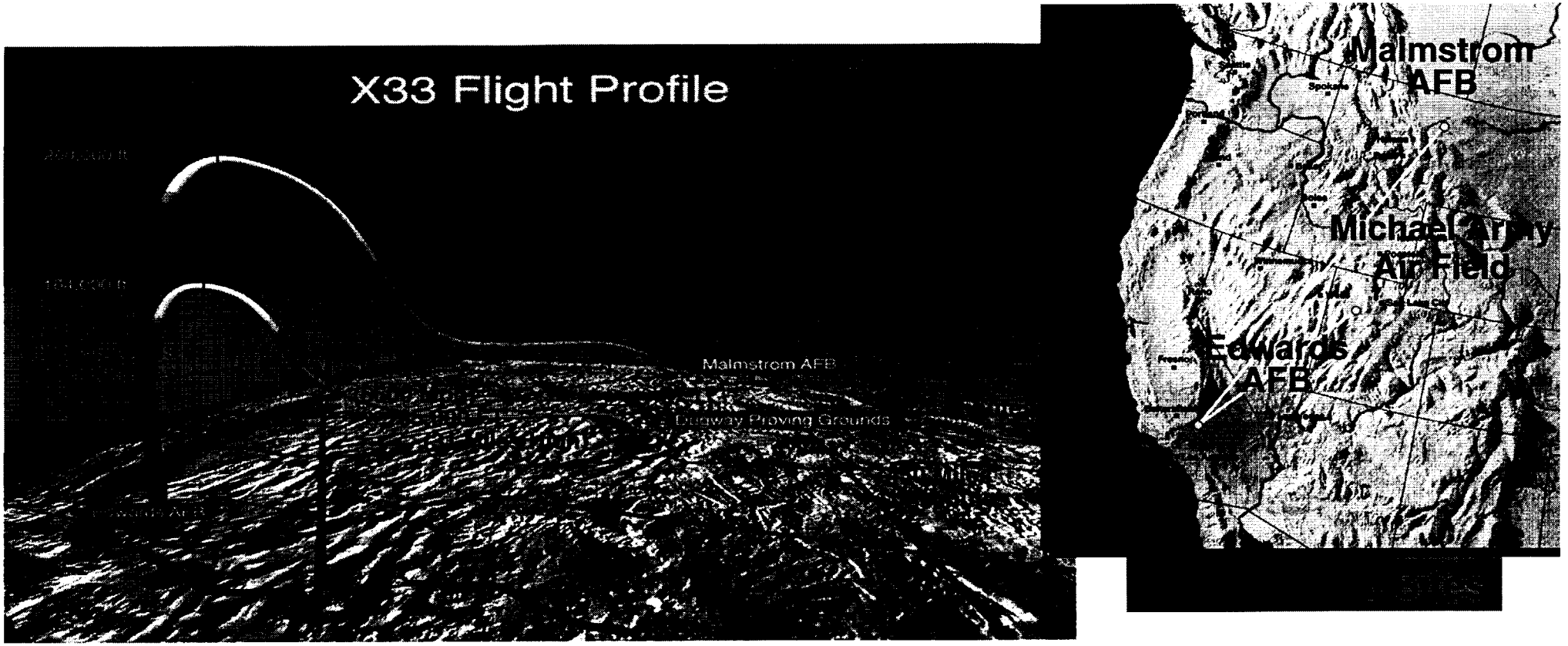


X-33

X-33 Elements



X-33 Flight Test



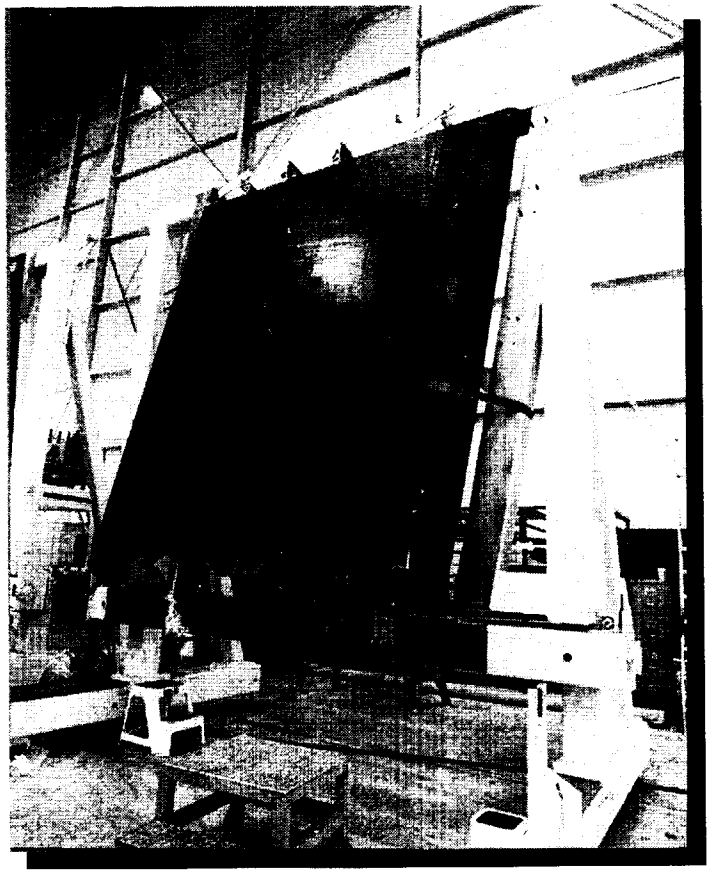
Flight 1	Benign Thermal/Loads
Flight 2	Intermediate
Flight 3	Real Gas Effects
Flight 4	Transition Laminar to Turbulent Flow
Flight 5	Max Speed
Flight 6	Additional Increment of Real Gas Effects
Flight 7	Same Additional Increment
Flights 8-15	Margin to Repeat Specific Flight Profiles, Data Points

Aircraft-like Operations: Two Seven-Day Turnarounds and One Two-Day Turnaround During Flight Test Series

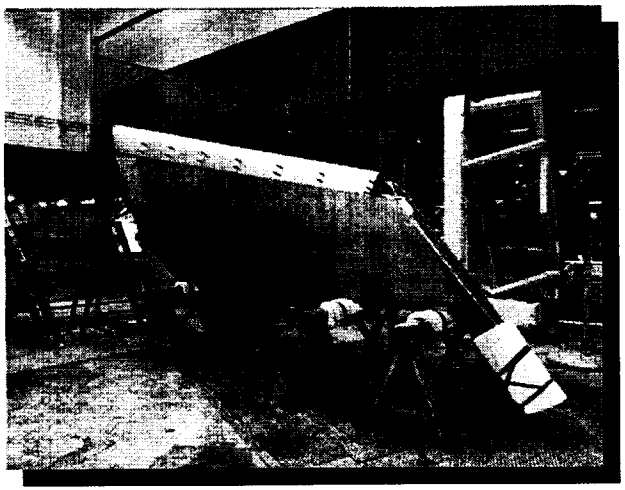
X-33
Assembly and Test Status

X-33 Vehicle Assembly in Palmdale

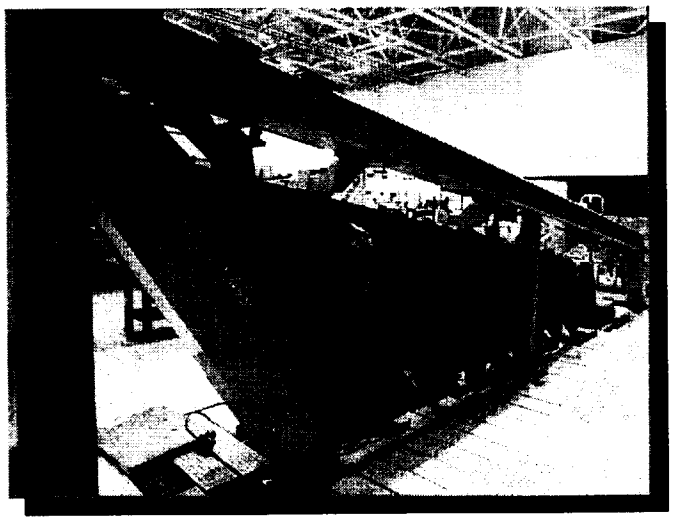
Flight Control Assembly



Both Body Flap Box Structures Nearly Complete Final Fastener Installation In Process.



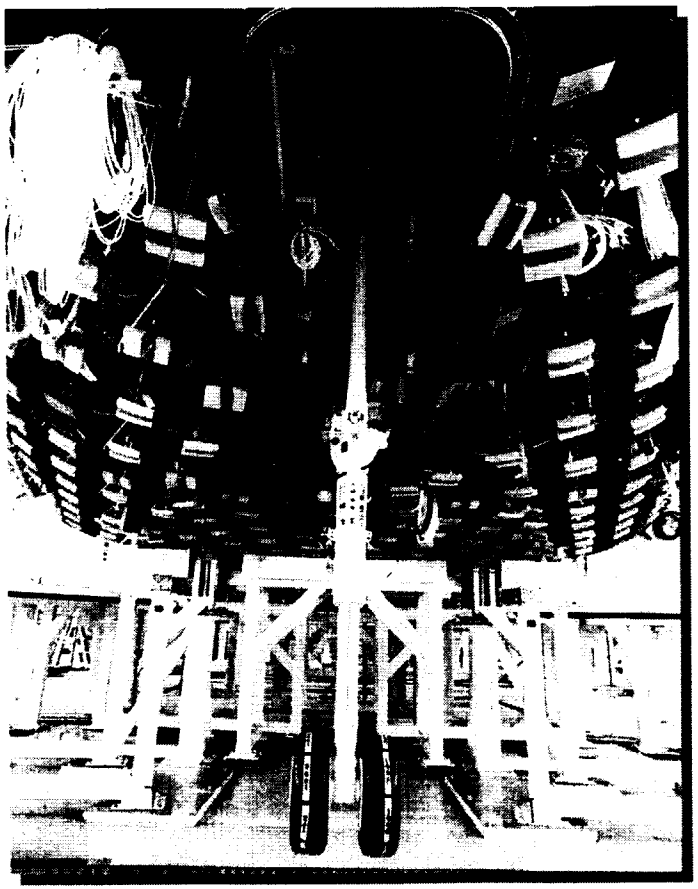
R/H Vertical Stabilizer Box Structure Complete. L/H in Final Skinning Operations.



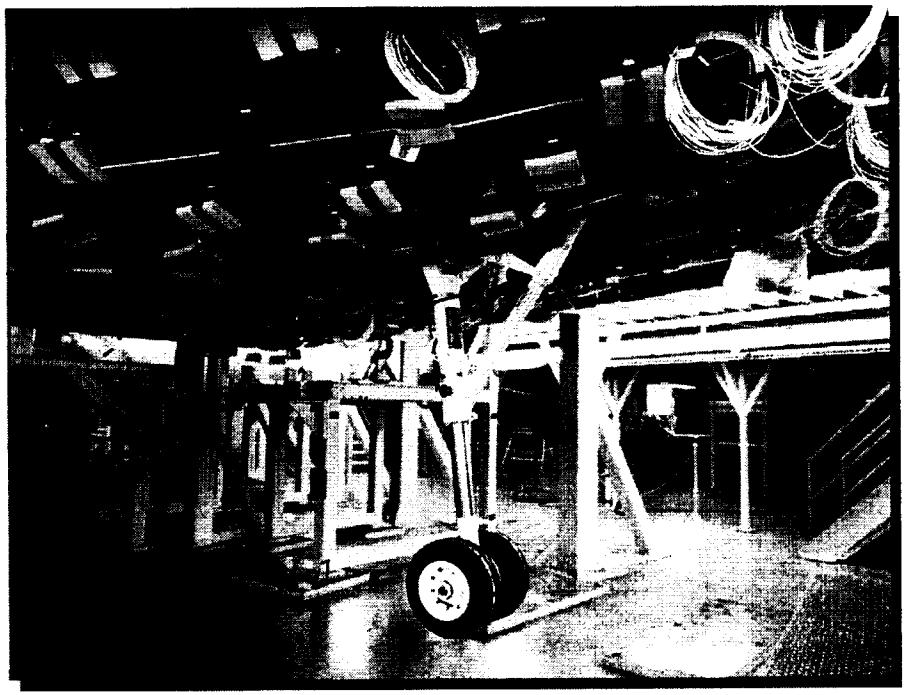
Permanent Skins Installed on Both L/H and R/H Canted Fins

X-33

Nose Landing Gear

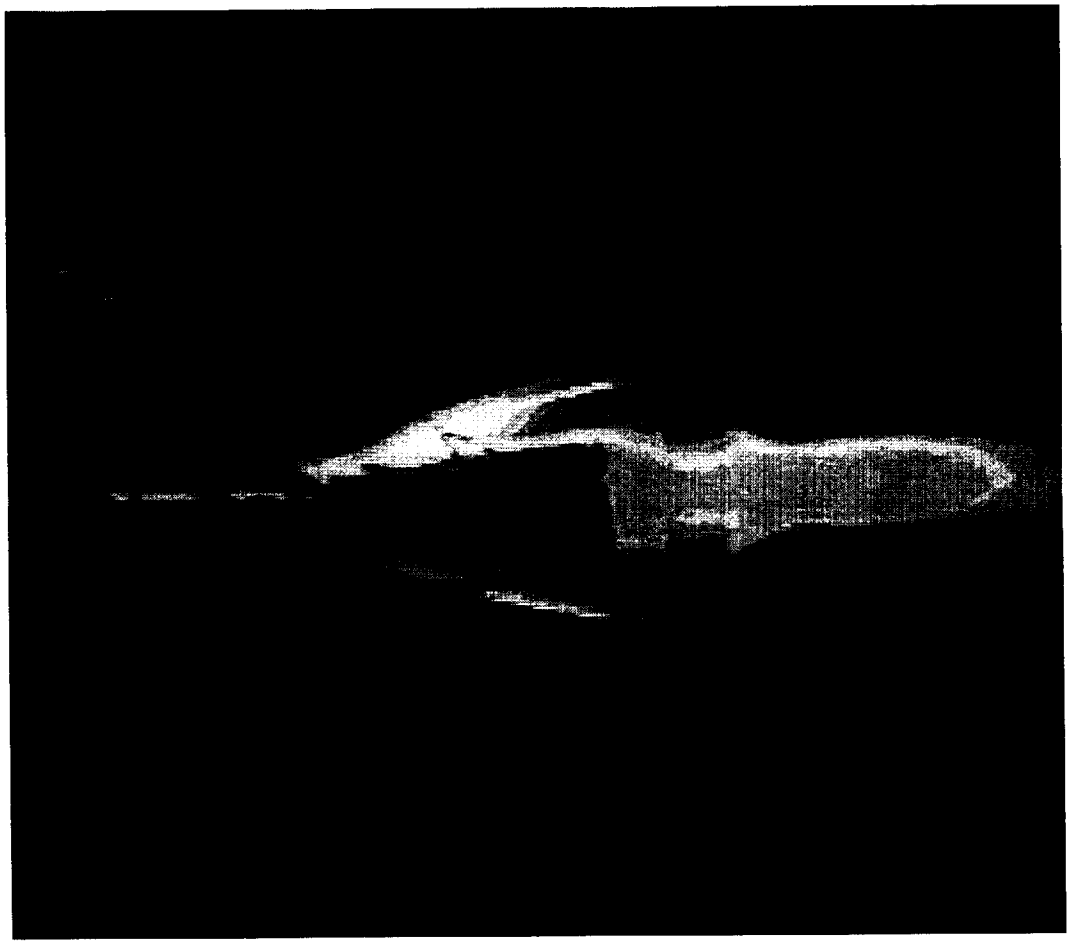


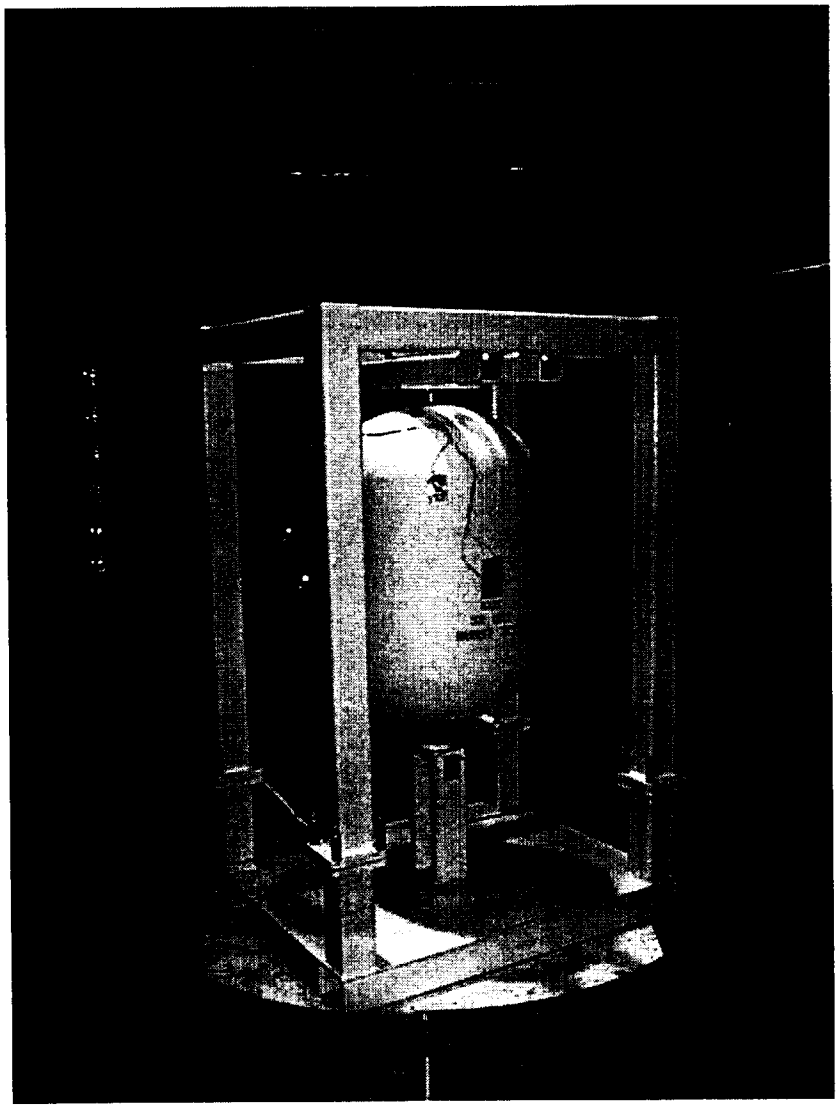
Nose Landing Gear Installation



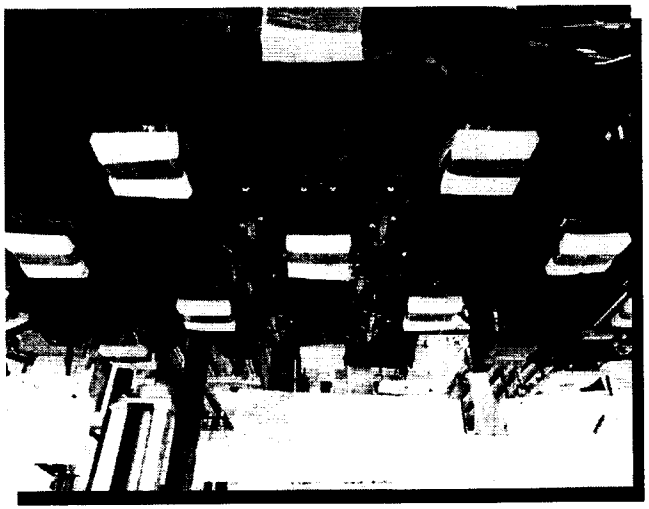
Modified F-15E Strut / F-16 Tire/Wheel

Reaction Control System

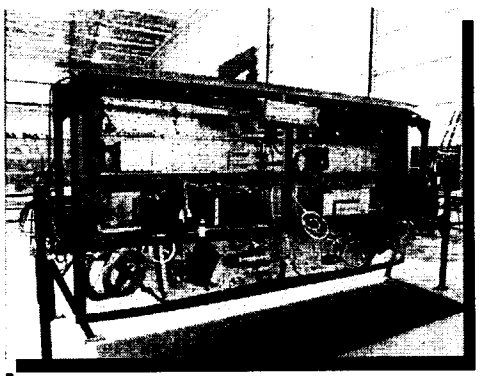


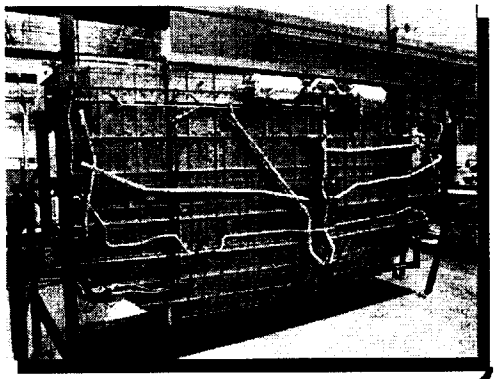


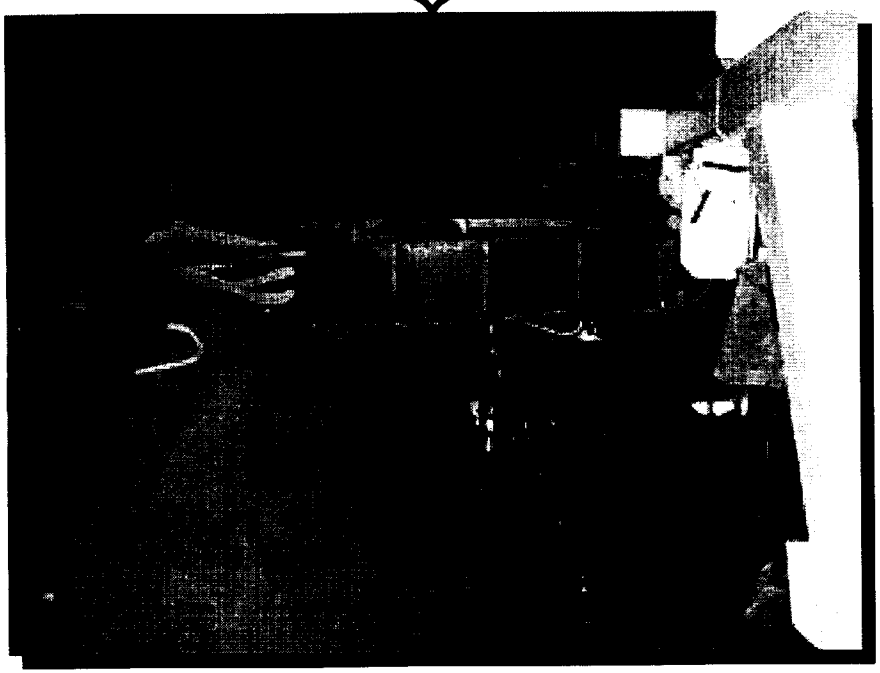
Systems Installation



RCS Auxiliary Propellant Tank and Control Valve Pallets. All LOX Tank Installations Complete.

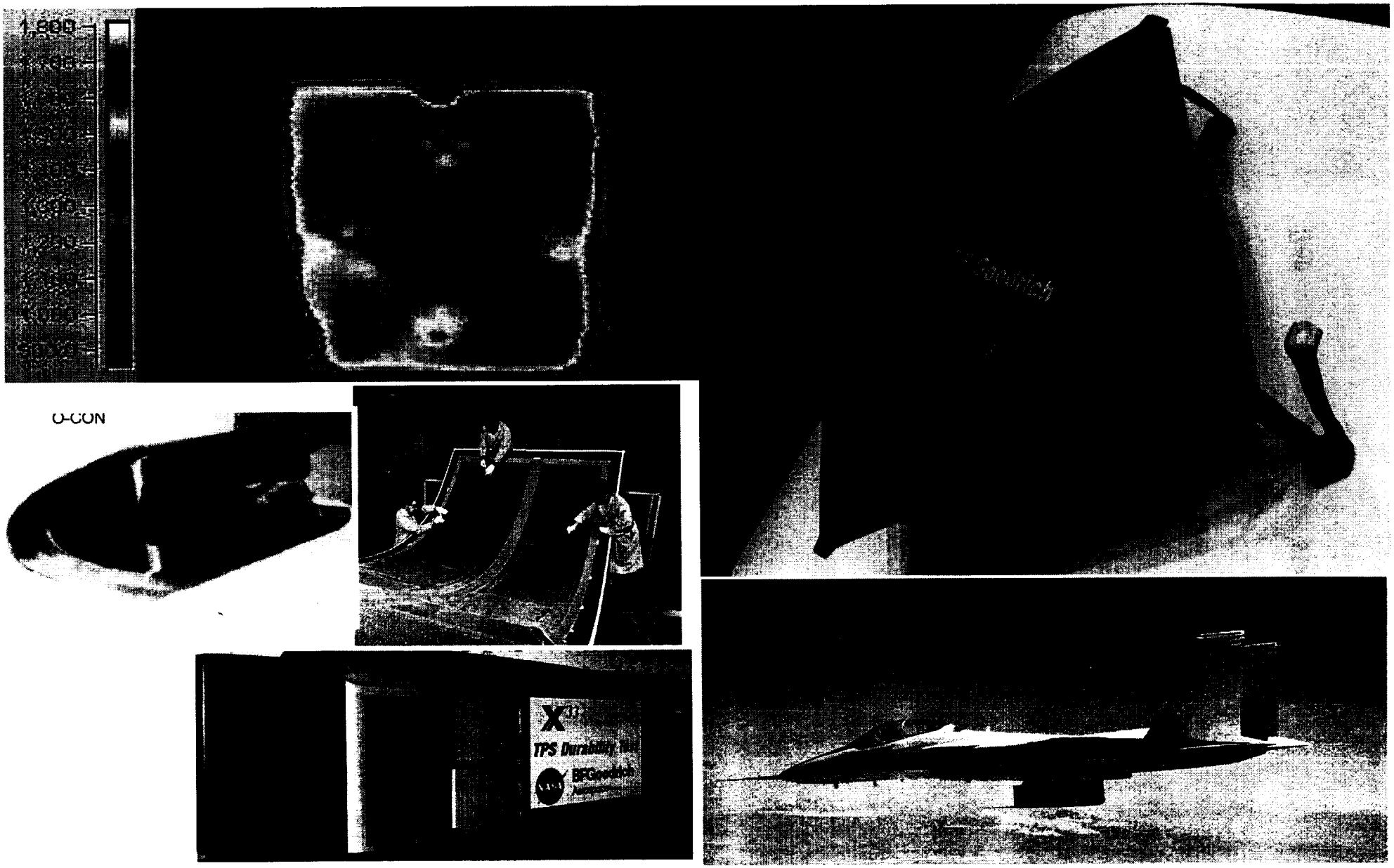






Avionics Bay Attached To LOX Tank To Finalize Wire and Connector Placement.

X-33 Metallic Thermal Protection System



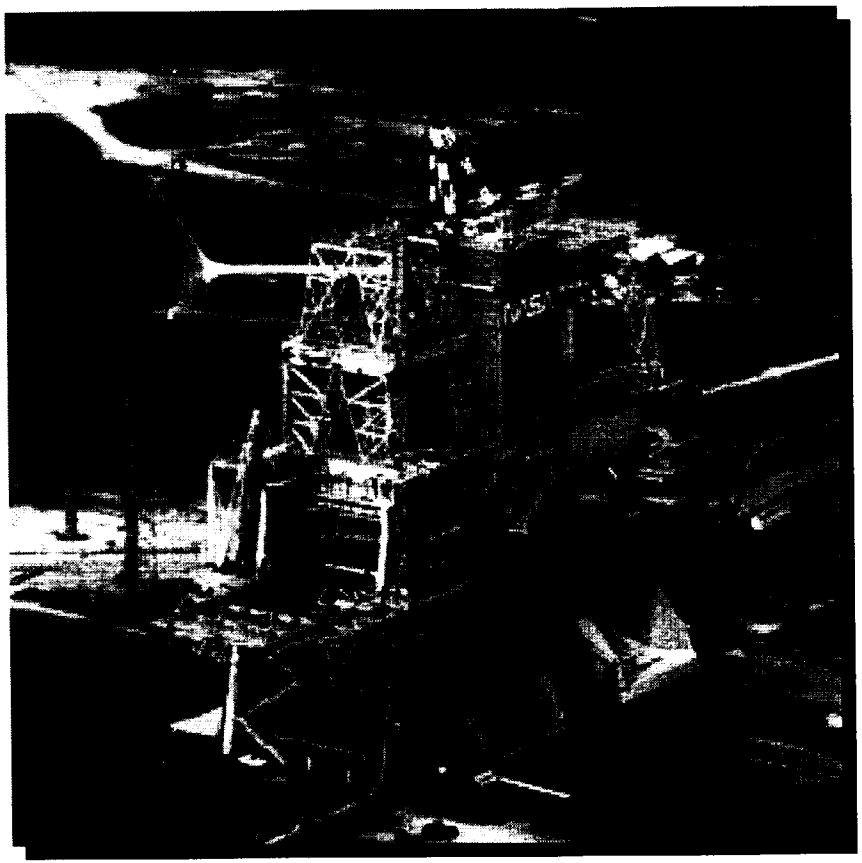
X-33 Thermal Protection System

Metallic TPS Fit Test

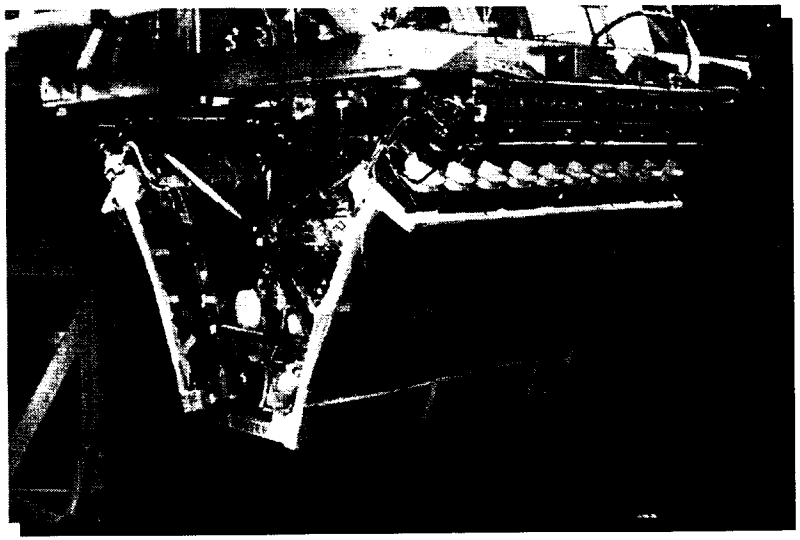
LO_2 Tank Testing At MSFC

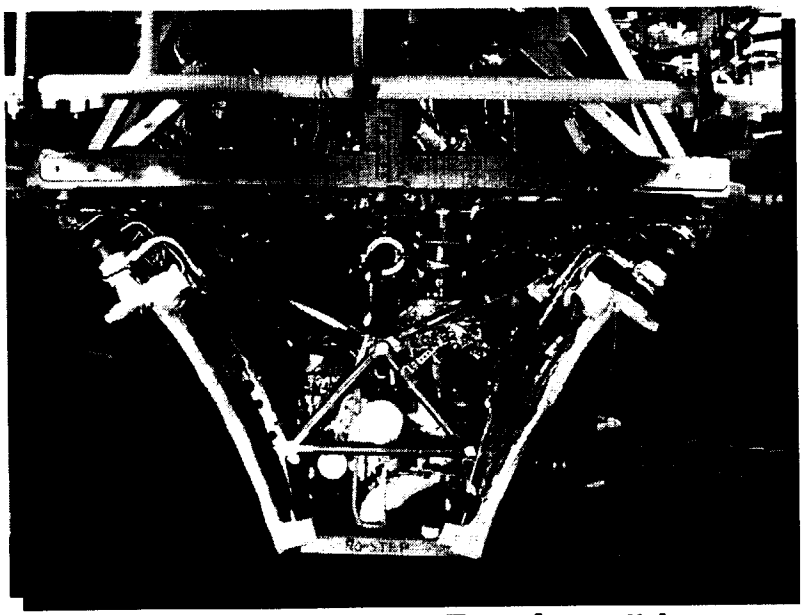
- Test Conducted on Structural Test Article (STA) - Identical to X-33 Flight Tank
- Successfully Completed LO_2 Flight Tank Structural Verification
- STA Tank currently at Glenn Research Center for Propellant Densification Tests

Aerospike Engine Testing



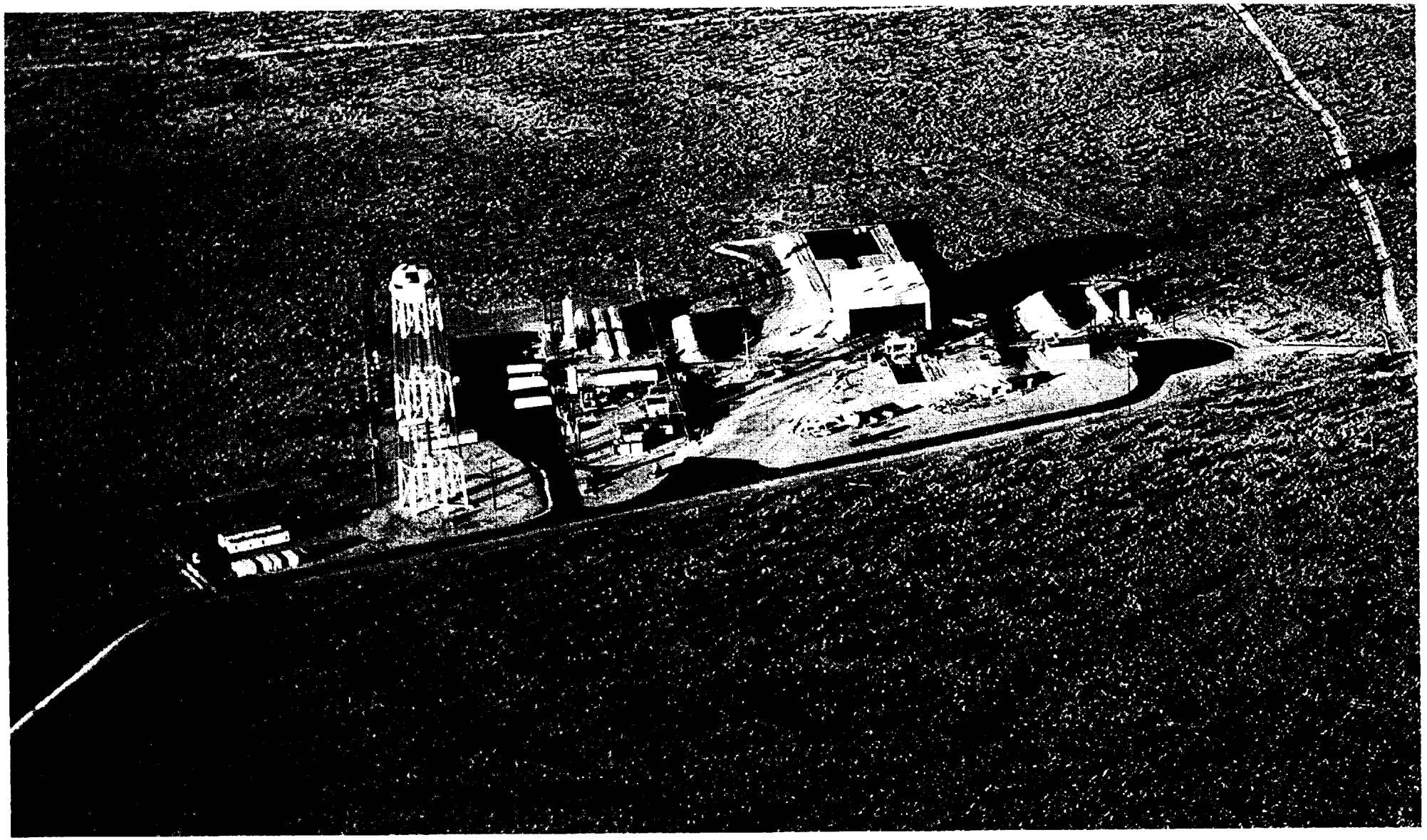
- Stennis Space Center Test Stand





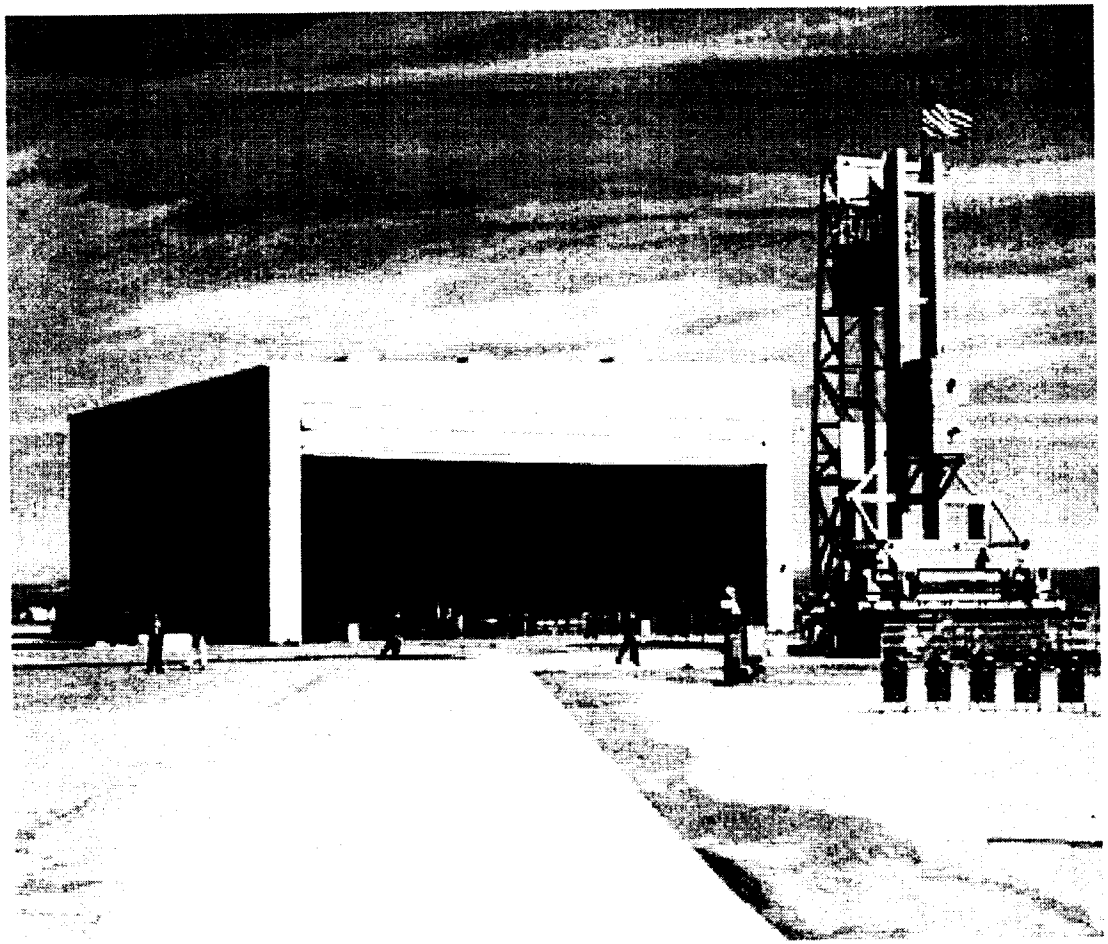
- Aerospike Engine #1

Flight Operations Center

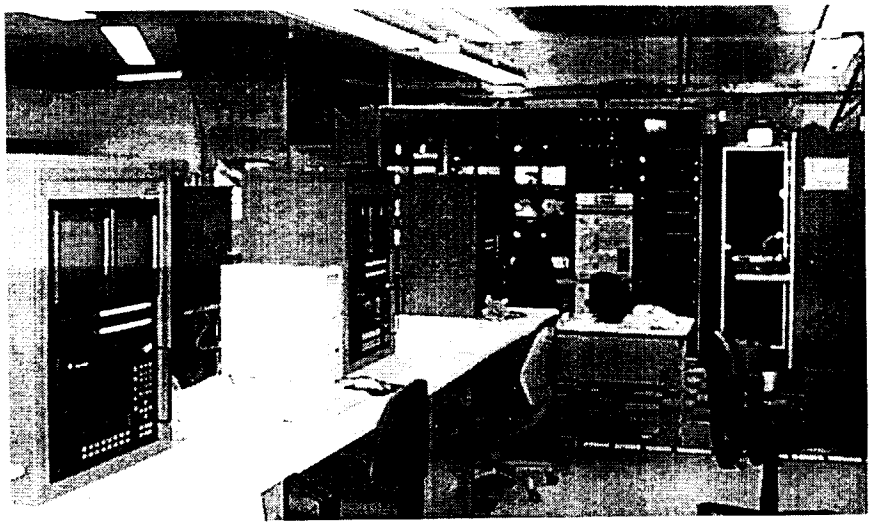


Completed 25-Acre, $32 Million X-33 Flight Operations Center on Edwards Air Force Base, Calif.

Flight Operations Center



Translating Shelter and Strong Back with Weight Simulator



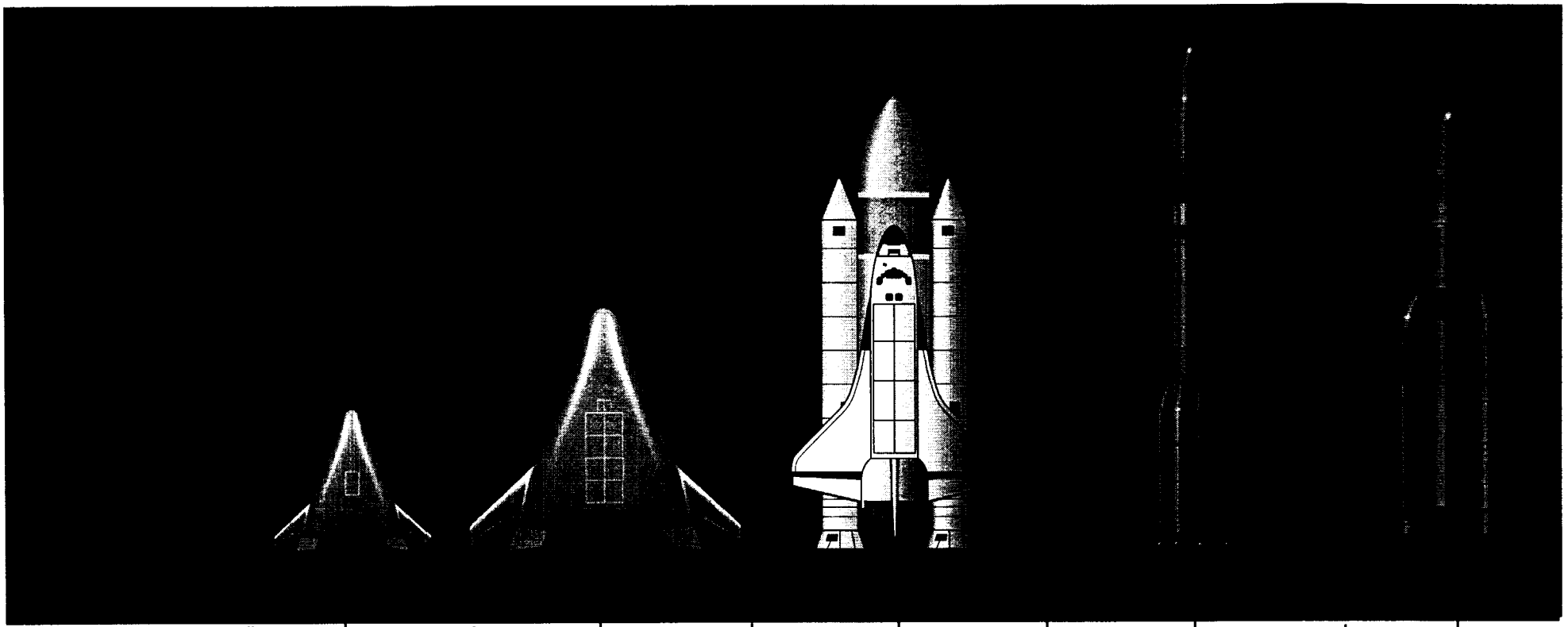
Eight-Person Control Room

Strong Back with Weight Simulator

X-33

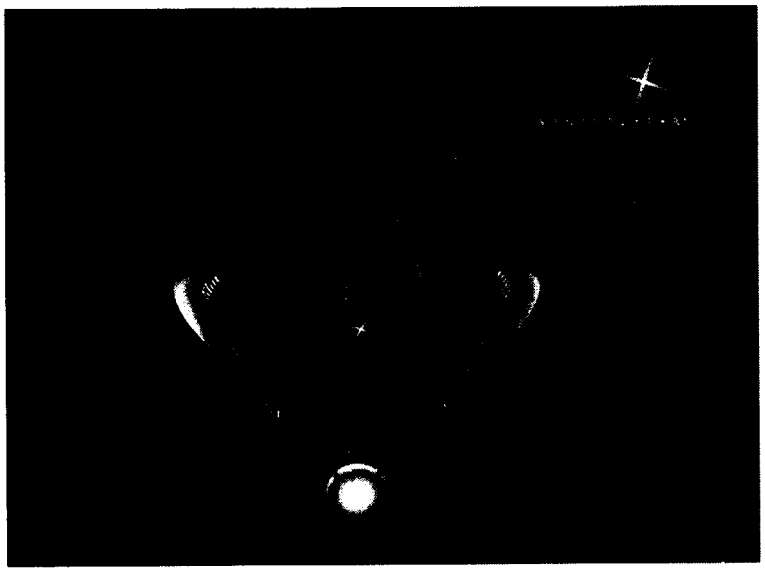
VentureStar™

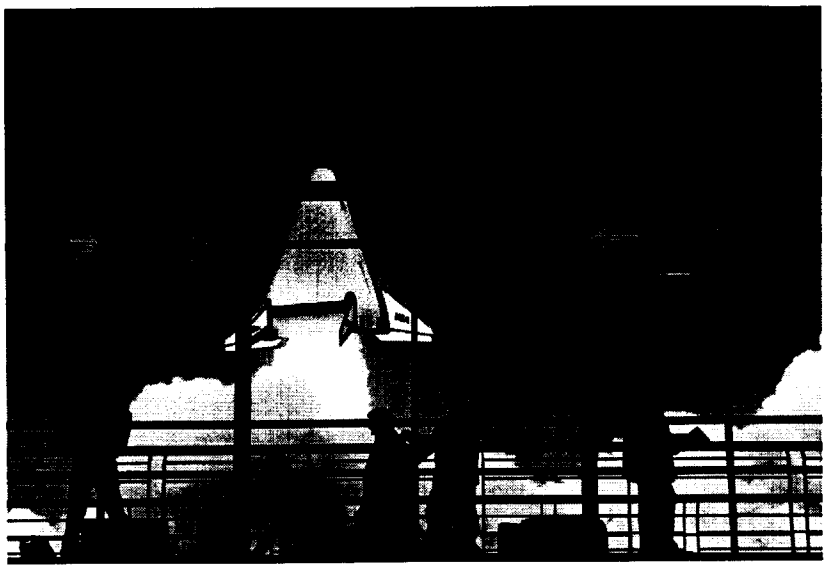
X-33 Vehicle Comparison



Weight	273K lb	2.6M lb	4.5M lb	1.6M lb	1.6M lb
Length	69 ft	144 ft	184 ft	188 ft	169 ft
LEO Payload (100 nm/28.58°)	N/A	> 50,000 lb	51,000 lb	46,000 lb	39,600 lb
Bay size	N/A	15 x 53 ft	15 x 60 ft	13.5 x 48 ft	14.7 x 49.7 ft
Propulsion	2 J-2S aerospikes	7 RS2200 aerospikes	3 SSME bells + 2 solids	6 single-chamber liquids	1 bell + 2 solids

Vehicle & Spaceport





Two Initial VentureStar™ Vehicles

Designed for Commercial Markets

- 56,000 lbs. to LEO
- 25,000 lbs. to ISS
- 18,000 lbs. to GEO
- 11,000 lbs. to Polar

Up to Two Spaceports in Continental United States

Safe System Operations

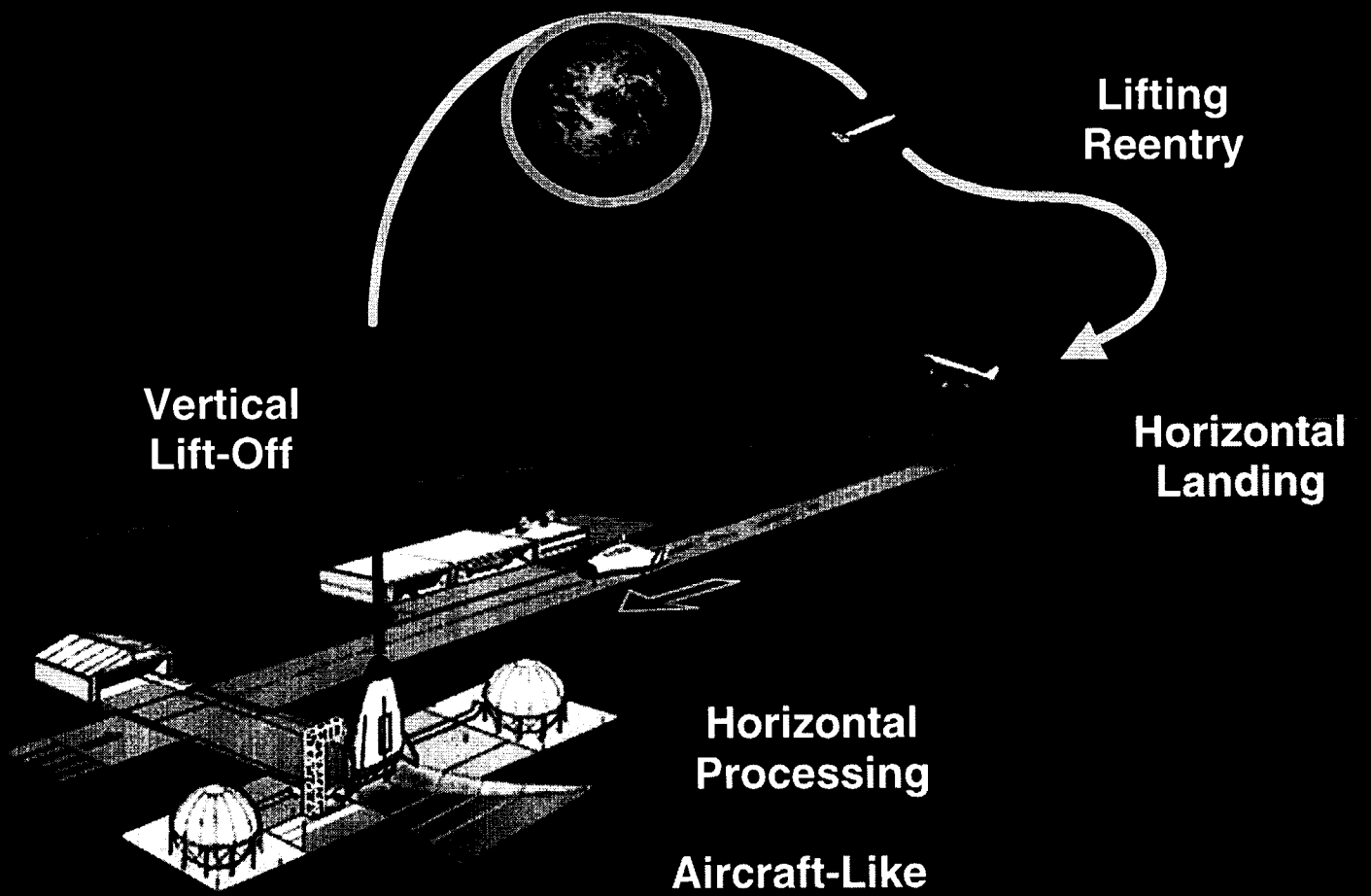
Full Access to Commercial Markets

Support Aircraft-like Operations

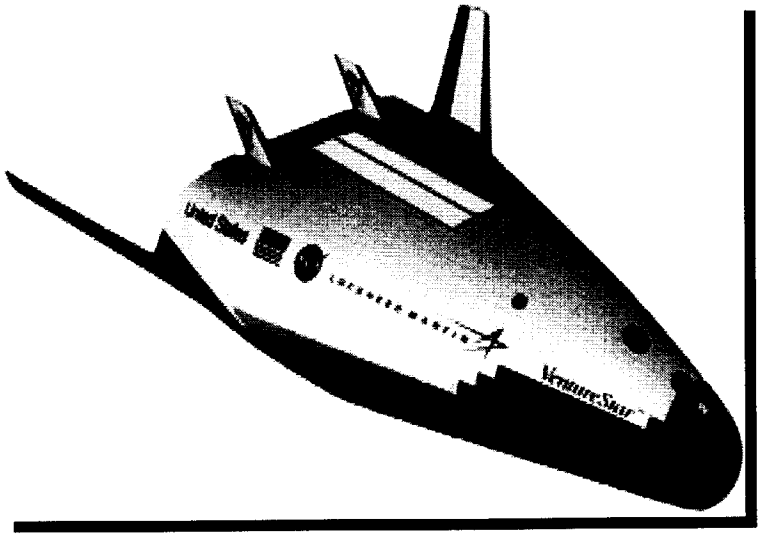
Support Operational Timelines

Customer Satisfaction

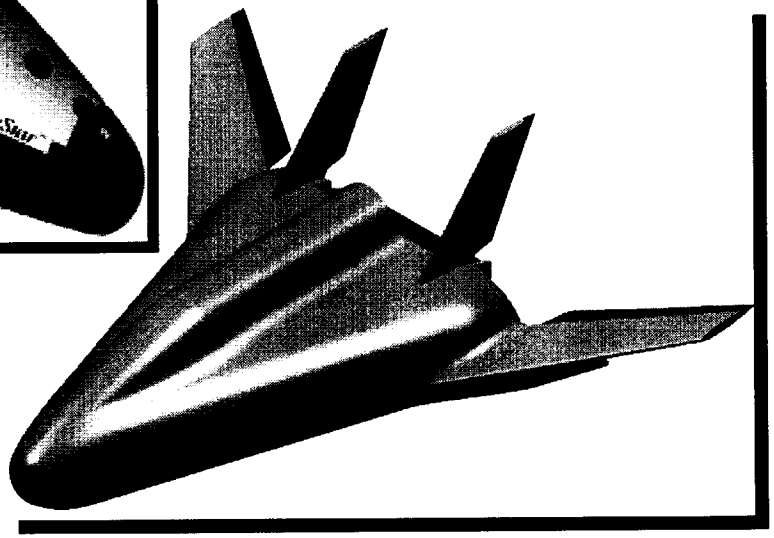
SSTO RLV Mission Concept



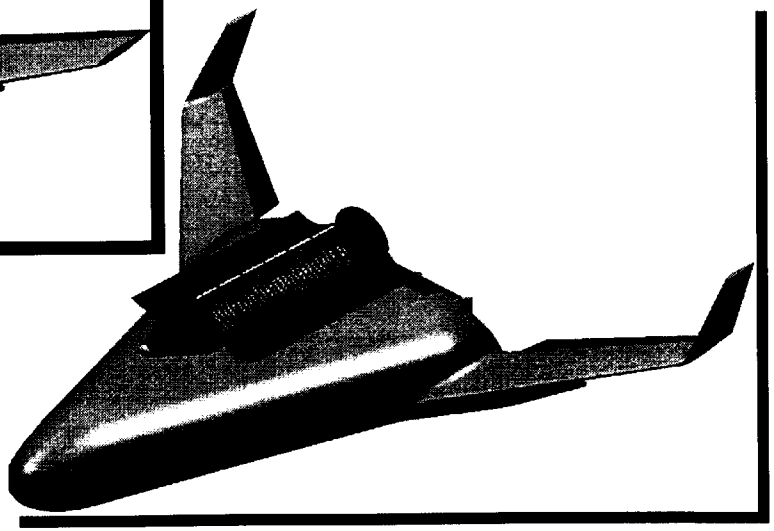
X-33 VentureStar™ Design Evolution



- X-33 Heritage: Internal Payload Concept

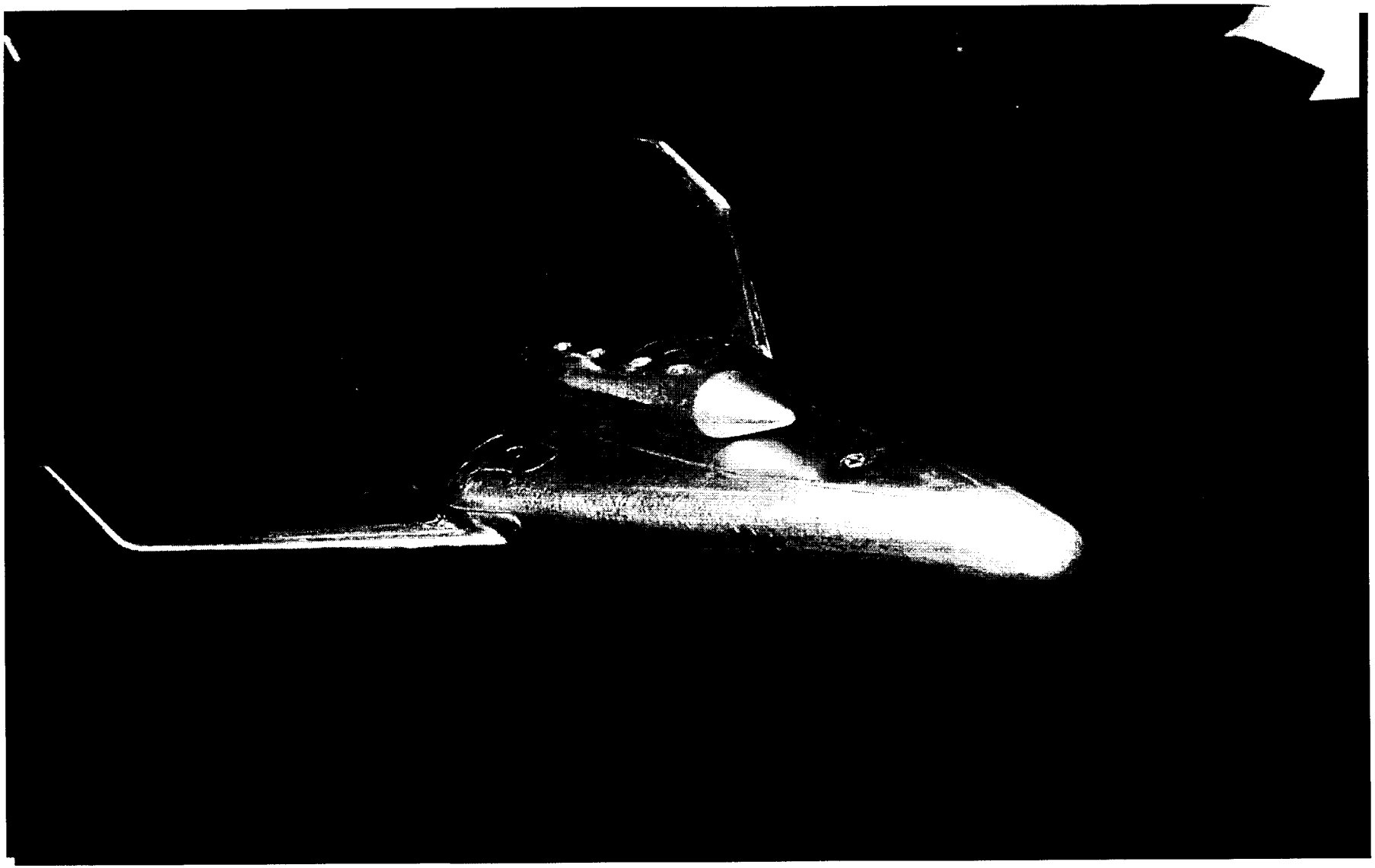


- Semi-Submerged Payload Concept

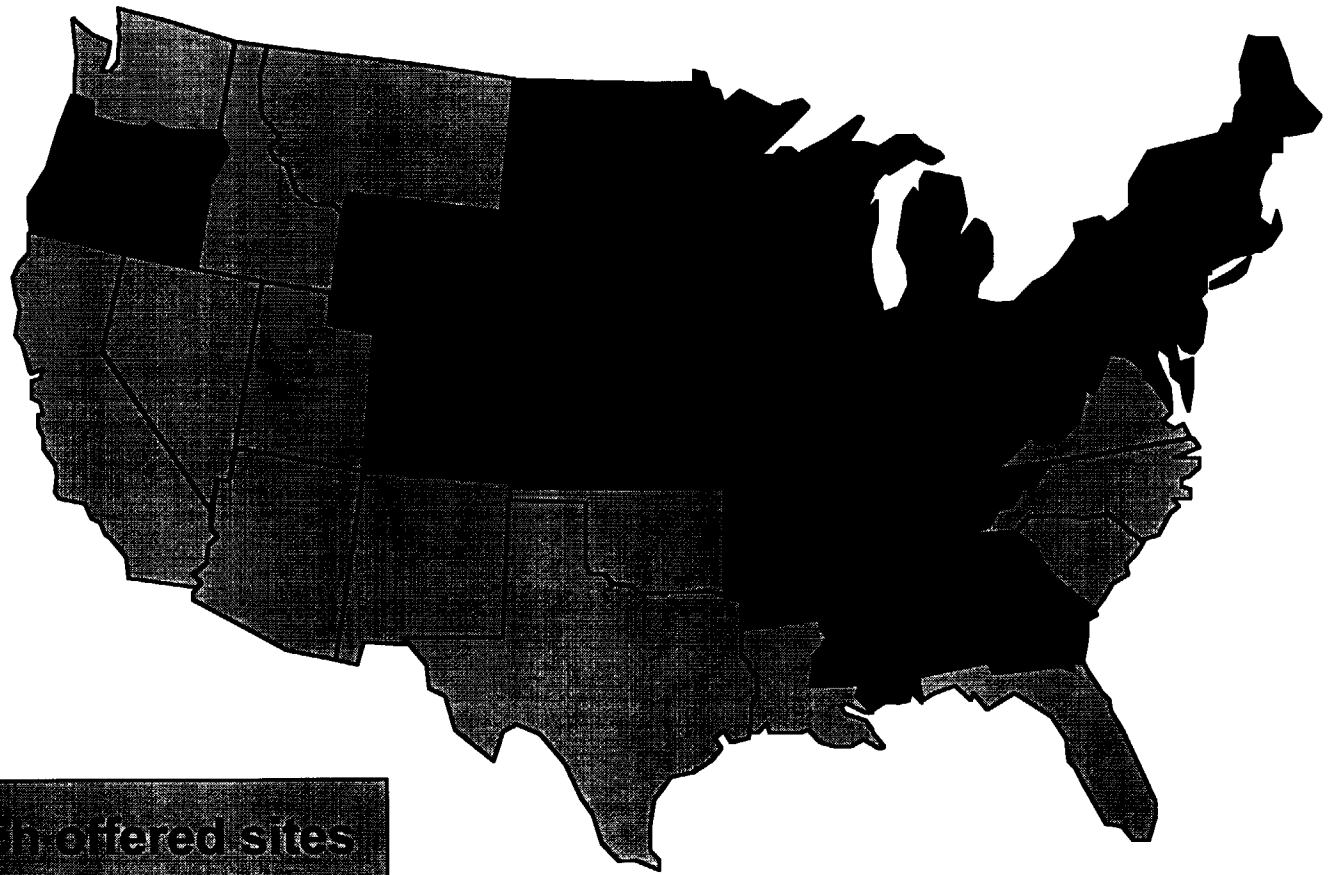


- External Payload Concept

X-33 Aero Closure Wind Tunnel Test Configuration



VentureStar™ Launch Site Competition



States which offered sites through qualification package submittal

X-33

Summary

- X-33 design completed
- X-33 fabrication and assembly progressing well
- X-33 launch site completed
- First LH_2 tank and engine in testing
- VentureStar™ design maturing