NASA’S INTEGRATED SPACE TRANSPORTATION PLAN

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Integrated Space Transportation Plan: A National Plan

Space Shuttle Safety Upgrades

Space Launch Initiative
- 2nd Generation RLV Risk Reduction
- NASA Unique Systems
- Alternate Access to the ISS

3rd Generation RLV and In-Space Research and Technology

NASA’s Long-Term Investment Strategy to Increase the Safety, Reliability and Reduce the Cost of Space Access
SLI Program Schedule

- Mid-Decade: Full-Scale Development Decision
- Early Next Decade: Initial Operational Capability

<table>
<thead>
<tr>
<th>Year</th>
<th>SLI Phase 1</th>
<th>SLI Phase 2</th>
</tr>
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<tbody>
<tr>
<td>FY01</td>
<td>$270 M</td>
<td></td>
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<tr>
<td>FY02</td>
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<td>FY03</td>
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<tr>
<td>FY04</td>
<td>$1,003 M</td>
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<tr>
<td>FY05</td>
<td>$1,056 M</td>
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<tr>
<td>FY06</td>
<td>$1,256 M</td>
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</tbody>
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- Initial Contracts: $900 M (including Options)
- Initial Arch/Tech Review (~15 Architectures)
- Realign Risk Reduction
- Cycle 2 Awards
- CTV/CRV Study
- Full Scale Development Decision
- IOC
- ~ Two Architectures and Advanced Development Tasks
- Architecture Systems Requirements Review
Technology Linked To Architecture Needs

- OMS/RCS
  - "Non-Toxic" Propellants
  - Propellant Management Devices
- Control System
  - Electro-Mechanical Actuators
- IVHM
  - Reliability enhancements resulting from IVHM implementation
- Electrical Power
  - Proton Exchange Membrane (PEM) Fuel Cells
  - High Voltage Dist.
  - APUs
- Jet Back Propulsion
  - Jet Back Engine Integration
- Landing Systems
  - Landing Gear – Tires & Brakes
  - ACC Nose Cap & Wing Leading Edges
  - Conformal Reusable Insulation (CRI)
  - Reusable Cryogenic Insulation
- TPS
- Main Engine Propulsion
  - Kerosene / LO2 Booster Engines
  - LH2 / LO2 Engines
- Structure
  - Propellant Tanks
  - Stage Attach & Thrust Structures
  - Composite Wings
- Avionics
  - Fault Tolerant Autonomous Avionics
  - Adaptive GNC
  - Fault Tolerant Autonomous Avionics
  - Adaptive GNC

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Air Breathing Hypersonics
Applications and Benefits

- Hypersonic Missiles
  - Near-Term
    - This Decade
  - Mid-Term
    - Next Decade
- Hypersonic Cruiser
  - Next Decade
- Reusable Launch Vehicles
  - Long-Term
    - Decade after Next
Large 3rd Generation RLV Design Space

- Over 30 concepts (primarily using airbreathing propulsion)
- Selected by aerospace community (NASA, DOD, Industry)
- Probabilistic systems analysis for key technologies

Horizontal Take-Off SSTO

Vertical Take-Off SSTO

Vertical Take-Off TSTO

Horizontal Take-Off TSTO
Representative Flight Corridors
Air Breathing Hypersonic Flight

![Diagram showing flight corridors for high-speed aircraft and missiles, with altitude on the y-axis and Mach number on the x-axis.](image)
Technologies and Systems Analysis

Propulsion Research and Technology Project
♦ Rotating Components and Seals
♦ Flowpath Components
♦ Engineering Capabilities

Pursing Enabling Propulsion and Airframe Technologies

Systems Analysis Project
♦ Requirements
♦ Synthesis
♦ Analysis and Assessment

Airframe Research and Technology Project
♦ Integrated Airframe Design
♦ Integrated Thermal Structures
♦ Thermal Protection
♦ Aerothermodynamics
♦ Propulsion Airframe Integration
Propulsion Ground Demonstrations

Rocket Based Combined Cycle Ground Demonstration (ISTAR)
- Demonstration of a Rocket Based Combined Cycle Engine System
- Testing in 2006-8
- Aerojet, Rocketdyne, P&W Consortium (RBC³)

Turbine Based Combined Cycle Ground Demonstration (RTA)
- Development and test of a High Speed Turbine Engine
- Primary element of a Turbine Based Combined Cycle Engine
- Testing in 2006-8
- General Electric selected in July, 2002

Pursing Parallel Paths
Propulsion Flight Demonstrations

X-43A Flight Demonstrator
- Flight validation of a Ma 7 and 10 Hydrogen Ram/Scramjet
- 2nd Flight in late 2003 (Ma 7)
- 3rd Flight TBD (Ma 10)
- Microcraft/Boeing Team

X-43C Flight Demonstrator
- Flight validation of the USAF HyTECH Hydrocarbon Ram/Scramjet (Ma 5 – 7)
- Integrated with vehicle
- Flights in 2007-8
- Contractor selection in mid-2003
Air Breathing Hypersonics
Access to Space Roadmap

Today
- X-43A
  - Ma 7
  - X-43C
  - Ma 5 to 7
  - X-43D
  - Ma 15

Propulsion
Ground Testbeds
- HC/H\textsubscript{2} Scramjet
- Turbine &
  Rocket Based
- Combined
  Cycle
- Ma 0.7-7
- Turbine &/or
  Rocket Based
- X-43B

Combined Cycle
Flight Demo(s)

Large Scale Reusable
Flight Demo

Airframe Testbeds

Supporting Component Research and Technology

Full Scale
Development

IOC

IOC
Propulsion R&T Project Objectives

♦ FY06 Data Products for Vision Propulsion Design
  • Technology and Design Advancement
  • Feasibility information

♦ Data that feeds FY06 Program Decision Gate(s)
  • Input for Build 2 definition for Ground Based Demonstrators
  • Identification of technology insertions to flight demonstrators
  • Information for update of program goals, requirements, and vision system design

♦ 06 Deliverables
  • Actively cooled panels characterization
  • Rotating component materials
  • High temperature seals
  • Instrumentation
Propulsion R&T Project Elements

- Component and capability advances
- Feasibility
- Decision gate products

Competitive sourcing
Project Overview

♦ **Airframe project goal**
  - Advance airframe technology providing reduced cost and increased safety through increased performance margin and reusability

♦ **Performance margin and reusability will be increased by focusing efforts on airframe technical challenges such as**
  - Composite tanks
  - Light weight control surfaces
  - Hot structures
  - TPS
  - Boundary layer transition
  - Transonics
  - Design and analysis tools
  - Sharp leading edges
  - Dynamic seals
  - Health monitoring

♦ **Customer driven objectives**
  - Increased weight margin
  - Increased combined loads margin
    - Thermal
    - Structural
    - Acoustic
    - Aero/aerothermo
  - Increased operational margin
Airframe Project Tasks

♦ Integrated Airframe Design
  • Airframe Health Monitoring
  • Analysis and Design Tools

♦ Integrated Thermal Structures and Materials
  • PMC Constituents and Processes
  • Metallic Hot Structures for Airframe
  • CMC Constituents and Processes
  • Integrated Airframe Structure Development

♦ Thermal Protection Systems
  • Ceramic Acreage TPS
  • Refractory Composite Leading Edges
  • Advanced Control Surface Seals

♦ Aerothermodynamics
  • Rapid Aerothermodynamic Environment Definition
  • Essential Aerothermodynamic Technologies

♦ Propulsion Airframe Integration
  • Scramjet Flowpath Development and Aero-Propulsive Interaction
  • Airframe/Propulsion Aerothermodynamic Technologies
Hypersonics University Research and Engineering Technology Institutes

♦ URETIs were awarded in August to University of Florida and University of Maryland consortiums

University of Florida
- Principal Investigator: Dr. Wei Shyy
- University Partners
  - Mississippi State University
  - Cornell University
  - Georgia Institute of Technology
  - Syracuse University
  - North Carolina A&T State University
  - Prairie View A&M University
- Propulsion Technologies
- Airframe Technologies
- Vehicle Life Prediction and Health Management
- Systems Integration & Design Optimization
- Educational Program Plan

University of Maryland
- Principal Investigator: Dr. Mark Lewis
- University Partners
  - University of Michigan
  - University of Washington
  - North Carolina A&T State University
  - Johns Hopkins University (APL):
- Mission Analysis
- Cost and Reliability Analysis
- Propulsion
- Aerodynamics/Configuration
- Structures and Materials
- Education Program Plan
The NASA/USAF

X-43C
**Propulsion System - Structural Architecture**
- Hot Seals for the Propulsion Flowpath
  - Static
  - Dynamic

**Airframe – Structural Architecture**
- Airframe and Control Surface Seals
  - Static
  - Dynamic