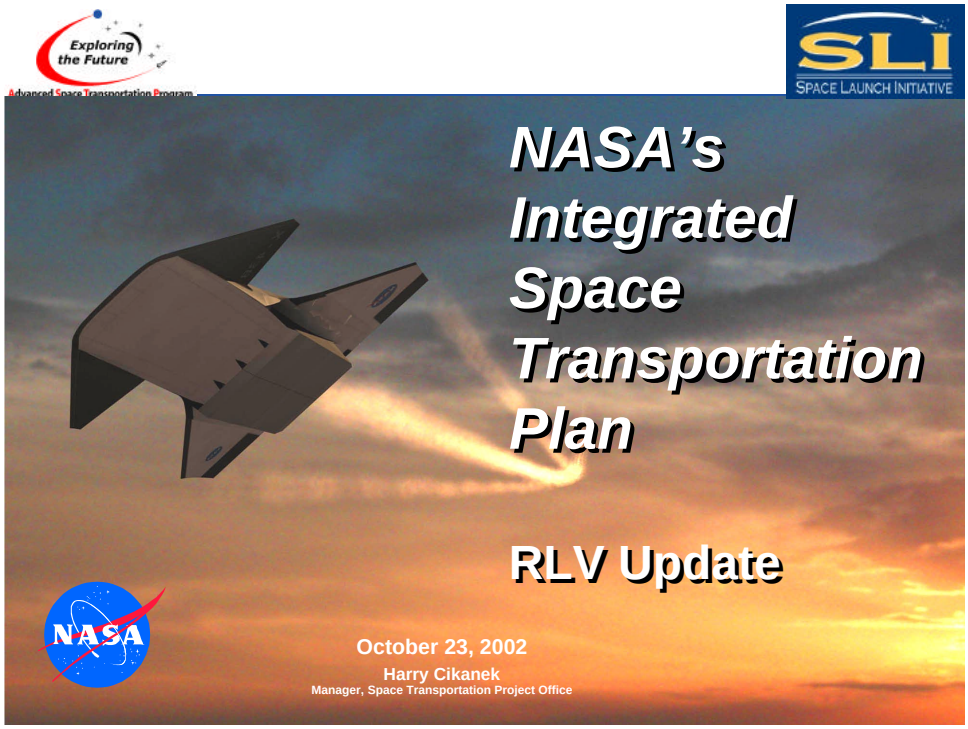
NASA'S INTEGRATED SPACE TRANSPORTATION PLAN

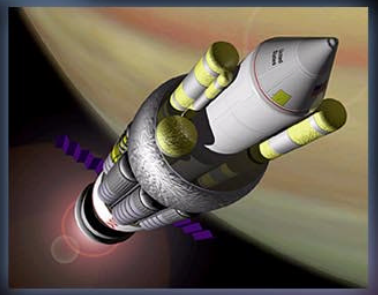
Harry Cikanek
National Aeronautics and Space Administration
Glenn Research Center
Cleveland, Ohio



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

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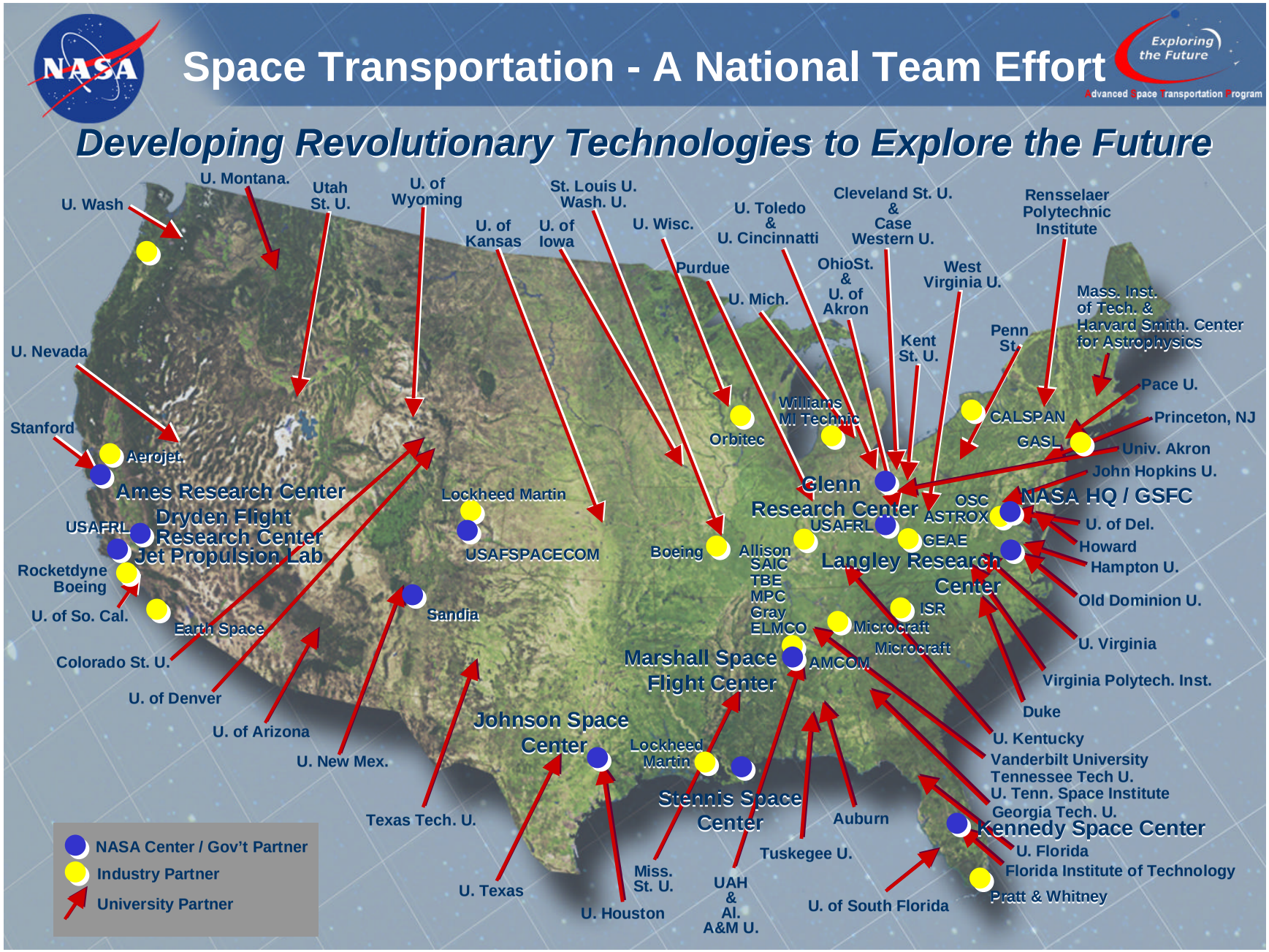
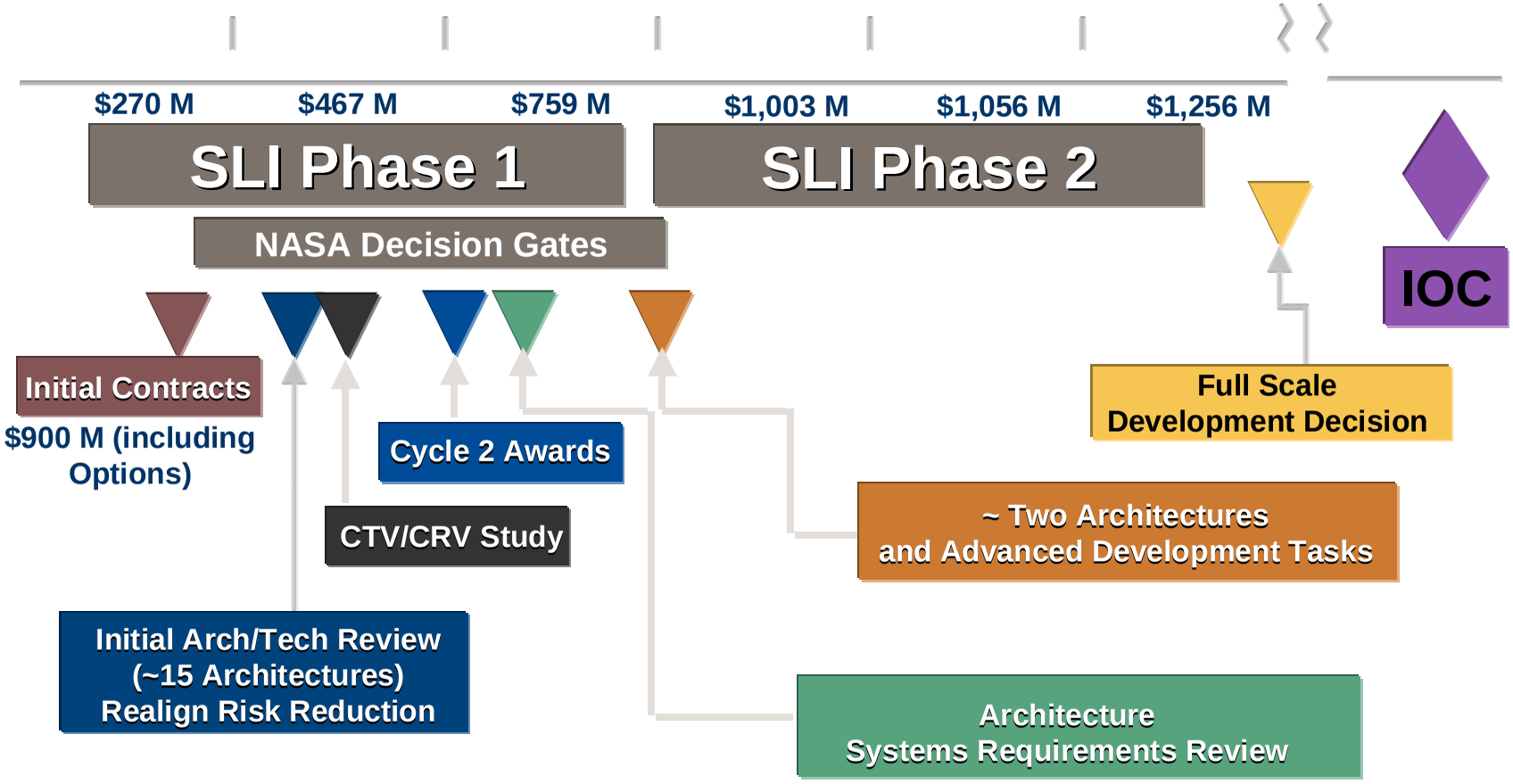

Space Transportation - A National Team Effort
Exploring the Future
Advanced Space Transportation Program
Developing Revolutionary Technologies to Explore the Future
U. Wash
U. Montana.
Utah St. U.
U. of Wyoming
St. Louis U.
Wash. U.
U. of Kansas
U. of Iowa
U. Wisc.
U. Toledo & U. Cincinnati
Cleveland St. U. & Case Western U.
Rensselaer Polytechnic Institute
Purdue
OhioSt. & U. of Akron
West Virginia U.
U. Mich.
Mass. Inst. of Tech. & Harvard Smith. Center for Astrophysics
U. Nevada
Penn St.
Kent St. U.
Pace U.
Stanford
Williams MI Technic
CALSPAN
Princeton, NJ
Orbitec
GASL
Univ. Akron
Aerojet
John Hopkins U.
Ames Research Center
Lockheed Martin
Glenn Research Center
OSC
NASA HQ / GSFC
Dryden Flight Research Center
USAFRL
ASTROX
U. of Del.
USAFRL
Jet Propulsion Lab
USAFSPACECOM
Boeing
Allison
GEAE
Howard
Rocketdyne
Boeing
SAIC
TBE
MPC
Gray
ELMCO
Langley Research Center
Hampton U.
U. of So. Cal.
Sandia
ISR
Old Dominion U.
Earth Space
Microcraft
Microcraft
U. Virginia
Colorado St. U.
Marshall Space Flight Center
AMCOM
Virginia Polytech. Inst.
U. of Denver
Duke
U. of Arizona
Johnson Space Center
U. Kentucky
Lockheed Martin
Vanderbilt University
U. New Mex.
Tennessee Tech U.
U. Tenn. Space Institute
Stennis Space Center
Georgia Tech. U.
Texas Tech. U.
Auburn
Kennedy Space Center
Tuskegee U.
U. Florida
Miss. St. U.
Florida Institute of Technology
U. Texas
UAH & Al. A&M U.
U. of South Florida
Pratt & Whitney
U. Houston
NASA Center / Gov't Partner
Industry Partner
University Partner

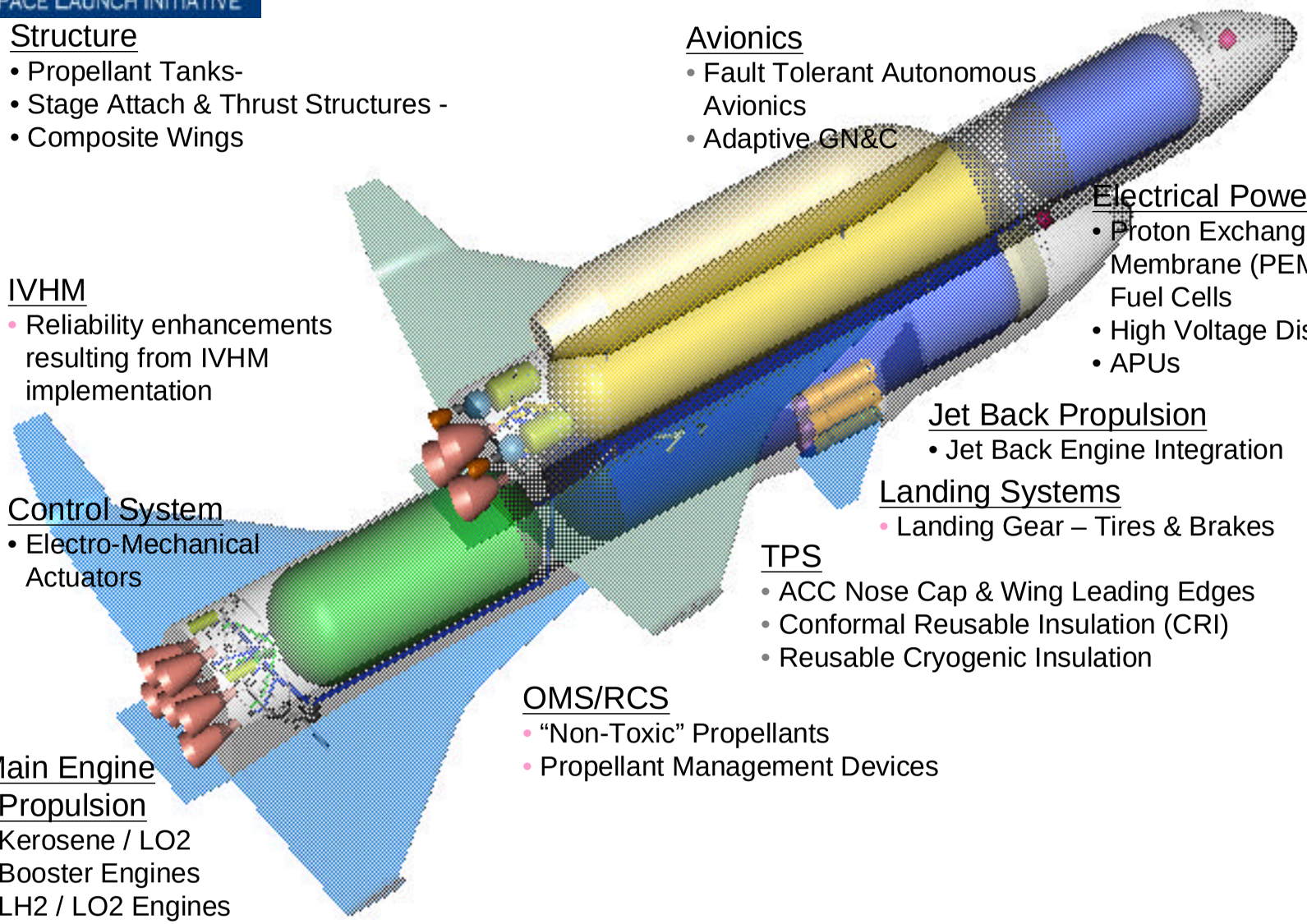
SLI Program Schedule

♦ **Mid-Decade: Full-Scale Development Decision**

• Early Next Decade: Initial Operational Capability



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

IVHM
- Reliability enhancements resulting from IVHM implementation

Jet Back Propulsion
- Jet Back Engine Integration

Landing Systems
- Landing Gear – Tires & Brakes

Control System
- Electro-Mechanical Actuators

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

OMS/RCS
- "Non-Toxic" Propellants
- Propellant Management Devices

Main Engine Propulsion
- Kerosene / LO2 Booster Engines
- LH2 / LO2 Engines

Exploring the Future
Advanced Space Transportation Program

Air Breathing Hypersonics
Applications and Benefits

Reusable Launch Vehicles

Long-Term
Decade after Next

Hypersonic Cruiser

Mid-Term
Next Decade

Hypersonic Missiles

Near-Term
This Decade

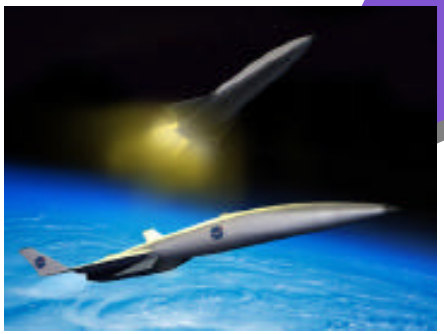
Exploring the Future
Advanced Space Transportation Program

Large 3rd Generation RLV Design Space

Horizontal Take-Off SSTO

Vertical Take-Off SSTO

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



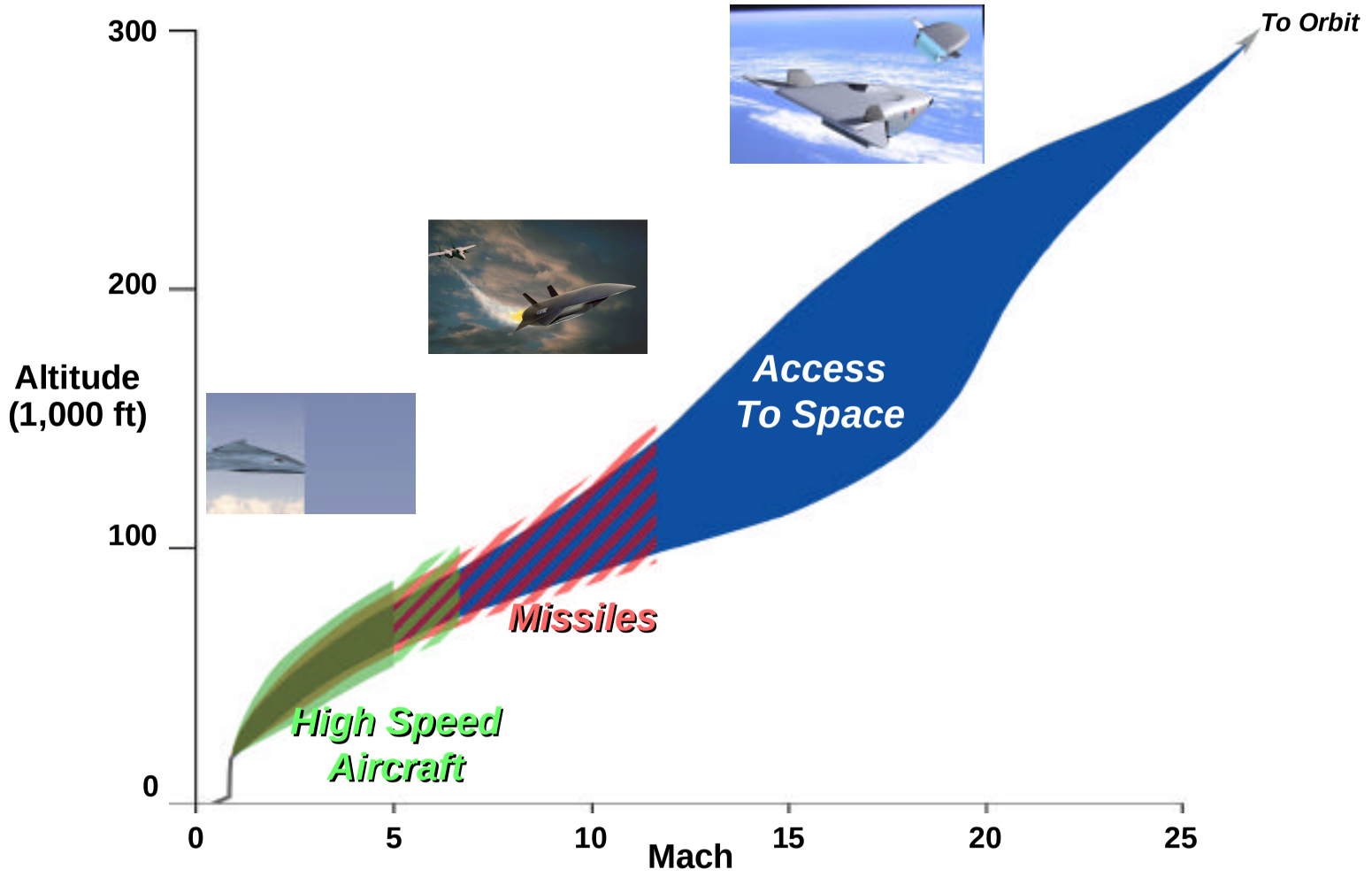
Horizontal Take-Off TSTO

Vertical Take-Off TSTO

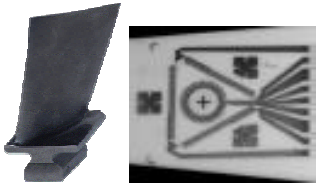
Exploring the Future
Advanced Space Transportation Program

Representative Flight Corridors

Air Breathing Hypersonic Flight



Technologies and Systems Analysis



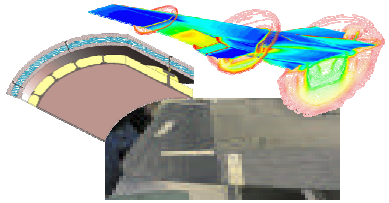
Propulsion Research and Technology Project

- Rotating Components and Seals
- Flowpath Components
- Engineering Capabilities

Systems Analysis Project

- Requirements
- Synthesis
- Analysis and Assessment

Pursing Enabling Propulsion and Airframe Technologies



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 (RBC^3)

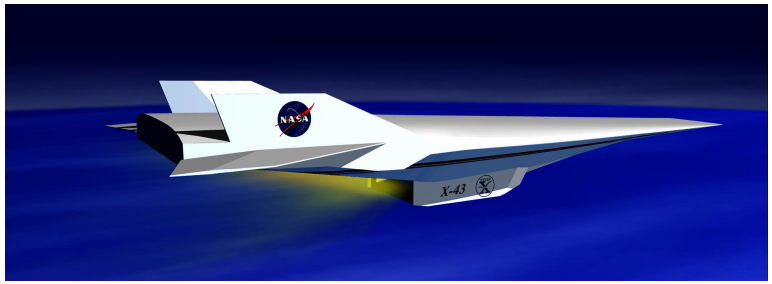
Pursing Parallel Paths

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

Exploring the Future
Advanced Space Transportation Program

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

Validation of A Key Element of Any Airbreathing Propulsion System

X-43C Flight Demonstrator

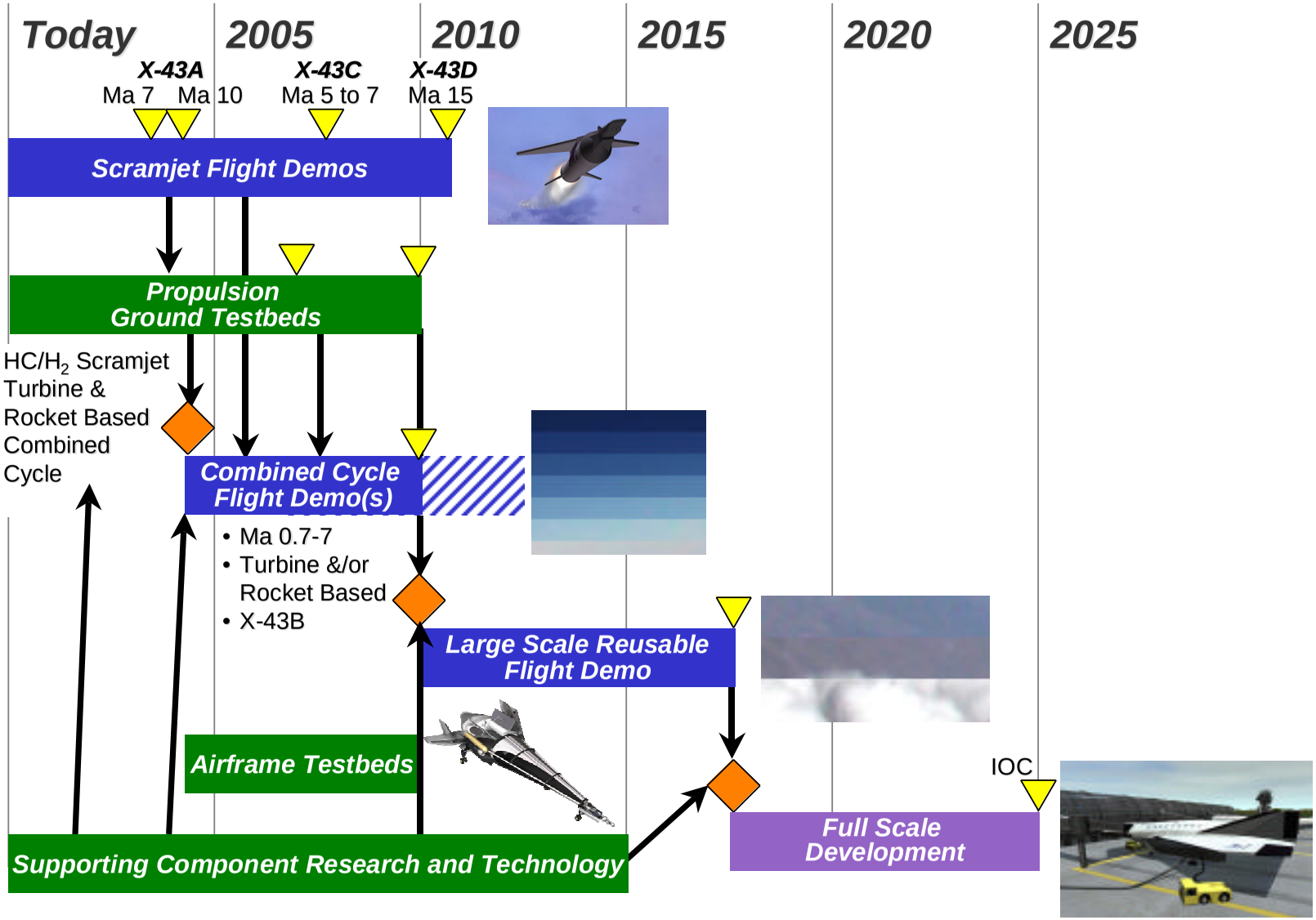
- Flight validation of the USAF HyTECH Hydrocarbon Ram/Scramjet (Ma 5 – 7)
- Integrated with vehicle
- Flights in 2007-8
- Contractor selection in mid-2003

Exploring the Future

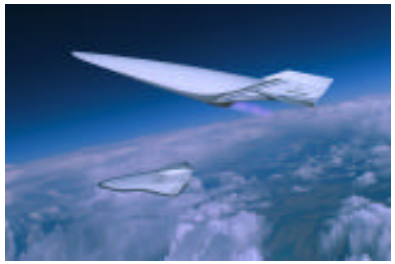
Advanced Space Transportation Program

Air Breathing Hypersonics

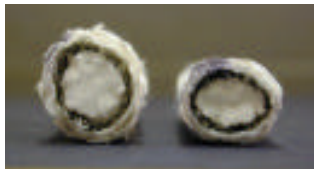
Access to Space Roadmap

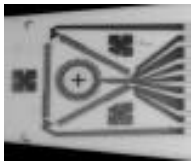


Propulsion R&T Project Objectives

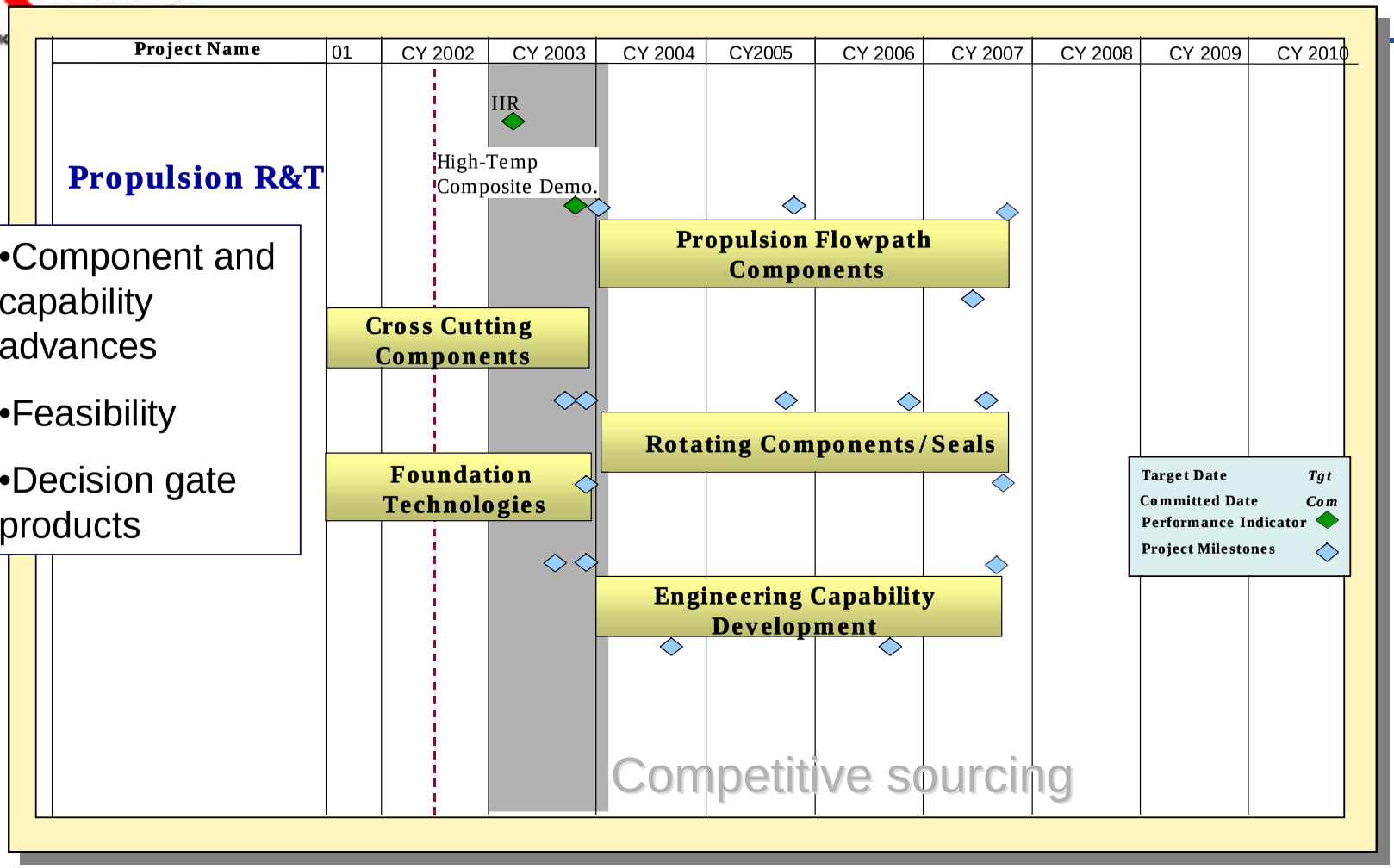


- **FY06 Data Products for Vision Propulsion Design**
  - Technology and Design Advancement
  - Feasibility information
- **Data that feeds FY06 Program Decision Gate(s)**
  - Input for Build 2 definition for Ground Based Demonstrators
  - Identification of technology insertions to flight demonstrators
  - Information for update of program goals, requirements, and vision system design
- **06 Deliverables**
  - Actively cooled panels characterization
  - Rotating component materials
  - High temperature seals
  - Instrumentation





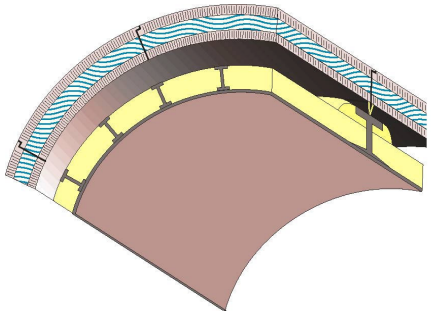
Propulsion R&T Project Elements



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

Seal WBS Linkages

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

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