Space Exploration Via Technology Demonstration and Small Satellite Missions Flown on Reusable Launch Vehicles

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Debra Facktor Lepore
Director of Marketing
# New Space Exploration Vision

**Presents Opportunities**

## Goals & Objectives

- Implement a sustained and affordable human and robotic program to explore the solar system and beyond
- Extend human presence across the solar system
- Develop innovative technologies, knowledge, and infrastructures; and
- Promote international and commercial participation in exploration

## Exploration Mission Examples

- Space weather station
- Solar observatory
- Earth observatory
- Lunar and Mars resource mapping
- Lunar and Mars positioning satellites
- In-space communications relays
- Logistics support

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Technology Demonstration, Small Satellites and Robotic Missions will Play a Key Role

*Mosaic of the near side of the Moon*
### Small Satellites Have Contributed to Exploration

**The Future Is Reusable Aerospace Vehicles**

<table>
<thead>
<tr>
<th>Mission Name</th>
<th>Launch Date</th>
<th>Nation</th>
<th>Mission Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giotto</td>
<td>1985</td>
<td>ESA</td>
<td>Study Comet P/Halley</td>
</tr>
<tr>
<td>Pegasus</td>
<td>1990</td>
<td>US</td>
<td>Chemical release experiment</td>
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<tr>
<td>Ulysses</td>
<td>1990</td>
<td>US/ESA</td>
<td>Fly over the poles of the sun</td>
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<tr>
<td>Hiten/Muses-A</td>
<td>1990</td>
<td>Japan</td>
<td>Lunar swingby techniques, ejected lunar orbiter</td>
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<tr>
<td>Solar</td>
<td>1991</td>
<td>Japan</td>
<td>X-ray imaging of sun</td>
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<tr>
<td>MSTI</td>
<td>1992</td>
<td>US</td>
<td>Test Miniature Seeker Technology</td>
</tr>
<tr>
<td>Clementine</td>
<td>1994</td>
<td>US</td>
<td>Sensor technology demo; map lunar surface</td>
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<tr>
<td>MSTI-2</td>
<td>1994</td>
<td>US</td>
<td>Investigate spaceflight techniques and technologies</td>
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<tr>
<td>Mars Pathfinder</td>
<td>1996</td>
<td>US</td>
<td>Mars lander with surface rover</td>
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<tr>
<td>MSTI-3</td>
<td>1996</td>
<td>US</td>
<td>Sensor technology tests</td>
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<tr>
<td>NEAR</td>
<td>1996</td>
<td>US</td>
<td>Rendezvous with and orbit asteroid Eros</td>
</tr>
<tr>
<td>ACE</td>
<td>1997</td>
<td>US</td>
<td>Determine composition of interplanetary matter</td>
</tr>
<tr>
<td>Deep Space 1</td>
<td>1998</td>
<td>US</td>
<td>To flyby asteroid and cometary targets</td>
</tr>
<tr>
<td>Lunar Prospector</td>
<td>1998</td>
<td>US</td>
<td>Determine origin, evolution, and state of lunar resources</td>
</tr>
<tr>
<td>Mars Climate Orbiter</td>
<td>1998</td>
<td>US</td>
<td>Mapping and weather studies of Mars</td>
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<tr>
<td>TRACE</td>
<td>1998</td>
<td>US</td>
<td>Ultraviolet imaging telescope for studies of the sun</td>
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<tr>
<td>Noxon/Planet-B</td>
<td>1998</td>
<td>Japan</td>
<td>Test spacecraft technology, study Mars atmosphere</td>
</tr>
<tr>
<td>Mars Polar Lander</td>
<td>1999</td>
<td>US</td>
<td>Study Martian volatiles and climate history</td>
</tr>
<tr>
<td>Stardust</td>
<td>1999</td>
<td>US</td>
<td>Fly near comet and recover and return cometary material</td>
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<tr>
<td>Simplesat</td>
<td>2001</td>
<td>US</td>
<td>Test methods for building cheap astronomical satellites</td>
</tr>
<tr>
<td>TIMED</td>
<td>2001</td>
<td>US</td>
<td>Study the thermosphere mesosphere and lower ionosphere</td>
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<tr>
<td>Odin</td>
<td>2001</td>
<td>Sweden</td>
<td>Study galactic molecular clouds</td>
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<tr>
<td>CONTOUR</td>
<td>2002</td>
<td>US</td>
<td>Explore three comets</td>
</tr>
<tr>
<td>HESSI</td>
<td>2002</td>
<td>US</td>
<td>Imaging hard X-ray flares form the sun</td>
</tr>
<tr>
<td>Galex</td>
<td>2003</td>
<td>US</td>
<td>Observe galaxies ultraviolet wavelengths</td>
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<tr>
<td>MER-A</td>
<td>2003</td>
<td>US</td>
<td>Search, characterize rocks and soils on Mars</td>
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<td>US</td>
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<tr>
<td>SIRTF</td>
<td>2003</td>
<td>US</td>
<td>Observatory for infrared astronomy</td>
</tr>
<tr>
<td>Hayabusa/MUSES-C</td>
<td>2003</td>
<td>Japan</td>
<td>Technology demo, collect, return sample from asteroid</td>
</tr>
</tbody>
</table>

**Mars Pathfinder**

**Mars Polar Lander**

**HESSI Satellite**

**Galex Satellite**
K-1 Fully Reusable Vehicle Overview

- K-1 vehicle can accommodate Exploration Missions
  - Deliver payloads to space
  - Return payloads from space
  - Test technology, instruments, and experiments
  - Re-use hardware for repeat flights

- K-1 offers wide range of performance for dedicated or rideshare missions
  - LEO satellites
  - Technology demonstrations
  - Interplanetary missions
  - International Space Station
K-1 LEO Satellite Delivery

- 12,500 lbs to LEO (due east)
- Dedicated or rideshare of multiple small satellites
- Up to 3 minisatellites (< 500 kg each)
- Up to 8 microsatellites (< 125 kg each) plus primary payload
K-1 as Technology Testbed

- Test technology experiments in full flight environment
- Variety of experiment locations
- Standard experiment interfaces and integration approach
- Reusability enables experiment recovery and repeat flights

Experiment Containment Box (ECOBOX)

Externally Mounted (Passive) for TPS and Advanced Materials

Internally Mounted (Active) for Avionics and Microgravity
The Future Is Reusable Aerospace Vehicles

Space Exploration: Moon/Mars & Beyond

• Use K-1 expendable active dispenser
  – Preliminary design complete

• Well suited for small Lunar and Mars missions

• 3,500 lbs to GTO

• 2,000 to 3,000 lbs to interplanetary targets

Example is Mars Exploration Rover
K-1 ISS Missions: Cargo Resupply and Return

- 3200 kg cargo delivered
- 900 kg cargo recovered
- 30 m$^3$ of cargo volume
- Up to 40 km reboost
- Berth to U.S. node

K-1 Inherent Reusability Gives the U.S. Another Capability to Recover Cargo
K-1 Program Overview

- K-1 vehicle 1 is ready for integration and launch
  - 75% hardware, 85% design, 100% Guidance Navigation & Control (GN&C) software complete
  - System requirements tasks completed
  - Numerous tests conducted

- Over $600 million in private capital invested
  - In process of finalizing plan of reorganization

- Existing technologies, hardware on hand, testing status, and the experienced K-1 team assures the accomplishment of the K-1 mission
K-1 Vehicle Fabrication 75% Complete

The Future Is Reusable Aerospace Vehicles

Systems Engineering
- Design Specifications Complete
- Design Data Books Complete
- Aerodynamics, Loads, Thermal
- Design Reference Missions Complete
- Electrical Database Complete
- Vehicle Integrated Schematics Complete
- Wiring and Small Plumbing Line Drawings Complete

Vehicle Exterior Structure
- 21 of 23 Major Panels Complete

Parachutes
- Engineering 90% Complete
- Mains – Complete
- Drogue – Complete
- Stabilization – 95% Complete
- Mortar – Complete
- Drop Tests - Complete

LOX Retention Tank
- 100% Design Completed
- 75% Fabrication Complete

LAP LOX Tank
- 100% Complete

LAP RP Tank
- 100% Design Completed
- 30% Fabrication Complete

OG LOX Tank
- 100% Complete

OV RP Tank
- 100% Design Complete
- 35% Fabrication Complete

Avionics Hardware
- Vehicle Computer - Delivered
- GPS/INS Units - Delivered
- TDRSS Receiver - Off the Shelf
- FAA Transponder Delivered
- SMU - In Manufacturing
- PDU, MEC - In Test

Avionics Software
- GN&C Complete
- Hardware in the Loop (HWIL) With Flight
  Hardware/Software Testing

Final Assembly
- Commenced 5/98
- 1st Stage LOX Tank
  Delivered 6/98

NK-33 Engines
- 37 Engines at Aerojet
- Verification Engine in Test

NK-43 Engine
- 9 Engines at Aerojet

OMS Engine
- 40 Igniter Tests Complete
- 29 Injector Tests Complete

Airbags
- OV Fabrication 50% Complete
- LAP Fabrication 50% Complete
- ½ Scale Drop Tests Complete
- Airbag Inflation Tests Complete

Payload Module
- 100% Structural Design Complete
- 25% Fabrication Complete

Australia Launch Site
- Contract Executed for Site Design and
  Construction
- Launch Site Design 100% Complete
- Environmental Approval Received
- Launch Operation Contract Signed
- Native Title Agreement Signed
- Site Ground Breaking
- Export License Approved

Thermal Protection System (TPS)
- Overall Design Complete
- Detailed Design – 30%
- Arc Jet Testing Planned
- Production at Restart

September 2003
### K-1 VEHICLE PAYLOAD USER’S GUIDE

May 2001

With Active Dispenser Addendum

May 2002

### K-1 VEHICLE TA-10 FLIGHT EXPERIMENT DESIGN AND REQUIREMENTS DOCUMENT

December 2002

Includes:
- Interface Definition & Requirements Document
- Preliminary Questionnaire
- Detailed Experiment Questionnaire

Available at [www.kistleraerospace.com](http://www.kistleraerospace.com)
Kistler is Available to Support Exploration Missions

Contact: Debra Facktor Lepore
Director of Marketing
dflepore@kistleraero.com

3760 Carillon Point, Kirkland, WA 98033
Telephone = 425-889-2001 / Facsimile = 425-803-3303

Website = http://www.kistleraerospace.com