AERONAUTICS
research mission directorate

Dr. J. Victor Lebacqz
Associate Administrator

Exploration Conference
January 31, 2005

President's Vision for U.S. Space Exploration

- **On January 14, 2004, the President announced a new space exploration vision for NASA**
  - Implement a sustained and affordable human and robotic program to explore the solar system and beyond;
  - Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;
  - Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and
  - Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

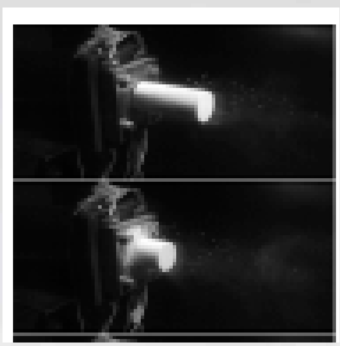
- Support Return to Flight
- **Complete and Demonstrate X-43A**
- **Continue Risk Reduction for Mars Airplane**

Return to Flight Support

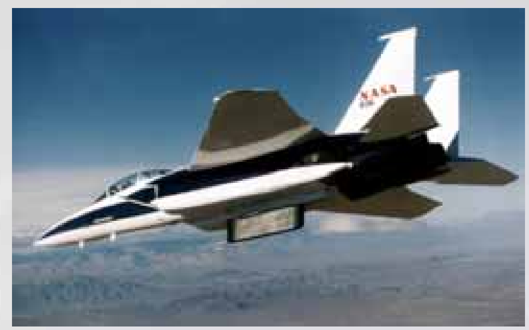
Plug development for on-orbit RCC repair led by Langley

Shuttle 3% model tested in the Ames 9X7 supersonic wind tunnel

Space Shuttle Program



Foam impact testing in Glenn Ballistic Impact Facility

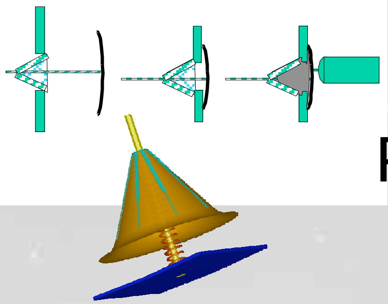


ET foam flight testing Dryden Aerodynamic Flight Test Fixture on F-15B aircraft

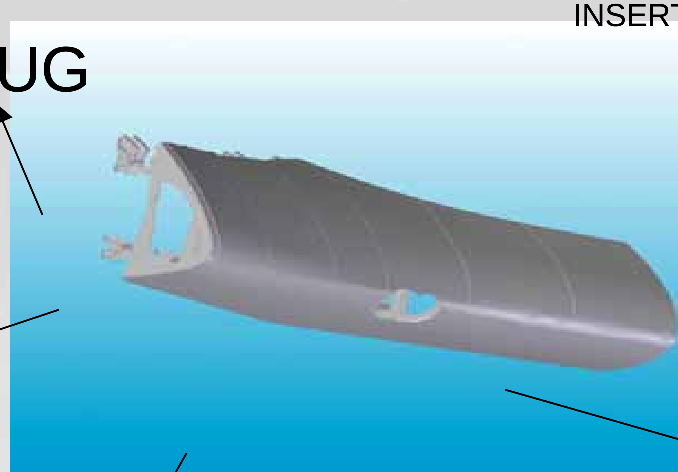
Return to Flight Support (Example)

Shuttle Wing Leading Edge Reinforced CarbonCarbon (RCC) Panel Damage and Proposed Repairs

STEP 1 INSERT | STEP 2 UNFOLD | STEP 3 FILL



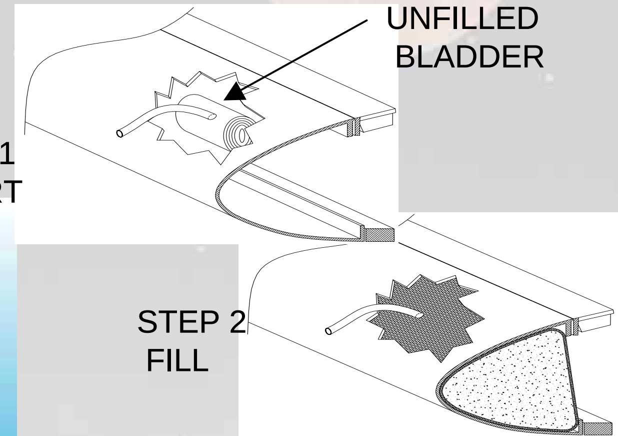
PLUG



STEP 1 INSERT

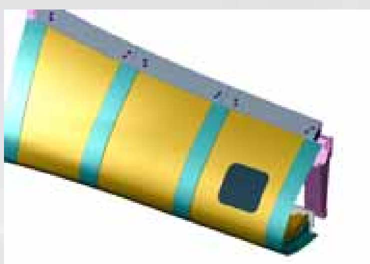
UNFILLED BLADDER

STEP 2 FILL



FILL

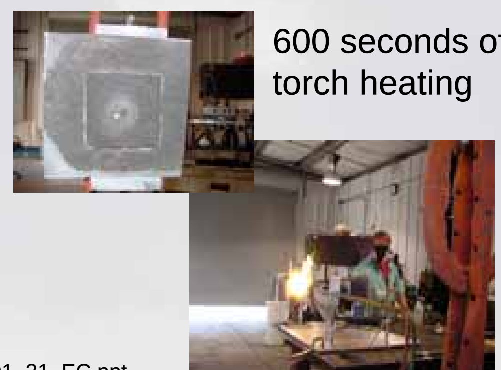
ADHESIVE PATCH



OVERWRAP

TESTING

600 seconds of torch heating



Arc Jet Simulated Shuttle Re-entry

- **Support Return to Flight**
- **Complete and Demonstrate X-43A**
- **Continue Risk Reduction for Mars Airplane**

NASA Aeronautics Research Mission Directorate X-43 Program

Goals: Demonstrate, validate and advance the technology (experimental techniques, computational methods, design tools, and performance predictions) for hypersonic aircraft powered by an airframe-integrated, scramjet engine

"One-NASA" Team

- 1997-2004

- $235M

Technical Objectives:

- Vehicle design & risk reduction

- Flight validation of design methods

- Design method enhancement

X-43A Flight
November 16, 2004

Hyper-X (X-43A) World Record Flights

- **Support Return to Flight**
- **Complete and Demonstrate X-43A**
- **Continue Risk Reduction for Mars Airplane**

Mars Airplane

Mars Flyer Challenges

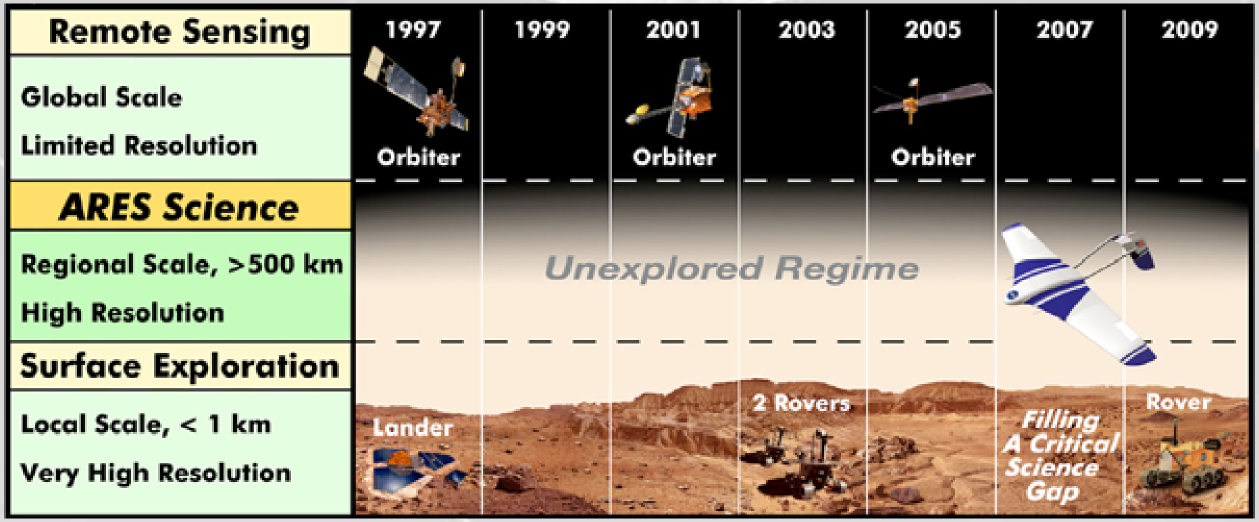
- **Transit to Mars**
  - Launch and entry vehicles place strict geometric constraints on airplane
  - Flyer in a dormant, stored configuration for long period of time
  - Additional thermal, acceleration, and radiation considerations
  - Transition from ballistic entry capsule to flying airplane
- **Flight Environment**
  - Atmospheric density 1/100th of Earth sea level – low dynamic pressure, low Reynolds number, low freestream mass flow
  - Lack of O_2 leads to inefficient non-air-breathing propulsion
  - Lower speed of sound - compressibility effects at lower flight speeds
  - 100°F colder than Earth
- **Guidance, Navigation, and Control**
  - Autonomous flight required – round trip communication time 15-35 minutes
  - No GPS, no global magnetic field – where am I? where am I going?
  - Considerable uncertainty in environment (e.g. winds, local topography)

Mars Airplane


The Wright brothers took humankind to our sky,
We will take humankind to the skies of other worlds.

Backup

Established Science Potential



- **ARES reached the "final four" in 2007 Mars Scout competition, with proposed science receiving "Category 1" rating**
- **Science potential of aerial platforms now widely acknowledged**
  - Possible to obtain simultaneous, in-situ measurements of the Mars atmosphere, surface, and interior
  - Bridges the scale and resolution measurement gaps between orbiters and landers/rovers
  - Possible to survey scientifically compelling terrain inaccessible from surface

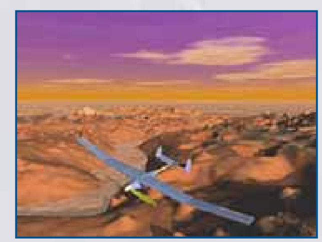
Exploration Aerial Vehicle Technologies

- **Mass and Volumetric Efficient Power & Propulsion Systems**
  - SOA: Propulsion and power systems demonstrated by the Helios (ERAST) flight research program
  - Goal: Compact, efficient propulsion and power systems with high specific power output to enable multi-day endurance and/or multi flight missions

- **Validated Design Tools for Unique Environments & Missions**
  - SOA: Non-integrated tools and labor intensive procedures customized for the specific mission/concept of interest
  - Goal: Integrated suite of generic design and simulation tools enabling full exploration of the EAV concept and mission design space

- **Deployment and Aero-entry Techniques**
  - SOA: Mid-air deployment of rigid 3-fold configuration
  - Goal: 3σ reliable deployment systems enabling enhanced mission performance

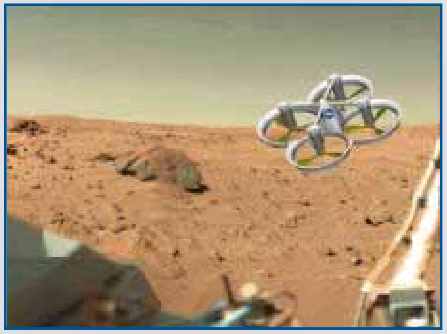
- **Advanced Airframes for Extreme Environments**
  - SOA: ARES concept
  - Goal: More aerodynamically efficient and/or lower mass airframe concepts to enhance mission performance



Exploration Aerial Vehicle Technologies

- **Precise Navigation and Control (including feature targeting and recognition)**
  - SOA: Simple Pre-Programmed flight paths
  - Goal: Fully autonomous flights with cognitive feature targeting and science-based flight path decisions

- **Flight Subsystem Miniaturization**
  - SOA: Discrete cPCI class boards: FCC, INS, GPS, and Comm
  - Goal: Integrated single-board MEMS-class flight systems

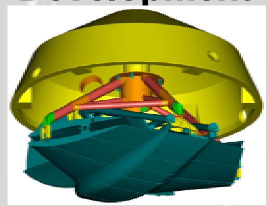


- **Robotic Aerial Exploration with Autonomous Launch and Recovery**
  - SOA: Single vehicle sortie with pre-programmed flight path
  - Goal: Multiple sorties and asset coordination including launch and recovery

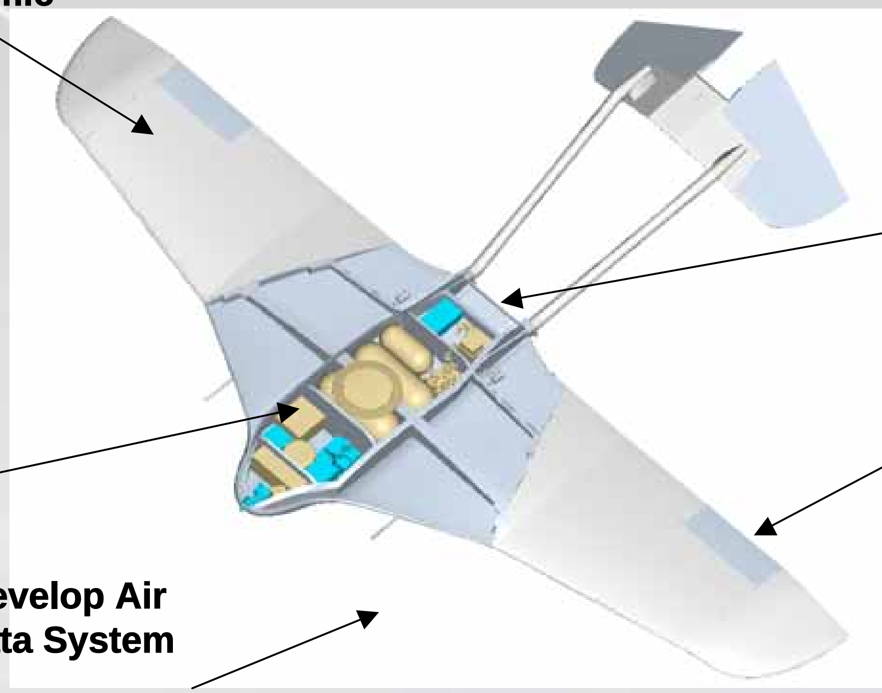
AERONAUTICS research mission directorate

Continued Maturation Planned

Extraction Development

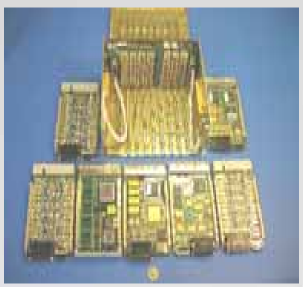


Characterize aerodynamic performance



Drogue Chute Development

Qualify Propulsion Subsystem



Develop Flight Control System

Qualify Control Surface Actuators

Develop Air Data System

Develop Tools & Simulations: 6-DoF FCS Sim.; 6-DoF GN&C Sim.; Multi-Body Dynamics Sim. For Extraction & Unfolding; CFD Models; 6-DoF Entry Sim.;

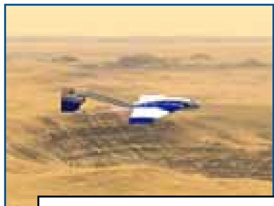
1999: Mars Airplane Micromission Project – *building expertise*

2002-2008: ARES Concept Maturation – *an initial capability*

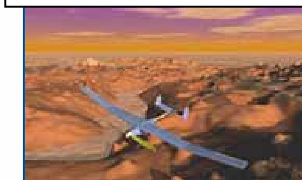
2006-2010: Exploration Aerial Vehicle (EAV) Technologies – *investing in the next generation capability*

Uncrewed Air Vehicles for Science and Exploration

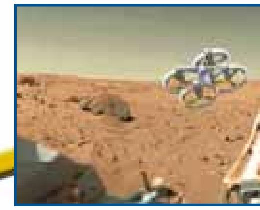
Planetary Exploration



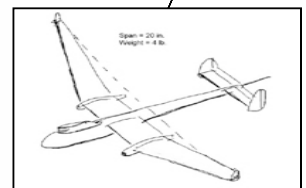
- Endurance: 1-2 hours
- Payload: 20-lb
- Pre-Programmed Flight Path



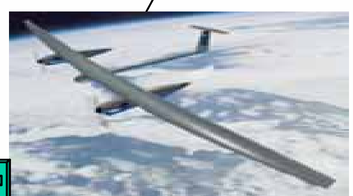
- Endurance: 8-10 hours
- Payload: 50-100-lb
- Feature targeting via terrain recognition



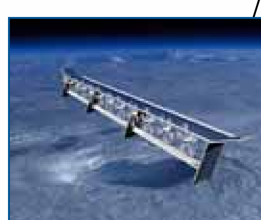
- Endurance: Multi-day
- Fully autonomous, sentient ops
- Surface interaction via deployed sensors and/or VTOL operations



Current SOA:
- 60K ft @ 14 hrs - 200-lb
- 100K ft @ 1 hrs - 100-lb
- Pre-Programmed



HALE-ROA Capability Set
- 14 days @ 60-70K ft
- 400-lb Payload
- Autonomous Operations



10-Year Capability Set
- 30+ days @ 60K ft
- 300-lb Payload
- Autonomous Operations
- Collaborative Engagement

Full Capability Set
- Global range
- 10x P/L increase @ 75K ft
- Autonomous Operations

Earth Science

Required Technologies @ TRL 6

FY04 FY09 FY14 FY19