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>
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<tbody>
<tr>
<td>FY01</td>
<td>$270 M</td>
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<td>FY02</td>
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<td>FY03</td>
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<td>FY04</td>
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<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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NASA Decision Gates

- Initial Contracts
- $900 M (including Options)
- Cycle 2 Awards
- CTV/CRV Study
- Initial Arch/Tech Review (~15 Architectures) Realign Risk Reduction
- Architecture Systems Requirements Review
- Full Scale Development Decision
- ~ Two Architectures and Advanced Development Tasks
- IOC
Technology Linked To Architecture Needs

Structure
- Propellant Tanks
- Stage Attach & Thrust Structures
- Composite Wings

Avionics
- Fault Tolerant Autonomous Avionics
- Adaptive GN&C

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

TPS
- ACC Nose Cap & Wing Leading Edges
- Conformal Reusable Insulation (CRI)
- Reusable Cryogenic Insulation

OMS/RCS
- “Non-Toxic” Propellants
- Propellant Management Devices

IVHM
- Reliability enhancements resulting from IVHM implementation

Control System
- Electro-Mechanical Actuators

Main Engine Propulsion
- Kerosene / LO2 Booster Engines
- LH2 / LO2 Engines
Air Breathing Hypersonics
Applications and Benefits

Hypersonic Missiles

Near-Term
This Decade

Mid-Term
Next Decade

Hypersonic Cruiser

Krusner 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
Representative Flight Corridors

Air Breathing Hypersonic Flight

Altitude (1,000 ft)

Mach

Access To Space

To Orbit

High Speed Aircraft

Missiles
Technologies and Systems Analysis

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

Pursing Enabling Propulsion and Airframe Technologies

Airframe Research and Technology Project
- Integrated Airframe Design
- Integrated Thermal Structures
- Thermal Protection
- Aerothermodynamics
- Propulsion Airframe Integration

Systems Analysis Project
- Requirements
- Synthesis
- Analysis and Assessment
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)

Pursing Parallel Paths

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
**Propulsion Flight Demonstrations**

**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

**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

**Validation of A Key Element of Any Airbreathing Propulsion System**

**X-43C Flight Demonstrator**
Air Breathing Hypersonics
Access to Space Roadmap

**Today**
- X-43A
  - Ma 7
- X-43C
  - Ma 10

**2005**
- X-43C
  - Ma 5 to 7
- X-43D
  - Ma 15

**2010**
- X-43D
  - Ma 15

**2015**
- X-43B
  - Ma 0.7-7

**2020**
- HC/H₂ Scramjet
- Turbine & Rocket Based
- Combined Cycle

**2025**
- Full Scale Development

- Large Scale Reusable Flight Demo

**Supporting Component Research and Technology**
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
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