Final

NEW MILLENNIUM PROGRAM

Directions in Space Flight Technology Validation

David T. Spencer

Jet Propulsion Laboratory, California Institute of Technology

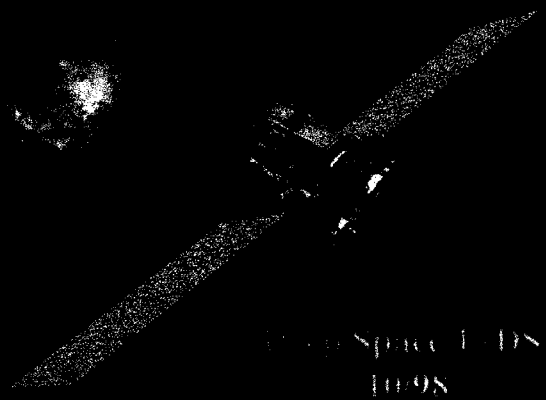
RideShare 2000 Conference

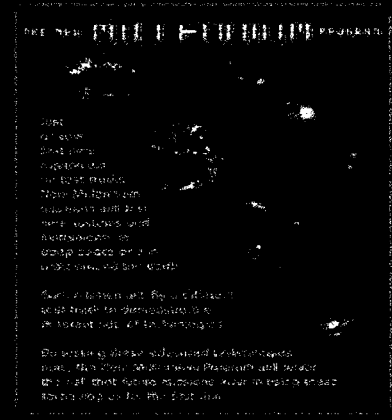
April 14, 2000

Goddard Space Flight Center

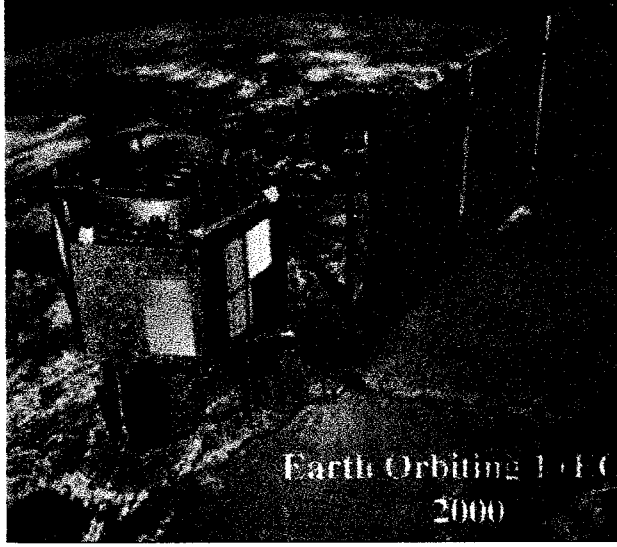
Program Overview

* Actual Launch Date

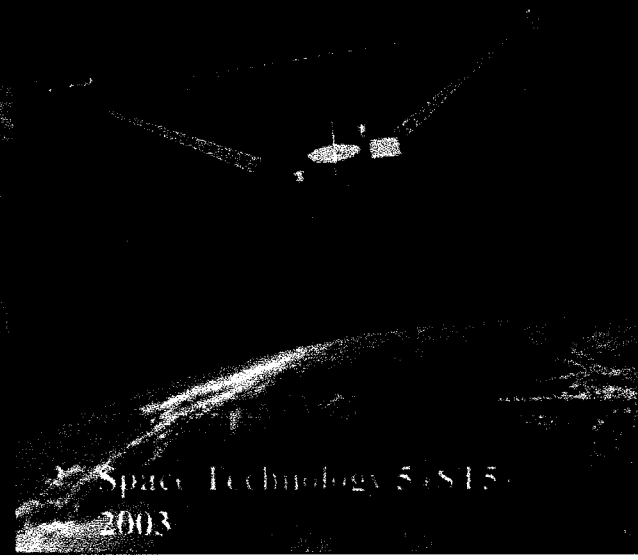




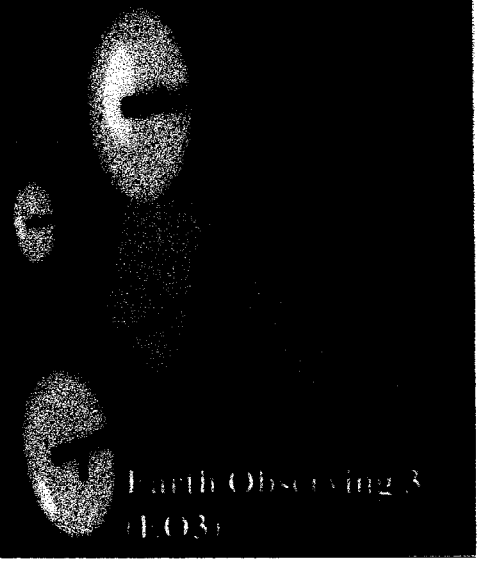
A cross-Enterprise program to identify and space flight validate breakthrough technologies that will significantly benefit future Space Science and Earth Science missions.



Earth Orbiting 1 (EO1)
2000

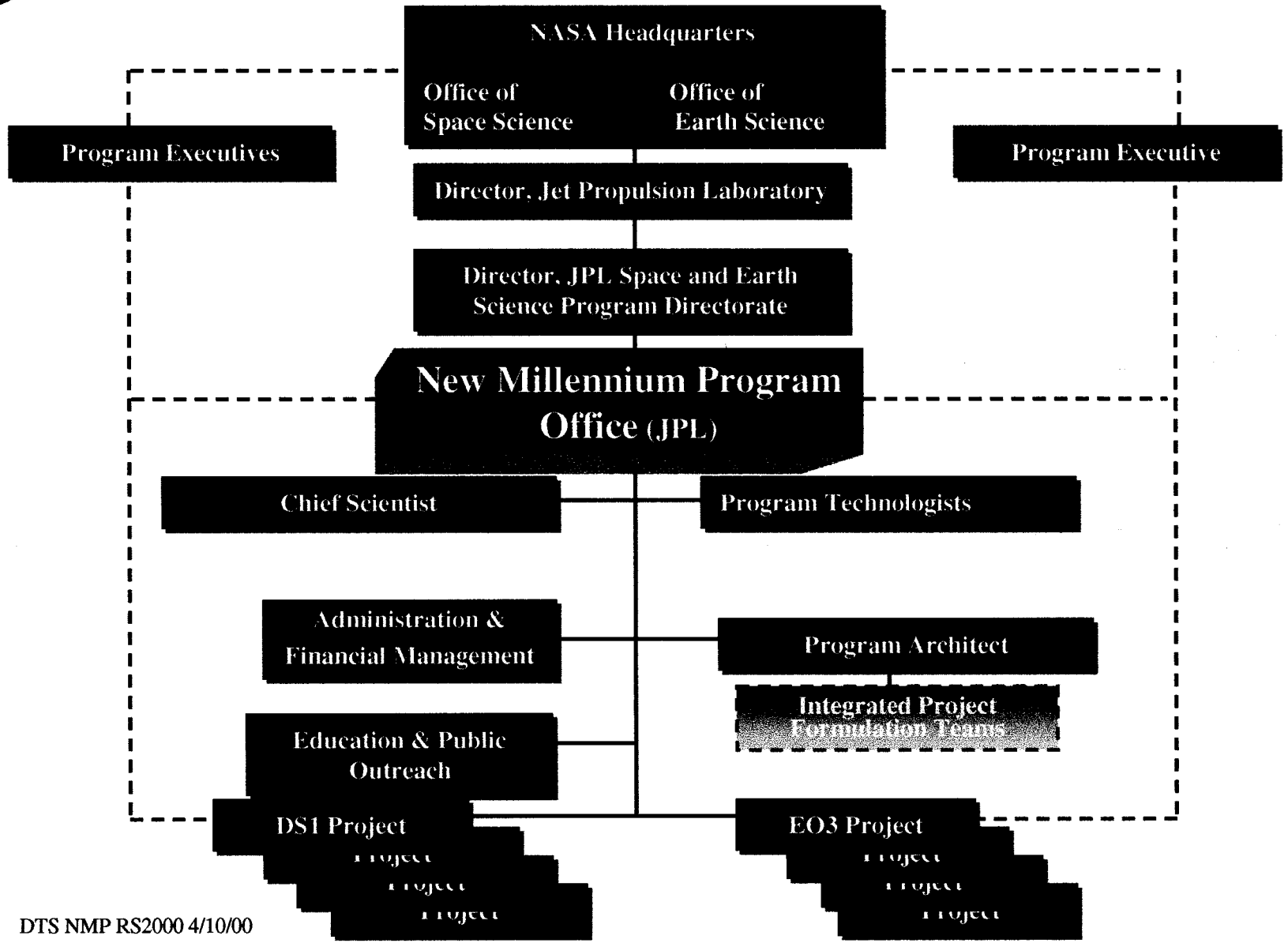


Space Technology 5 (ST5)
2003



Earth Observing 3
(EO3)

New Millennium Program Organization



Principal Points of Contact

NASA HQ Program Executives

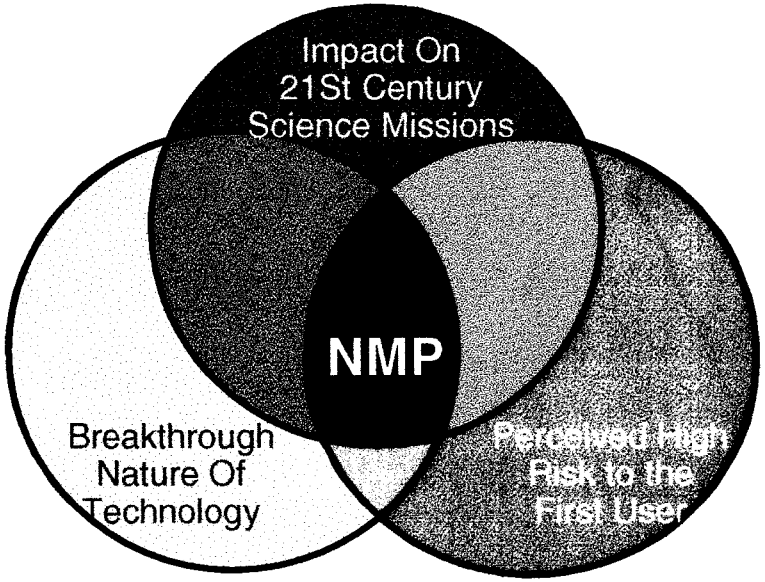
Office of Space Science Code: S	Dr. Dana Brewer	(202) 358-1678
Office of Earth Science Code: Y	Mr. Lou Schouster	(202) 358-0772

New Millennium Program Office (JPL)*

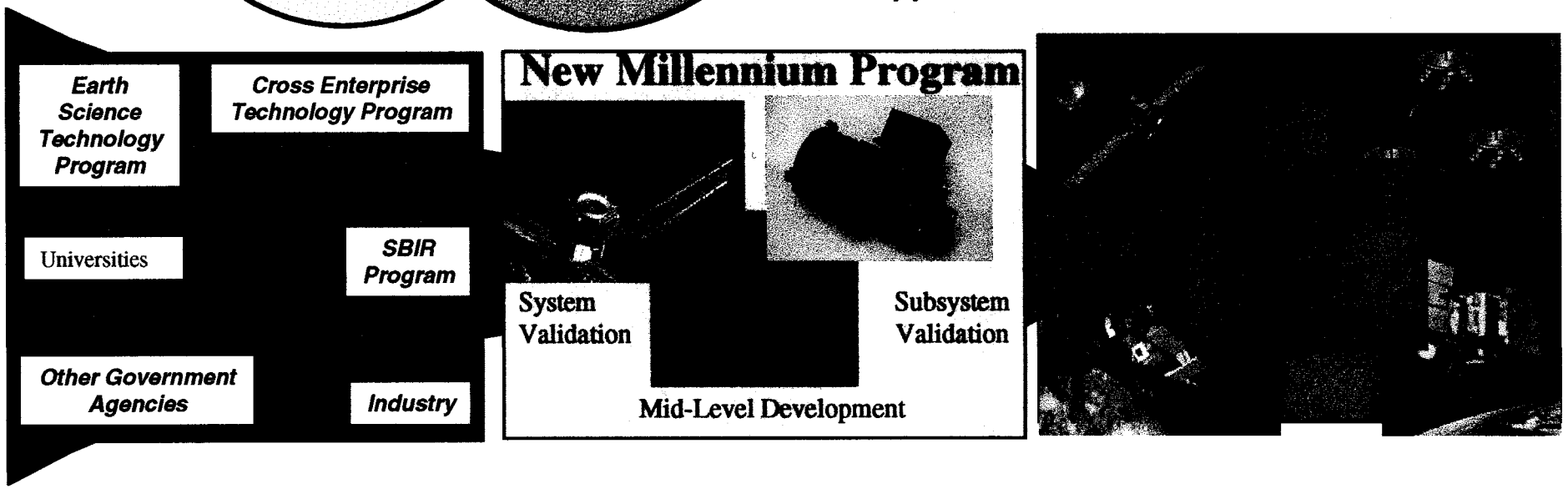
Program Manager	Dr. Fuk Li	(818) 354-2849
Deputy Program Manager	Dr. Chris Stevens	(818) 354-5545
Assistant Program Manager	Mr. David T. Spencer	(818) 354-4892
Chief Scientist	Dr. David Crisp	(818) 354-2224
Program Architect	Dr. Stuart Kerridge	(818) 354-0899
Goddard Space Flight Center	Mr. Ron Ticker	(301) 286-1380

* Jet Propulsion Laboratory
4800 Oak Grove Drive Mail Stop 180-404
Pasadena, CA 91109-8099

New Millennium Program Objectives

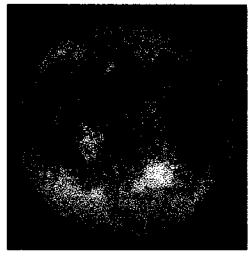


- Identify and select technologies for space flight validation
- Develop and implement flight project testbeds that effectively mitigate the risks for using selected technologies in science missions
- Facilitate the infusion of validated technologies into science mission opportunities

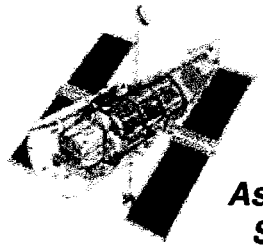


Space Science Strategic Plans Drive Technology Validation Needs

Strategic Plans /Technology Roadmaps



Solar System Exploration (SSE)



Astronomical Search for Origins (ASO)

Structure & Evolution of the Universe (SEU)

Sun Earth Connection (SEC)

Future Missions Technology Needs

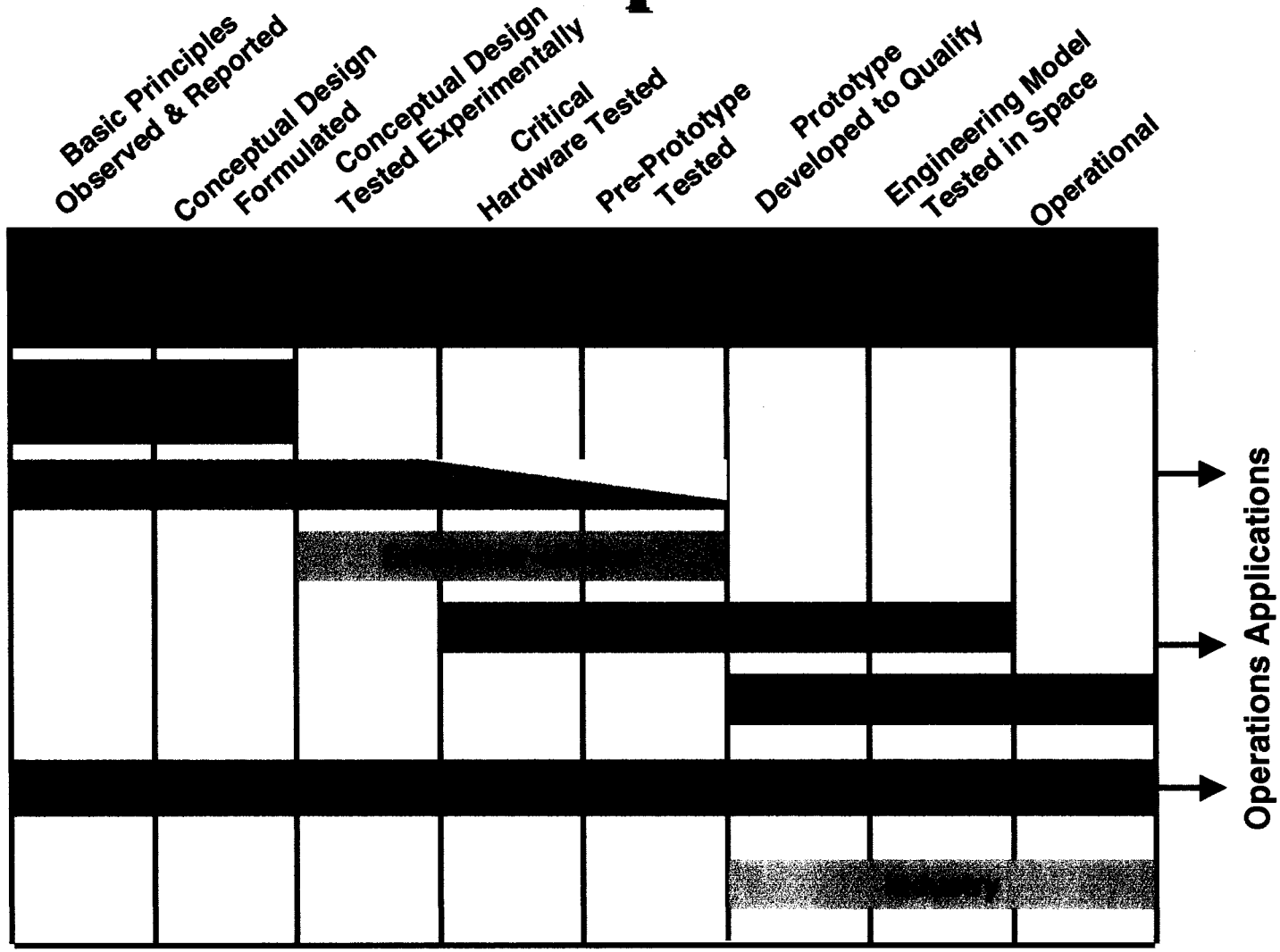
Space Science Technology Development Needs:

- *Systems*
- *Subsystems*

Technology Development/ Availability

TECHNOLOGY PIPELINE

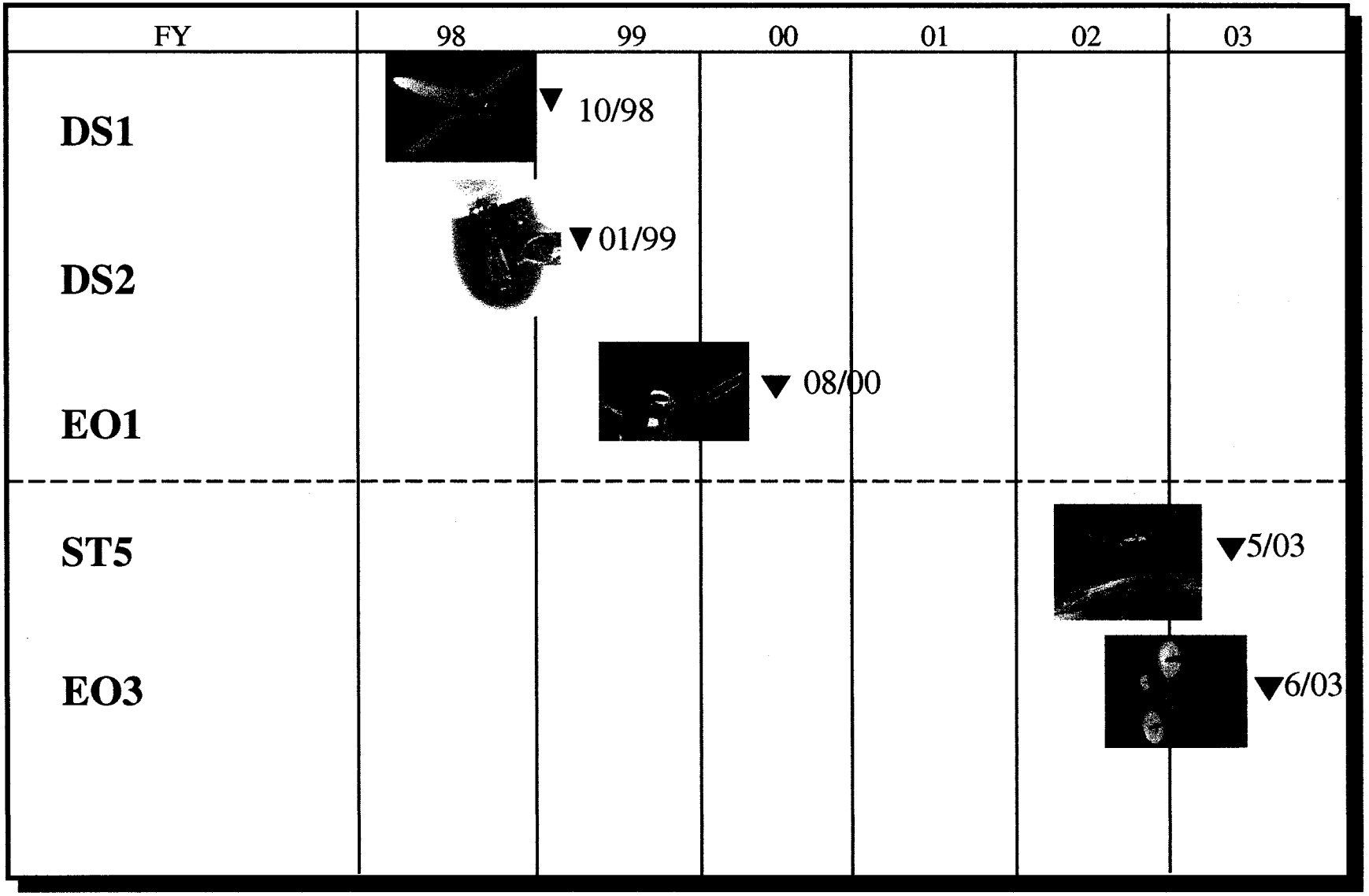
Role of NMP in Technology Development



NMP Technology Covers Wide Spectrum of Opportunities

Cross-Enterprise Technology Development Program (CETDP) Thrust Areas	Current NMP Validation Contributions (DS1,2 & EO1,2)
Advanced Power and On-Board Propulsion	4
Breakthrough Sensor and Instrument Component Tech.	6
Distributed Spacecraft	1
High Rate Data Delivery	5
Thinking Space Systems	3
Micro-Nano Sciencecraft	6
Surface Systems	7
Ultra-Lightweight Structures and Space Observatories	1
Next Generation Infrastructure	

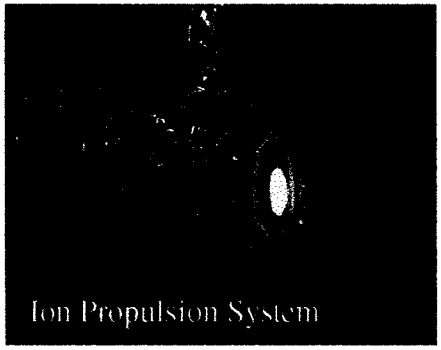
NMP Flight Validation Projects Past and Planned

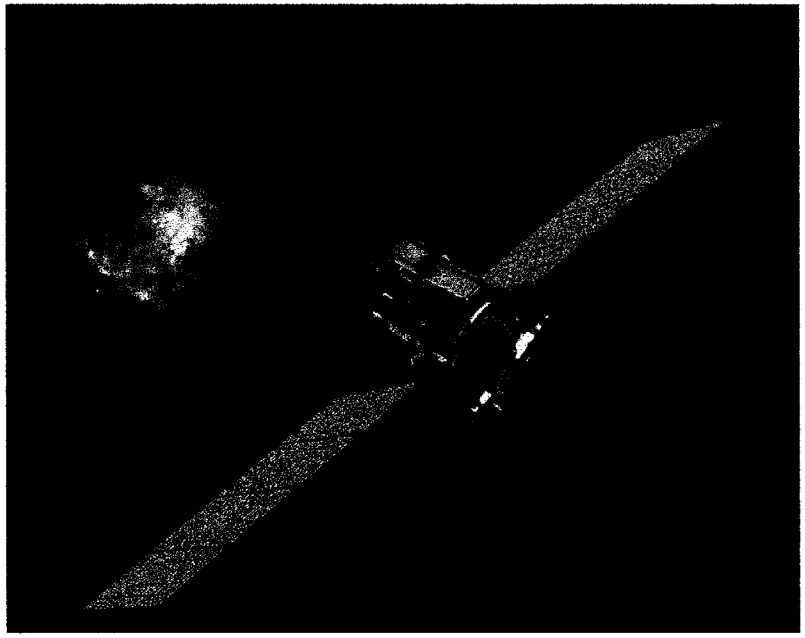


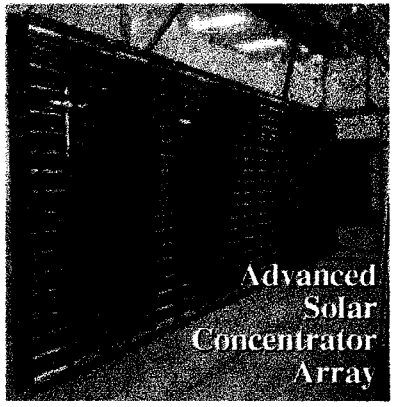
http://nmp.jpl.nasa.gov/

Deep Space 1

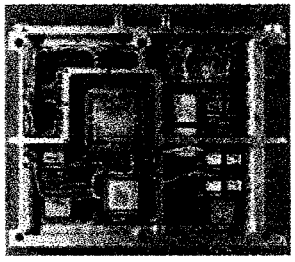
System Level Validation of 12 Breakthrough Technologies



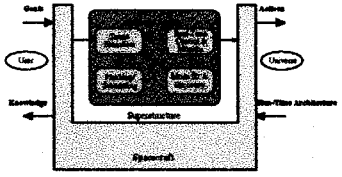


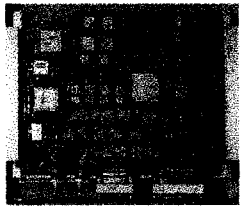


Small Deep Space Transponder

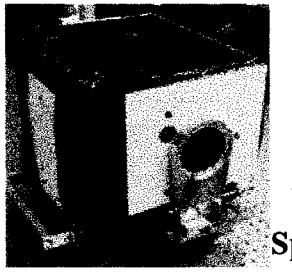


Remote Agent Architecture



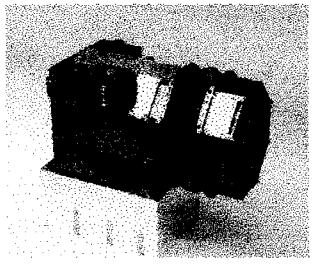


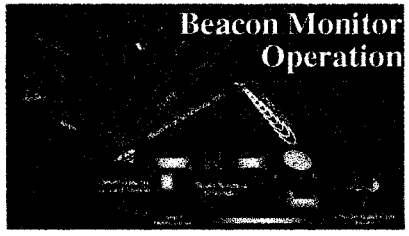
Low Power Electronics

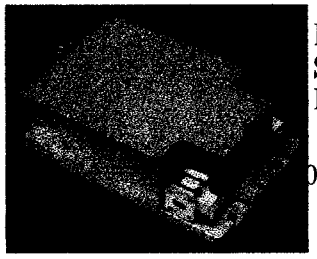


Miniature Integrated Camera Spectrometer

Plasma Experiment for Planetary Exploration

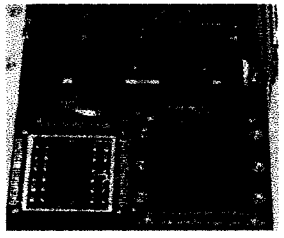




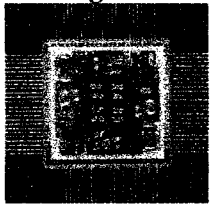


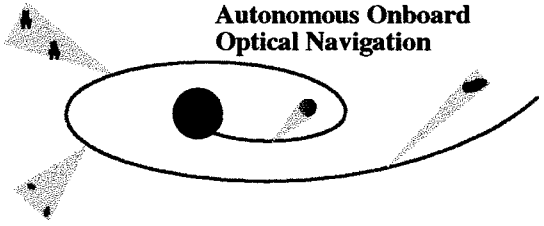
Ka-Band Solid State Power Amplifier

Multifunctional Structure



Power Activation & Switching Module

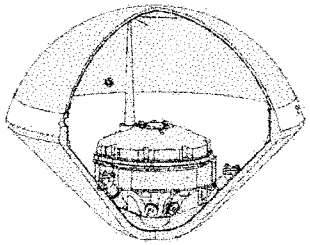




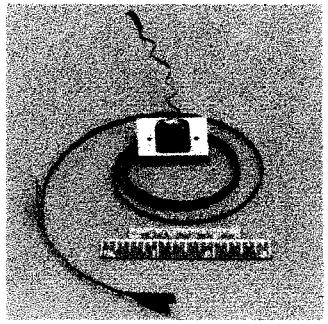
Autonomous Onboard Optical Navigation

Deep Space 2

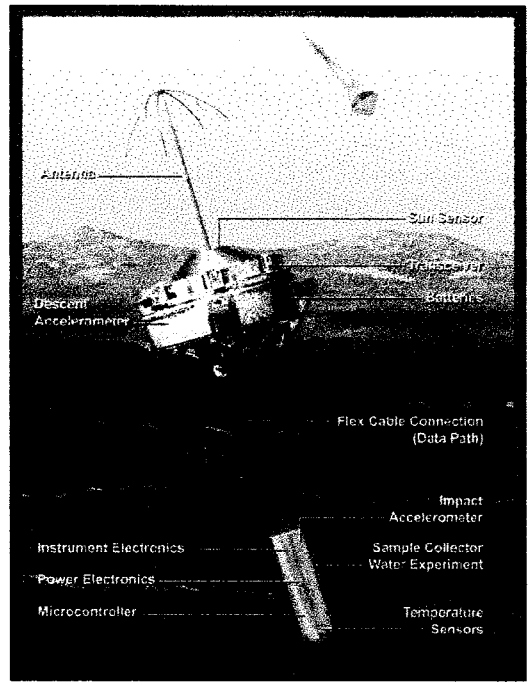
Technologies for Surface Penetrators and Network Science

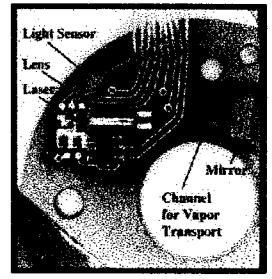


Single-Stage, Passive Aeroshell Entry System



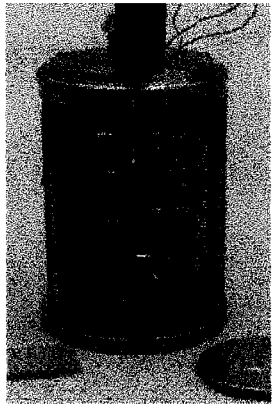
Flexible Interconnect



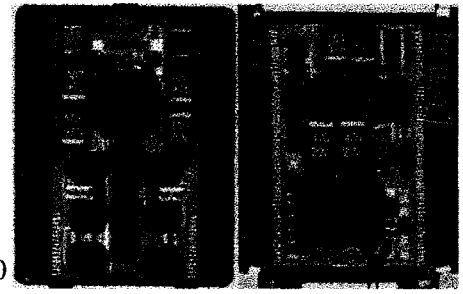


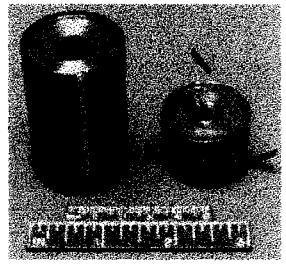
Miniaturized Tunable Diode Laser Spectrometer
Subsurface Water Detection

Advanced Microcontroller

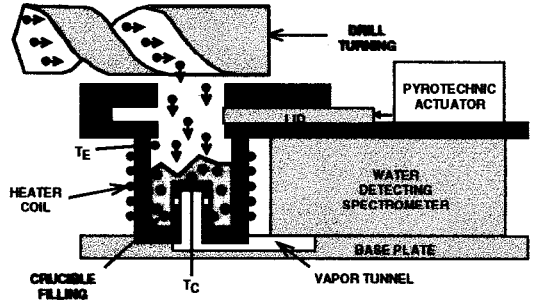


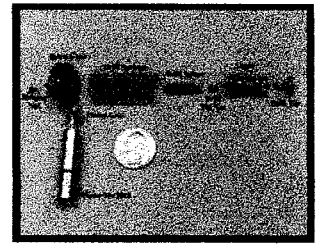
Power Microelectronics





Low Temperature Lithium Ion Batteries

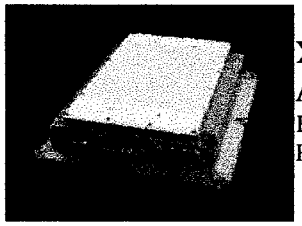




Soil Acquisition System

Earth Observing 1

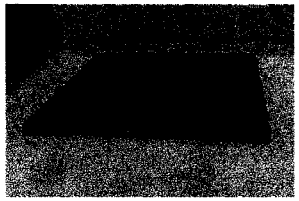
Validation of 9 Breakthrough Technologies



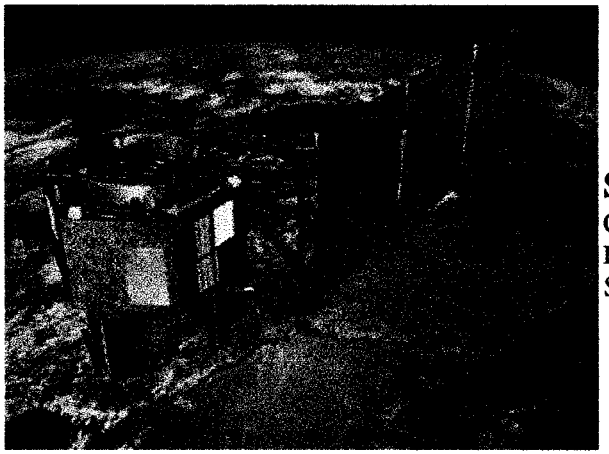
X-Band Phased Array Antenna:
Boeing, GSFC & Lewis Research Center

Leisa Atmospheric Corrector:
GSFC

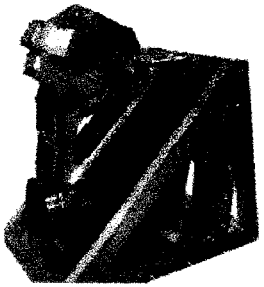
Advanced Land Imager:
MIT Lincoln Lab, GSFC, Raytheon / Santa Barbara Remote Sensing, & Sensor Systems Group



Carbon-Carbon Radiator:
Air Force Research Lab, Amoco Polymers, BF Goodrich, GSFC, Langley Research Center, Lockheed Martin, Naval Surface Warfare Center, & TRW



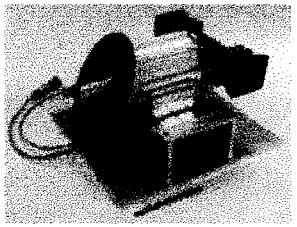
Spacecraft:
GSFC, Litton, SWALES



Hyperion:
TRW, JPL & GSFC

Wideband Advanced Recorder Processor:
GSFC, Litton, MIT Lincoln Lab, Swales, & TRW

Lightweight Flexible Solar Array:
GSFC, Lockheed Martin, & Phillips Lab



Pulsed Plasma Thruster:
GSFC, Lewis Research Center & PRIMEX

Enhanced Formation Flying
GSFC, JPL

Space Technology 5

Nanosat Constellation Trailblazer Mission

Miniature Spacecraft

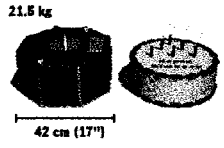
- Systems Design Integration and Test Technologies

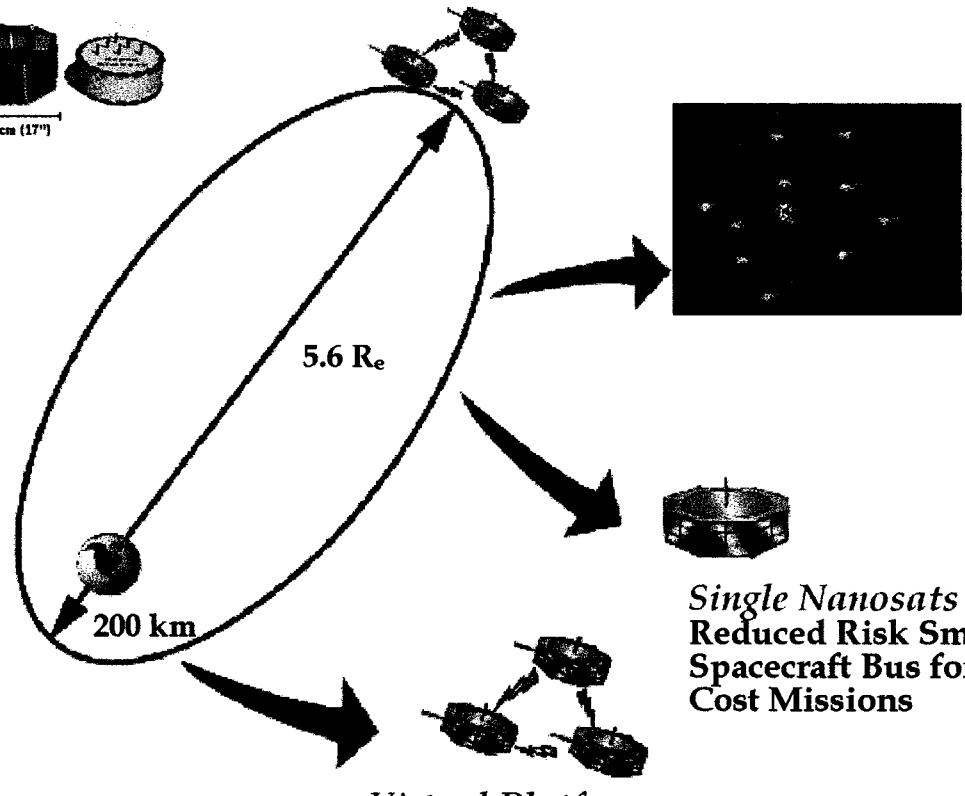
Candidate Spacecraft Technologies

- 5V bus - 1/4V logic
- Li-Ion batteries
- Miniature transponder
- Miniature Thrusters
- Multi-functional structure
- Variable emittance coatings

Constellation Control, Coordination, and Operations Architecture

- Ground system autonomy
- Relative ranging
- Intra-constellation communications





Constellation Class Missions
Simultaneous, Multipoint, In-Situ Characterization of the Magnetosphere

Single Nanosats and Probes
Reduced Risk Small Spacecraft Bus for Low Cost Missions

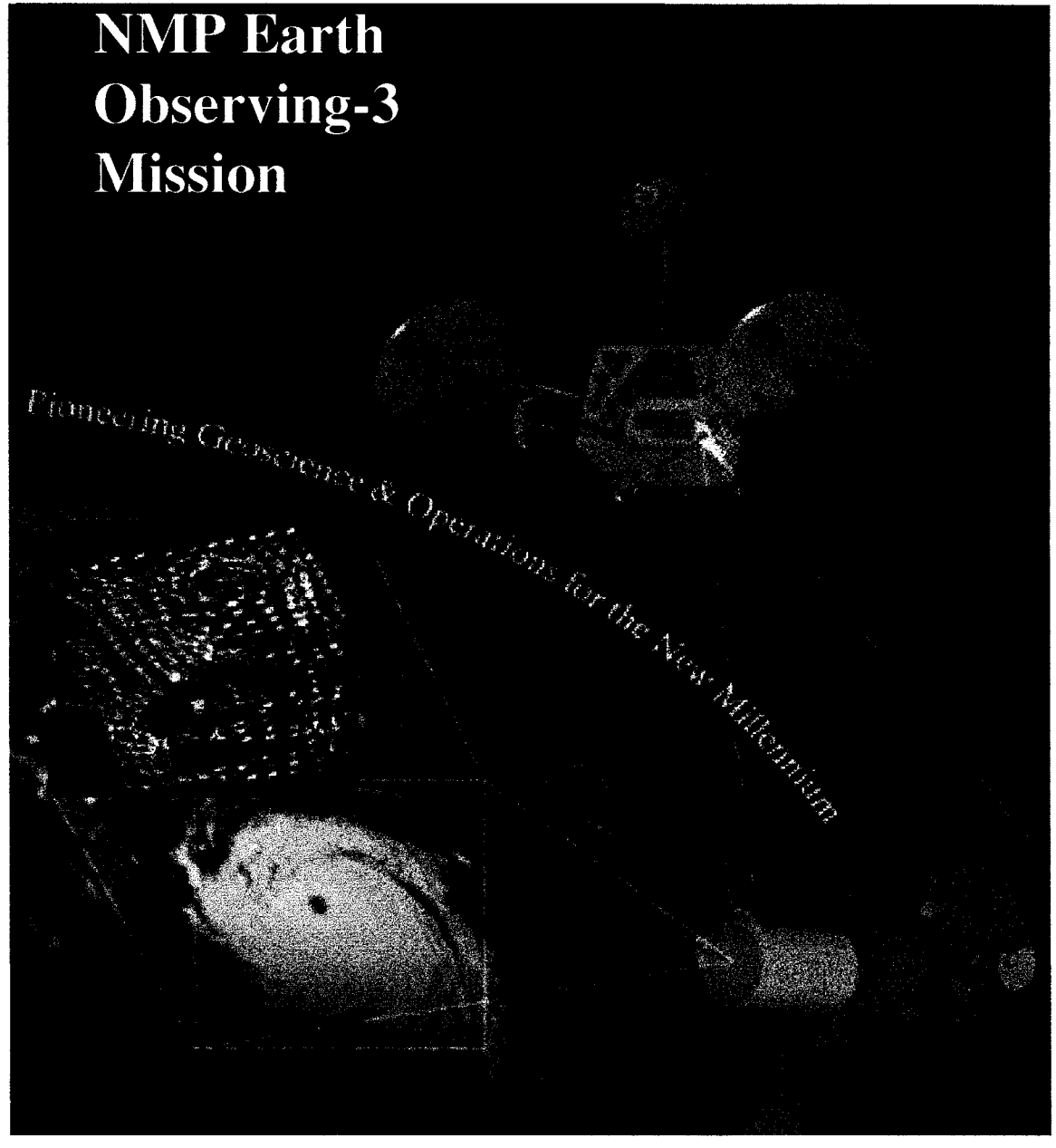
Virtual Platforms
For Science Missions

TECHNOLOGY → VALIDATION → INFUSION

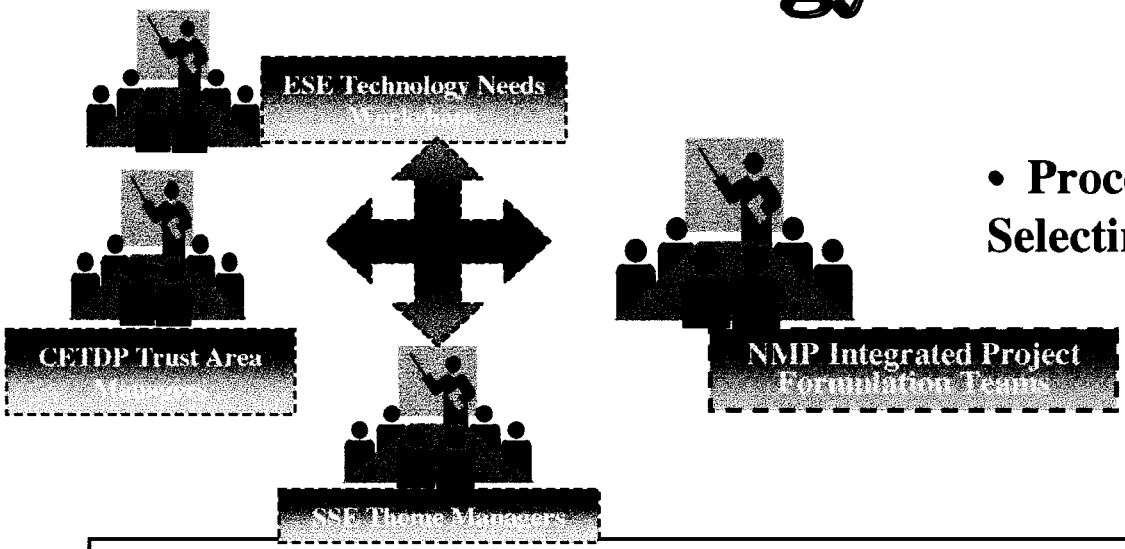
Geostationary Imaging FTS (GIFTS)

Breakthrough Technology To Revolutionize Temperature, Moisture, and Wind Sounding:

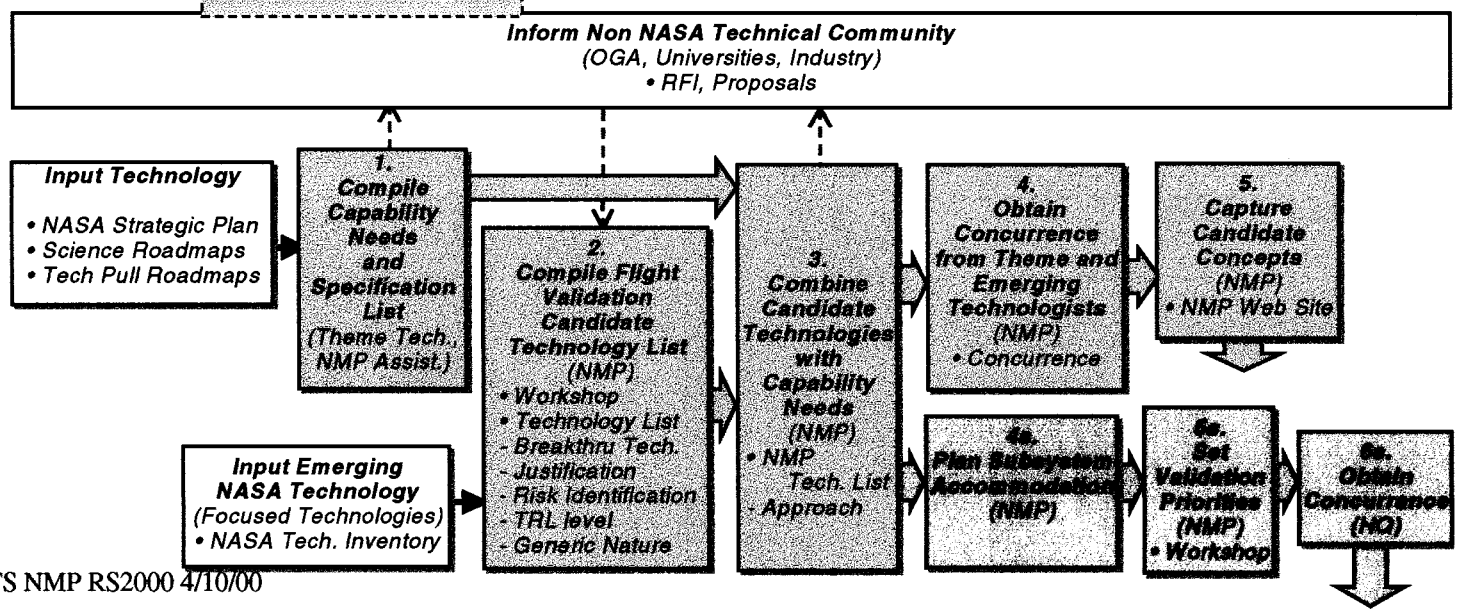
- **Fourier transform spectrometer (FTS)**
- **Large area format focal plane array (LEFA)**
- **Data readout and digital signal processing electronics**
- **Radiation shielding**
- **Lightweight structures and optics**
- **Redundant miniature**



Technology Planning



- **Processes for Capturing and Selecting Candidate Concept**

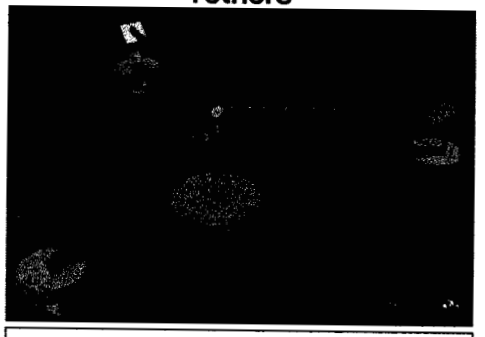


Technology Space Flight Validation Concept Examples

Drag Free Inertial Sensor

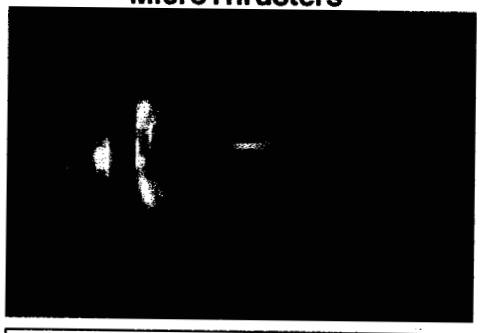
1st: LISA (Laser Interferometer Space Antenna)
Need: 2005
Other Missions: GRACE (EX-5, Code Y)
LIRE (Code U)
Gravitational Sky Mapper
Flight Validation Justification: Environment, Paradigm Shift, Complexity

Actuators for Formation Flying - Tethers



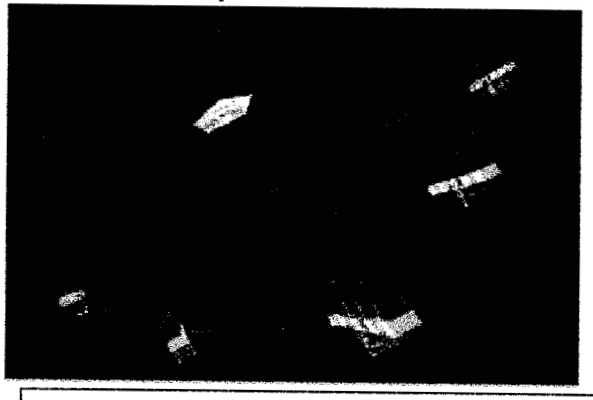
1st: SPIRIT(Space IR Interferometer Telescope)
Need: 2010
Other Missions: SPECS
Flight Validation Justification: Environment, Paradigm Shift, Complexity

Actuators for Formation Flying - MicroThrusters



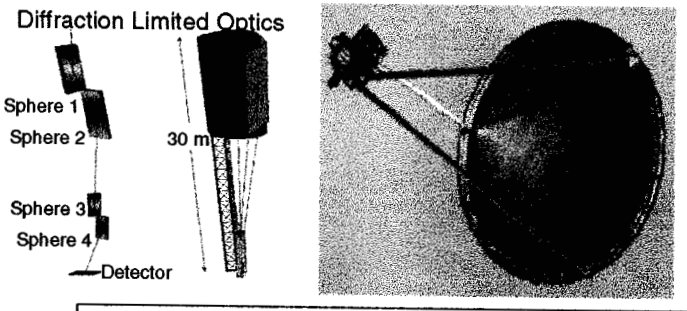
1st: LISA
Need: 2005
Other Missions: MAXIM, Gen-X, SPIRIT, TPF (Terrestrial Planet Finder)
Flight Validation Justification: Complexity

Autonomous Spacecraft Control & Coordination



1st: MAXIM (μ Arcsecond X-ray Interfer Mission)
Need: 2010
Other Missions: Gen-X, SPIRIT, SPECS, TPF
Flight Validation Justification: Environment, Paradigm Shift, Complexity

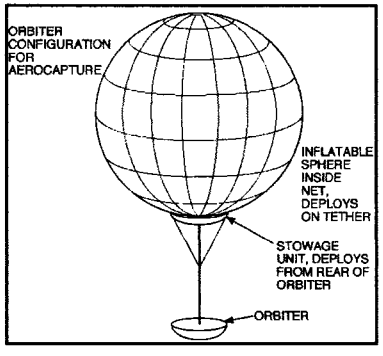
Light, Large, Deployable, High Precision Structures



1st: ARISE (Adv'd Radio Interferometry Between Space & Earth
Need: 2008
Other Missions: Next Generation Space Telescope, 8-m UV, SPIRIT
Flight Validation Justification: Environment

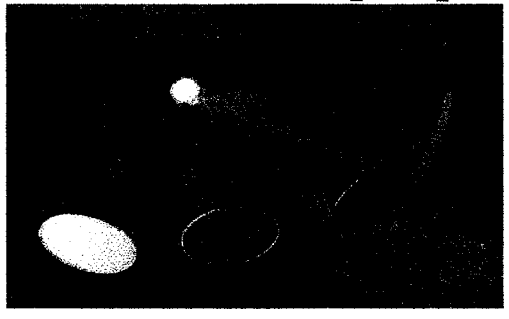
Technology Space Flight Validation Concept Examples

Ballutes for Aeroassist



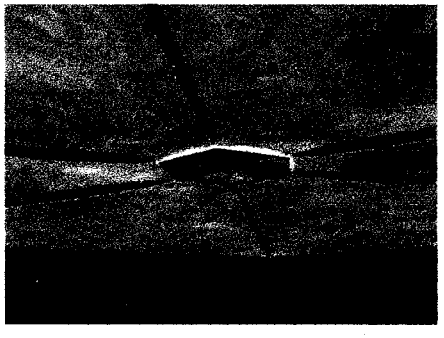
To enable planetary aerocapture, aerobraking and aeroentry at Mars, Venus and the outer planets

Gossamer Telescope Optics



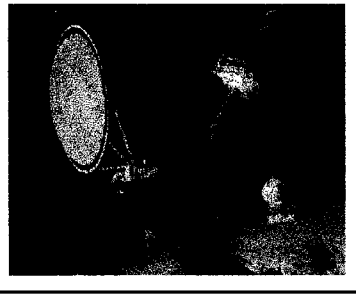
To enable technologies to locate planetary bodies around nearby stars

Solar Sails



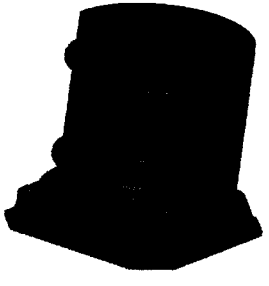
To enable faster and more capable missions to planetary targets

Microelectronics and microspacecraft technology



To enable smaller and more versatile flight systems

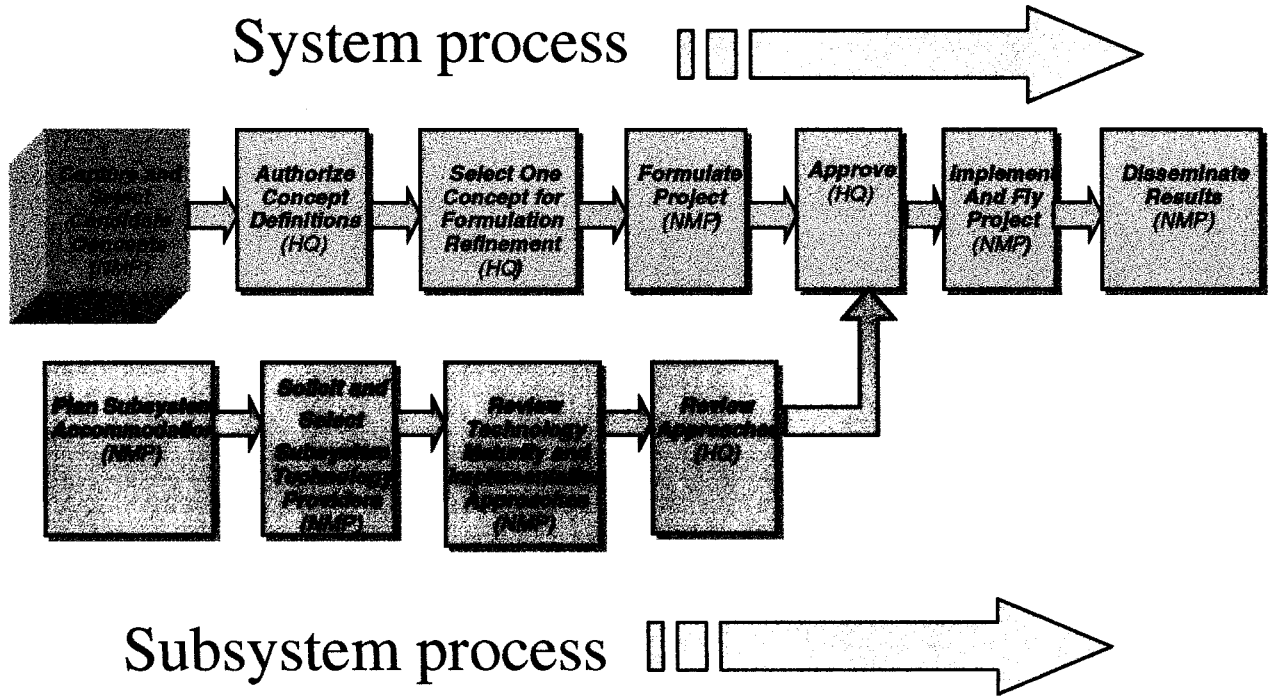
Optical Communications for outer planets missions



To increase higher science mission data return

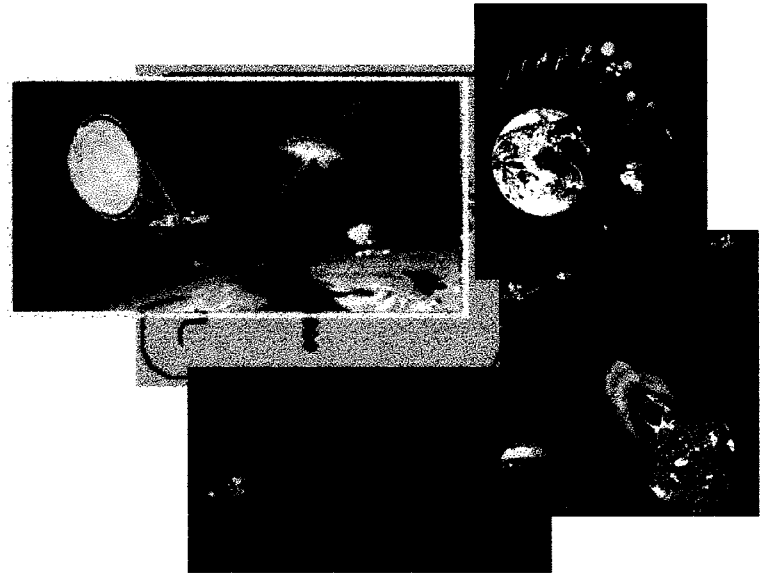
Formulating and Implementing NMP Projects

- **NMP SYSTEM AND SUBSYSTEM FLIGHT VALIDATION PROCESSES**

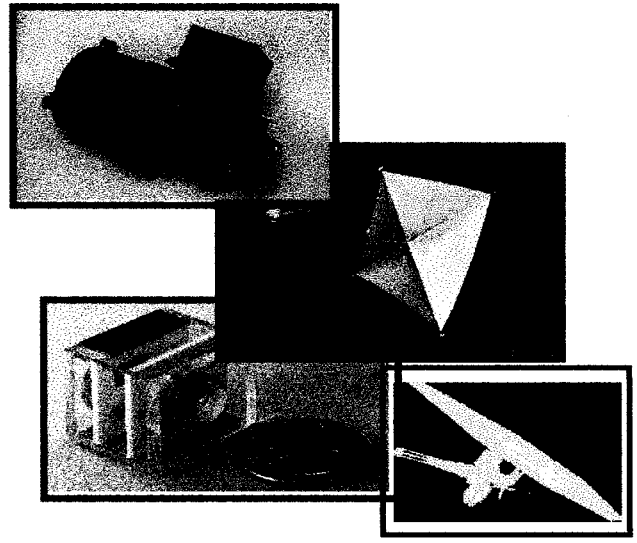


Flight Validation Concept Packaging

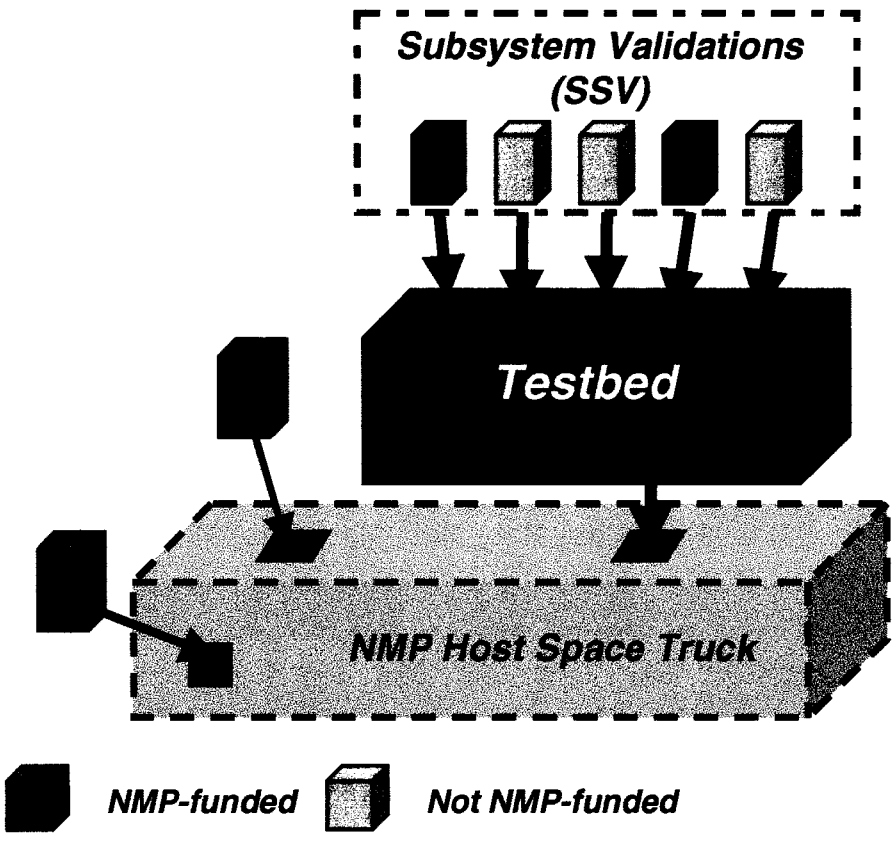
System-Focused Technology Validation



Subsystem-Focused Technology Validation



Testbeds for Sub-system Technology Validations



- Definition: Common support hardware & software to validate several subsystems or components
  - Facilitates harvesting subsystems & components developed in & outside space science

NMP Exporation in Collaboration and Partnering

Government

Establish an effective mechanism for collaboration in the demonstration, and validation of space technologies and capabilities

Bridging the Gaps

Reduce the cost of access to space for NMP and others by developing partnerships with other agencies and companies to obtain cheaper launches or spacecraft or to share technology demonstration costs by partnering

Non Government

Partnering with Commercial Satellite Companies, Universities, and other Institutions

END OF PRESENTATION