# NASA's X-37 Flight Demonstrator: A Path to Our Future


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# NASA Vision & Mission

## Vision

*To improve life here*
*To extend life to there*
*To find life beyond*

## Mission

*To understand and protect our home planet*
*To explore the universe and search for life*
*To inspire the next generation of explorers … as only NASA can*



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# X-37
# Vision & Mission

## Vision

- *Revitalize Our Nation's Capability to Build and Operate an Integrated Space Transportation System*

## Mission

- *Generate data to mature critical technologies that enable future space transportation systems and conduct experiments in flight environments that are beyond the capability of existing platforms, thereby extending our Nation's reach in space.*
- *Reduce the risk of developing new generations of safe, reliable, and affordable space transportation to inspire and empower a new generation of explorers..*
- *Provide an autonomous, reusable testbed for critical technologies and a platform for science payloads that will improve our understanding of life on Earth.*



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# Flexible, Reusable Testbed

- Contributes to the design of future space transportation systems through real-world testing in orbital, reentry, and landing environments
- Conducts experiments in orbit
- Demonstrates streamlined ground & flight operations
- Provides breakthorugh data in the Mach 10 – 25 range
- Demonstrates maneuvering at high speeds
- Serves as a testbed to transition technologies & raise technology readiness levels



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# Flexible, Reusable Testbed (cont.)

- **Validates a wide range of technologies to increase safety & reliability & reduce costs:**
  - **Thermal Protection Materials**
  - **Propulsion**
  - **Avionics**
  - **Guidance, Navigation, & Control**
  - **Autonomous Flight**
  - **Solar Arrays**
  - **Aerodynamics & Structures**
  - **Processes & Procedures**




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# Partners


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# Stakeholders

- **Primary**
  Orbital Space Plane (OSP) Program

- **Others**
  - Next Generation Launch Technology (NGLT) Program
  - National Aerospace Initiative (NAI)
  - Shuttle Service Life Extension Program



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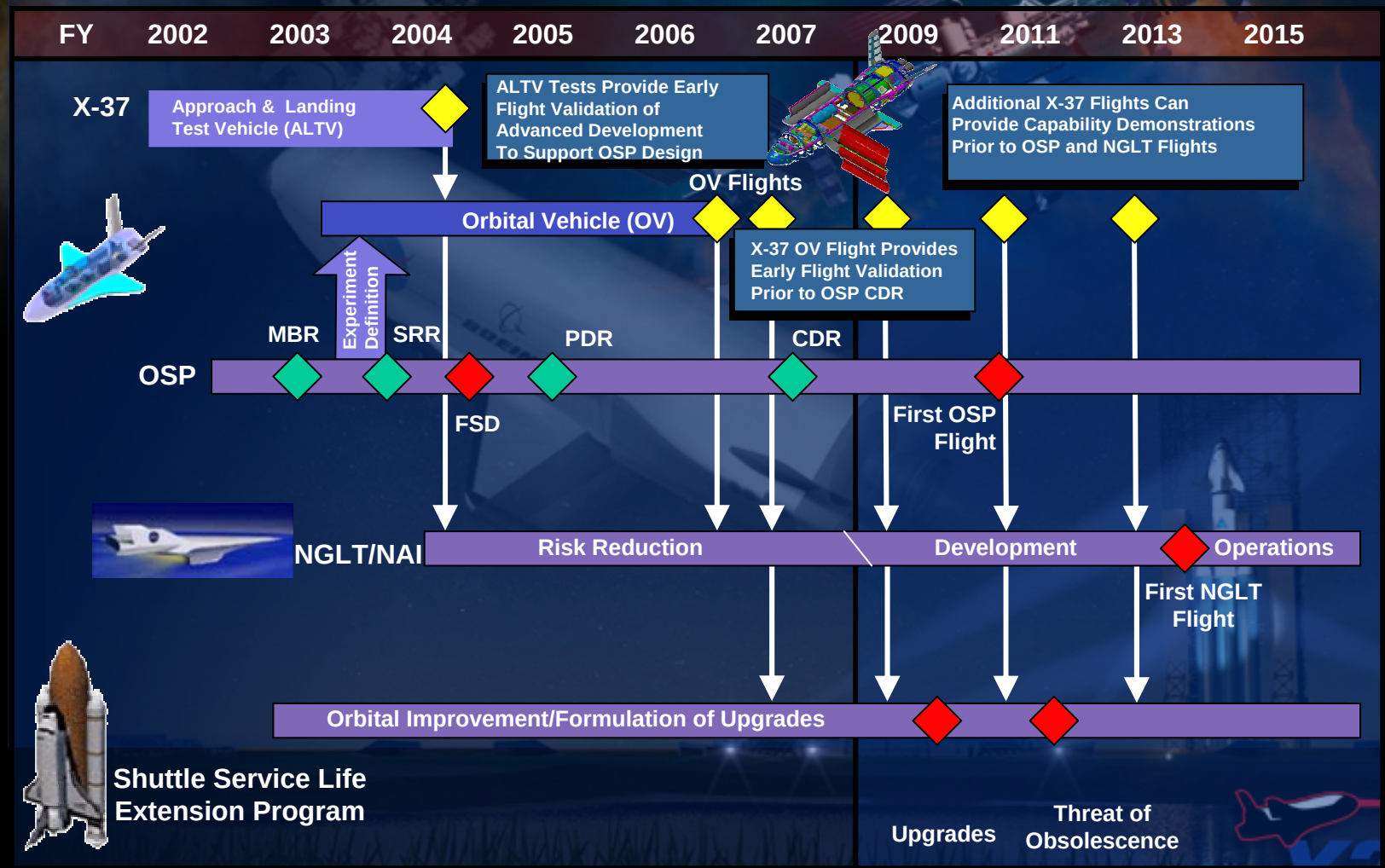
# Provides Capabilities for NASA & DoD Programs




MBR – Management Baseline Review

SRR – System Requirements Review

PDR – Preliminary Design Review

CDR – Critical Design Review

FSD – Full Scale Development



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# Phased Approach to Orbital Flight Demonstrations

**X-40A Completed 2001**

**Approach and Landing Test Vehicle Flies 2004**

**Orbital Vehicle Flies 2006**

Drop Tests


B-52 will carry ALTV up to 40,000 feet

Streamlined Ground Operations

On Orbit

EELV

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# How It All Started

- Cooperative Agreement, 1999
- Funding Shared between Contractor & Government
- The Boeing Company, NASA, and the U.S. Air Force
- NASA's Pathfinder-X Program:
  - X-33: Cancelled
  - X-34: Cancelled
  - X-37: On Track
- Better, Faster, Cheaper Model



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# Changing External Environment

- Mars Climate Orbiter Report released March 2000
- Shuttle manifesting policy changes secondary payload status Spring 2000
  - Space Station construction named top priority
  - Launch cost not in X-37 Budget
- Technical & Cost
- Re-competition for Funding
- Changes in NASA Management Philosophy & Approach
- Commercial & DoD Marketing  Dynamics



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# How It Struggled

- Space Launch Initiative (SLI) May 2001, NASA Research Announcement 8-30, Cycle 1
  - Boeing submitted proposal pending Air Force decision
    - Not Selected
  - Project continued under original Cooperative Agreement
    - Period of performance under Cooperative Agreement: July 1999 through March 2003
    - Project descoped to ALTV only



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# Ad Opportunity to Reduce Risks of Future Space Transportation Systems

- Space Launch Initiative 2002, NRA 8-30, Cycle 2
  - Funded $301M November 2002
- Goals & Objectives Made Relevant
  - Orbital Space Plane Program
  - Next Generation Launch Technology Program
  - National Aerospace Initiative
  - NASA Earth Sciences Enterprise



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# The Way Ahead: Major Milestones

- **X-40A Subscale Demonstrator (suborbital, 15,000 ft): Summer 2001**
  - Five successful flights that validated:
    - **Navigation sensors**
    - **Aerodynamics**
    - **Approach & Landing Guidance, Navigation, & Control**
    - **Streamlined Flight Operations Control Center**
  - Risk mitigation for X-37
- **Approach & Landing Test Vehicle (suborbital, 40,000 ft): 2004**
  - Five drop-tests planned from B-52
  - Precursor to orbital flight
  - Simulates orbital vehicle flight trajectories & landing patterns
- **Orbital Vehicle: 2006**
  - Carried on Expendable Launch Vehicle
  - Short duration mission (2-3 days) to validate flight capabilities in many areas
  - Long duration mission (270 days) for future science experiments & testbed activities



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# Recent Accomplishments

## Approach & Landing Test Vehicle

- June: Test Readiness Review for Airframe Structural Proof Test completed
- July: Airframe Structural Proof Testing completed

## Orbital Flight System

- June: Mission Concept Review and System Requirements Review completed
- July: System Definition Review in progress



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# X-37 ALTV Airframe Proof Test

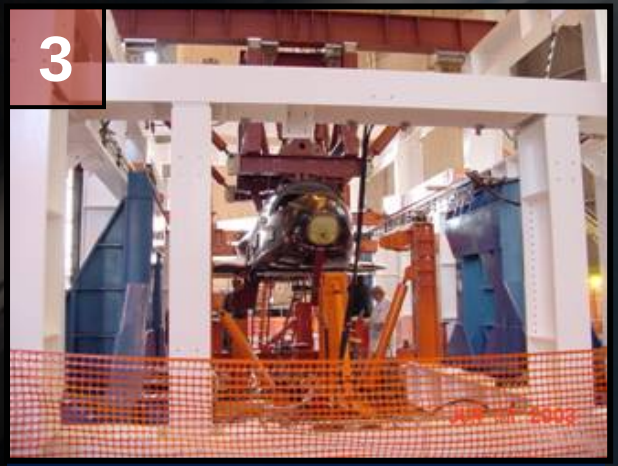
1

Ship from Palmdale to Huntington Beach

2

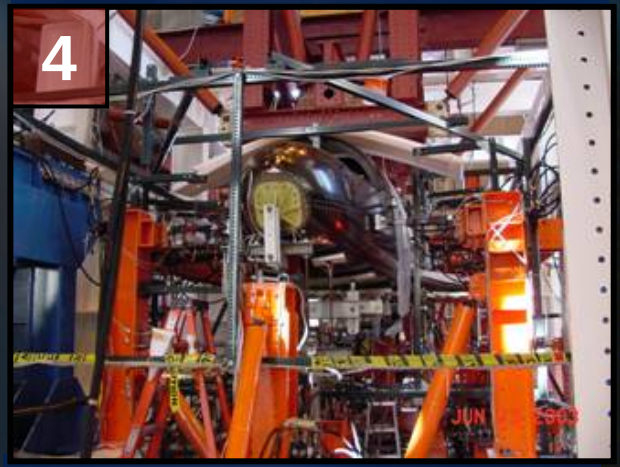
Attach Airframe to Dummy Pylon

3



Install Airframe into Test Fixture

4



Attach Actuators & Instrumentation

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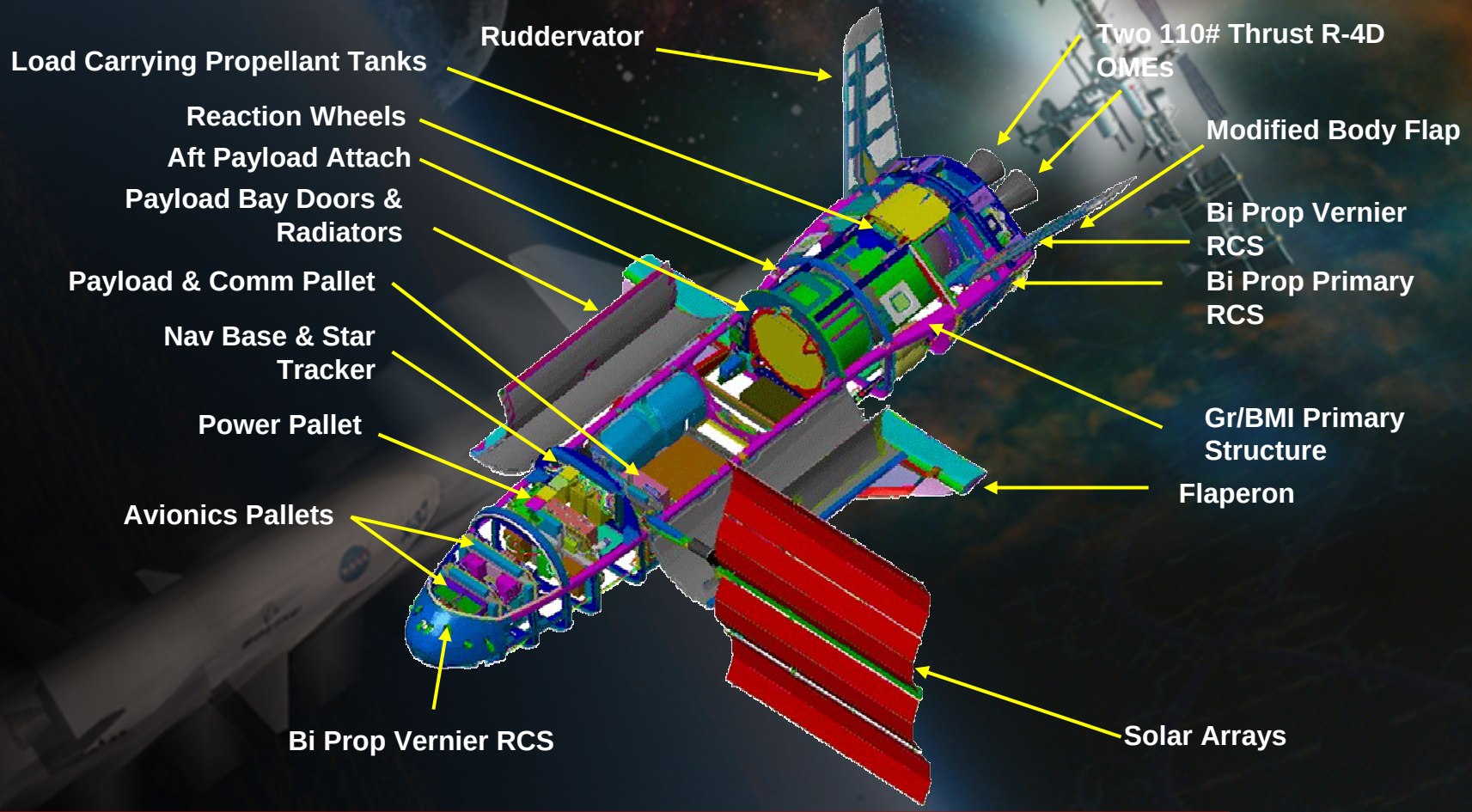
# X-37 Orbital Vehicle Configuration




**Much of X-37 OV will have Heritage Design from ALTV, Cooperative Agreement, & IRAD performed by the Boeing Company**



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# X-37
# Minimum Success Criteria

- **Flight Demonstration of an Integrated Thermal Protection System**
  Level 1 Requirement- *Shall provide maturation and validation of TPS within the confines of the X-37 re-entry heating environments*
  - Leading Edge > *2950 deg F*
  - Acreage TPS at *2400 deg F*
  - High Temp Gap Fillers and Seals to support Leading Edge (2950 deg F) and Acreage TPS (*2400 deg F)*
  - Durability/ Re-Usability of TPS better then existing Shuttle- *TPS Components are 10X more durable then current tile in windward high temperature environments. New TPS enable adverse weather flight conditions.*

- **Autonomous Re-entry and Landing**
  Level 1 Requirement- *Shall provide validation of automated approach and landing technologies.*
  - Fault tolerant ops- *Single Fault Tolerant*
  - Cross wind landing capability- *17 knots*
  - Calculated air data system accuracy- *AOA accuracy <1 deg, Dynamic Pressure > 5% and airspeed > 2%*
  - Landing Speed Capability > *200 knots*

- **Light-weight system**
  Level 1 Requirement- *The LDOV landing weight shall not exceed 7500 lbs including payload and residual propellants.*
  - Li-Ion batteries- *Charge cycles >6300, weight savings, MTBF >100,000 Hrs*
  - Gr/BMI Structure
  - Thin Hot Aero Surfaces
  - Lightweight Landing Gear

- **On-Orbit Stay Time up to 270 days**
  Level 1 Requirement- *Shall be capable of performing on-orbit missions with durations ranging from 2-270 days without on-orbit servicing.*
  - Minimum on orbit stay 2 days
  - Maximum on orbit stay 270 days

- **Demonstration of Low Cost Operations/Turnaround Capability**
  Level 1 requirement- *Shall be capable of performing ten missions within ten years with minimal subsystem maintenance and/or refurbishment, or replacement*
  - Low Cost Ops- Small Crew Flight Ops Center- *<11 personnel (ALTV-FOCC)*
  - Post Flight Turnaround- *90 Days*



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# ALTV & OV Technologies

**Flight Sciences**
T-22 High Enthalpy Flight Profile
T-39 Advanced Aero and Aerothermal Analysis

**Avionics/Software/Power**
T-12 Modular Open Architecture Avionics
T-19 Fault Tolerant Autonomous Ops
T-28 Small Crew FOCC
AFT-1 Solar Arrays
T-35 High-Energy/Density Batteries
T-36 Electrical Actuation for Aerosurfaces
T-37 Power Management and Distribution
T-38 Open Architecture Software

**Ground/Flight Operations**
T-21 Rapid TPS Waterproofing (Spray Coating)

**Structures**
T-6 High-Temp Gr/BMI Sandwich Structure
T-8 Thin, Hot Aerosurfaces
T-32 High Temp Gr/PETI-5 Structures

**GN&C**
T-13 Calculated Air Data System (CADS)
T-17 Windward Adaptive Guidance
T-26 Rapid Mission Data Loading
T-29 Crosswind Landing for Small RSVs

**Propulsion**
T-2 RCS

**Mechanical Systems**
T-10 Lightweight Landing Gear
T-31 Phase Change Brakes

**Thermal Systems**
T-3 High-Temp Windward TPS
T-4 High-Temp Upper/Side TPS
T-7 High-Temp Aerothermal Pressure /Seals
T-9 Loop Heat Pipe TCS
T-40 Durable, Low Conductivity/Density Tile
T-41 Durable Acreage Leeward Quilted Blankets
T-42 Durable Acreage Leeward Felted Blankets
T-43 Metallic TPS Experiment Panel
T-44 DurAFRSI TPS Experiment Panel
T-45 Failsafe Screening Surface TPS Test Panels
T-46 Ames Wing Leading Edge Tile

**Technologies Key:**

ALTV & OV

OV only



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# Summary

## The X-37 Project

- Generates data to mature critical technologies that enable future space transportation systems and conduct experiments in flight environments that are beyond the capability of existing platforms, thereby extending our Nation's reach in space.
- Provides an autonomous, reusable testbed for critical technologies and a platform for science payloads that will improve our understanding of life on Earth.
- Reduces the risk of developing new generations of safe, reliable, and affordable space transportation to inspire and empower a new generation of explorers.
- Revitalizes Our Nation's Capability to Build & Operate an Integrated Space Transportation System.



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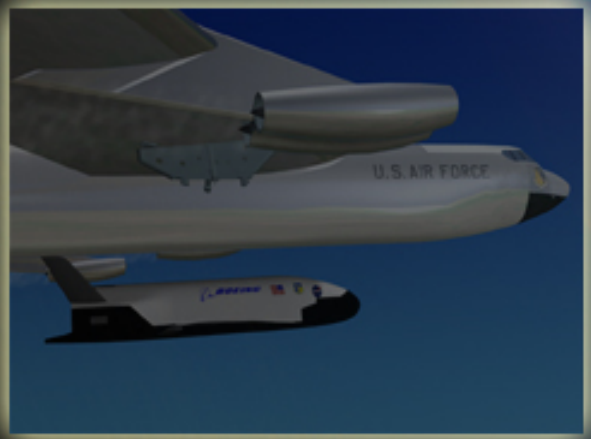
# X-37 Flight Demonstrator

*Technology Leadership for Space Transportation*




**For More Information**

WWW.OSPNews.com

WWW.NASA.gov

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