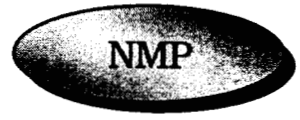

Technology Selection and Validation: New Millennium Flight Projects

IEEE Aerospace Conference

Big Sky, MT

20 March 2000

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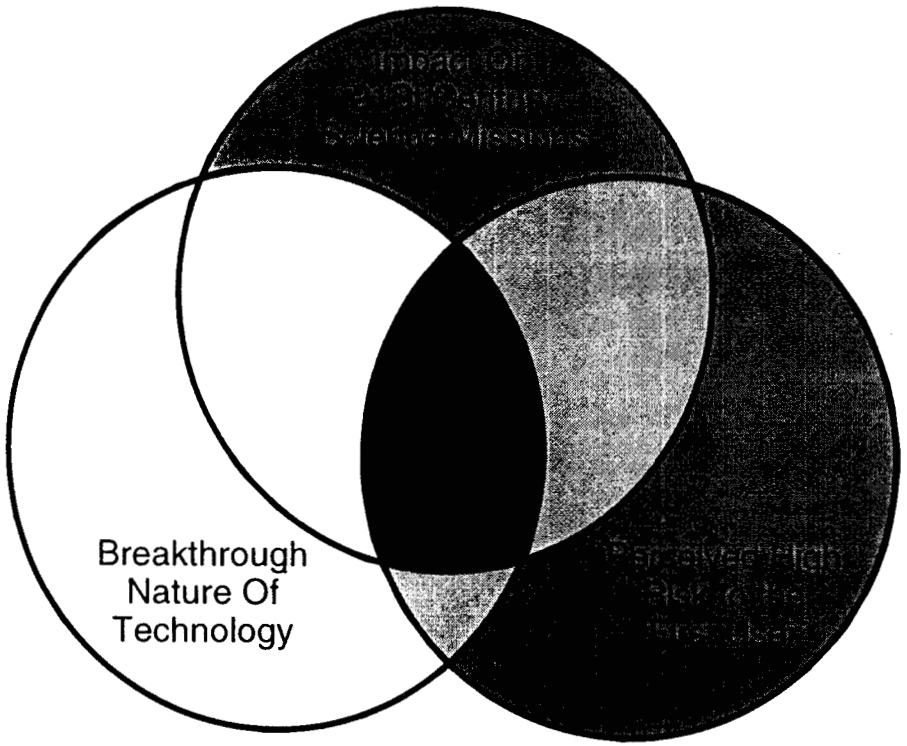
Topics

- New Millennium Program (NMP) objective
- Role of Program in technology development process
- Technology selection process: current and future missions
- NMP flight projects
- Summary

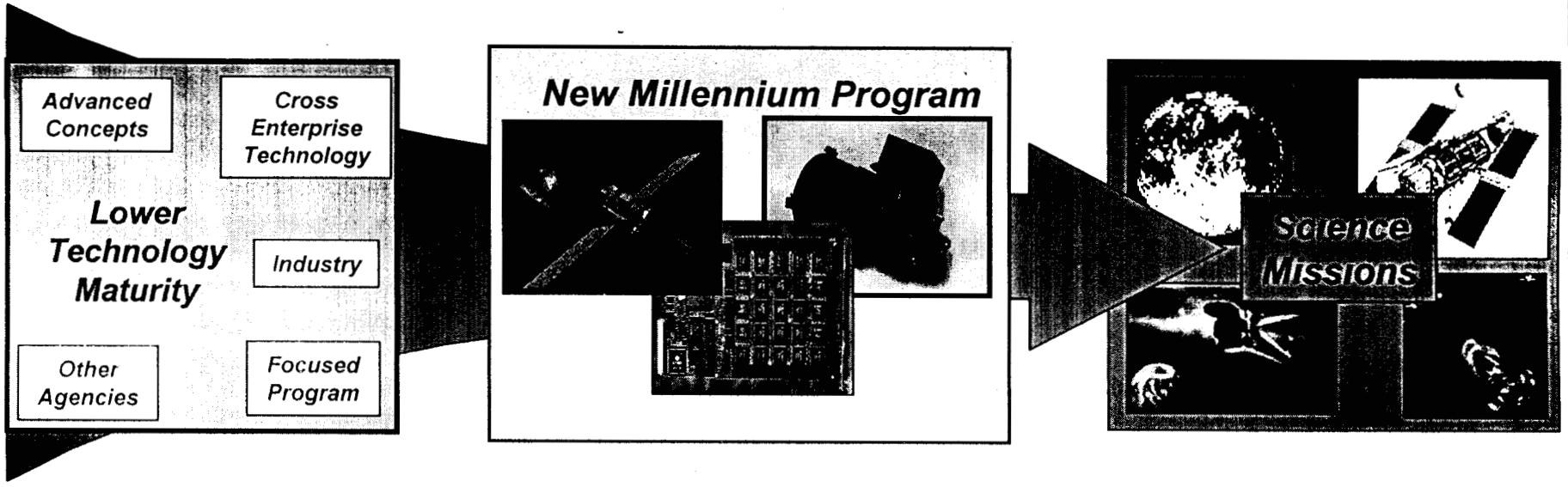
The New Millennium Program

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

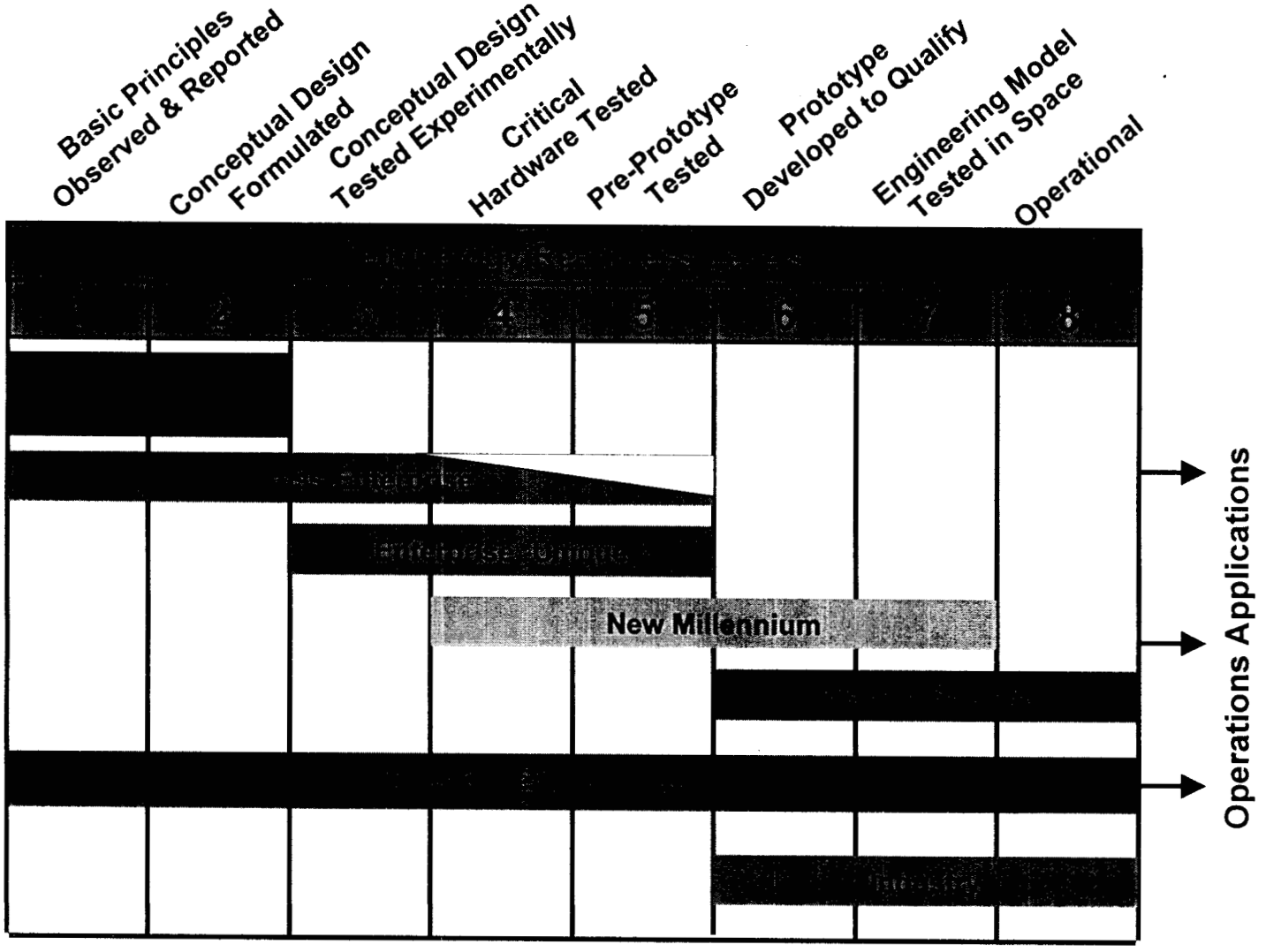


- **Breakthrough technologies**
  - **Enable new capabilities to meet Earth and Space Science needs**
  - **Reduce costs of future missions**
- **Flight validation**
  - **mitigates risks to first users**
  - **enables rapid technology infusion into future missions**

The New Millennium Program Fills a Critical Role in Space Science Technology Development



Role of NMP in Technology Development



Integrated Product Development Teams Performed Key Tasks in Early Days of the Program

- Technology Roadmapping
- Technology selection for flight validation missions
- Teams selected through a tiered, competitive evaluation process

IPDTs were a new way of teaming between NASA, industry, academia, other Government agencies, non-profit organizations, and Federally-Funded Research And Development Centers for technology planning process

IPDT's Represented Broad Spectrum of Government Agencies, Universities and Industry

IPDT	Member Organizations
Microelectronics	USAF Research Lab, Boeing, Georgia Tech, GSFC[a], Hughes, Honeywell, Irvine Sensors, JPL[b], APL[c], GRC[d], Lockheed-Martin, MIT/LL[e], Optical Networks Inc., Sandia National Lab, Space Computer Corp., Space Electronics Inc., TRW, Univ. of Calif./San Diego, Univ. of New Mexico, Univ. of So. Calif.
Telecommunications	Boeing, GSFC, JPL, APL, Lockheed-Martin, Raytheon
Modular and Multifunctional Systems	GSFC, Honeybee Robotics, JPL, LaRC[f], L'Garde, MIT, ARC[g], NOAA[h], Primex, SSG Inc., Univ. of Arizona, Univ. of Colorado, USAF Research Lab, Yardney, GRC, Lockheed-Martin Astronautics, NRL[i]
In-Situ Instrument and Micro Electro-mechanical Systems	DARPA, USAF Research Labs, Ball Aerospace, JPL, APL, LANL[j], National Science Foundation, U. S. Navy Postgraduate School, Sandia National Lab, Southwest Research Institute, Stanford Univ., Univ. of So. Calif./Information Sciences Institute
Autonomy	ARC, Carnegie-Mellon Univ., GSFC, ISX Corp., APL, JPL, Lockheed-Martin, Stanford Univ.,TRW, USAF Research Lab.
Instrument Technologies and Architectures	Ball Aerospace, GSFC, ITT Aerospace, JPL, APL, Lockheed-Martin, MSFC[k], MIT/LL, LaRC, NRL, NOAA, Orbital Sciences Corp., Raytheon, SSG Inc., TRW, Univ. of Wisconsin, NJIT[l]

[a] NASA Goddard Space Flight Center
[b] NASA Jet Propulsion Laboratory
[c] Johns Hopkins University Applied Physics Laboratory
[d] NASA Glen Research Center
[e] Massachussetts Institute of Technology/Lincoln Lab
[f] NASA Langley Research Center
[g] NASA Ames Research Center
[h] National Oceanic and Atmospheric Administration
[i] Naval Research Laboratory
[j] Los Alamos National Laboratory
[k] NASA Marshall Space Flight Center
[l] New Jersey Institute of Technology

Factors Leading to Formulation of New Technology Selection Process for Space Flight Validation

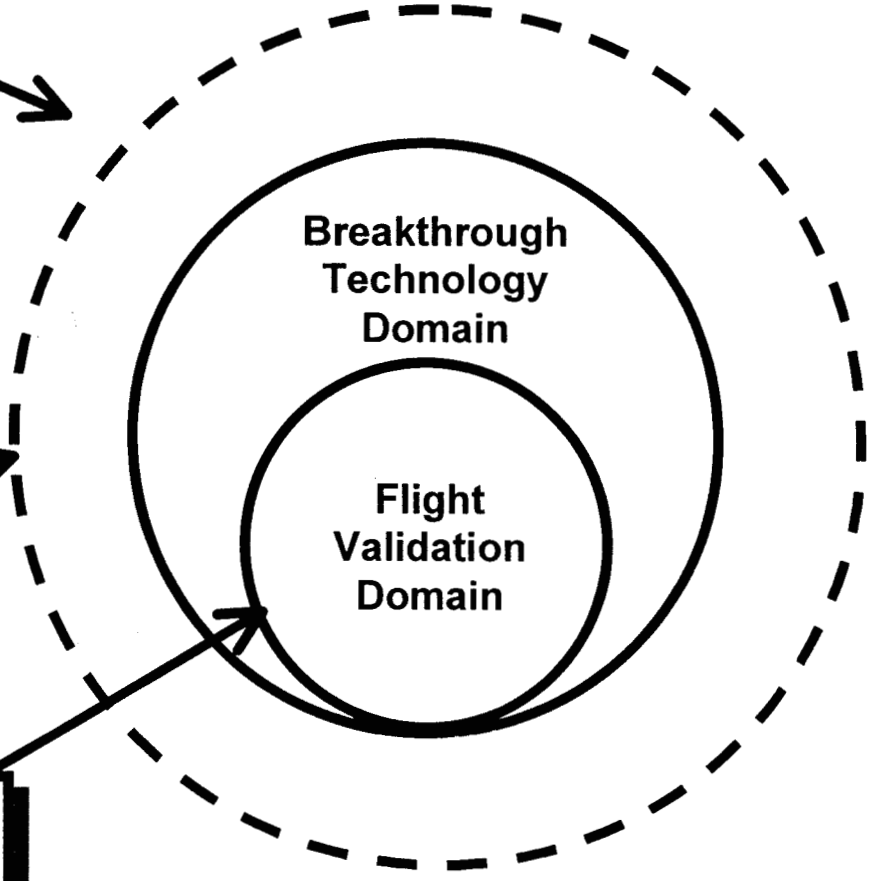
- NASA strategic plan created four strategic enterprises
  - Space Science
  - Earth Science
  - Human Exploration and Development of Space
  - Aeronautics and Space Transportation
- Enterprises have developed strategic plans
  - Science roadmaps
  - Focused technology roadmaps
- Cross-Enterprise Technology Development Program (CETDP) created to focus on technologies supporting multiple enterprises
- NMP technology selection process simplified by using mission specific technology solicitations

Relationship Between NASA Science Needs, Emerging Technologies and Flight Validation Domain

SCIENCE CAPABILITY NEEDS
- Space Science and Earth Science Enterprise Strategic Plans
- Science & Technology Roadmaps

EMERGING TECHNOLOGIES
- Cross Enterprise
- Focused Programs
- Non NASA Technology

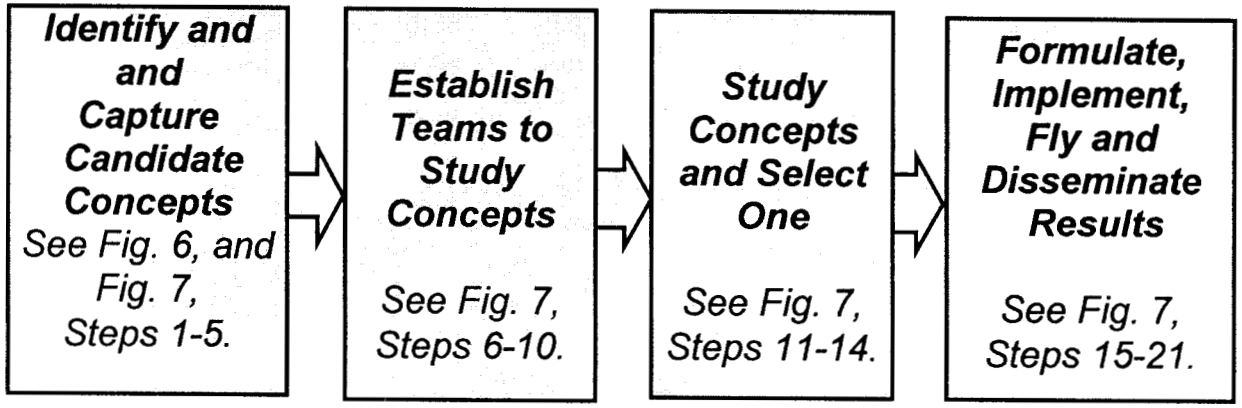
TECHNOLOGIES REQUIRING FLIGHT VALIDATION



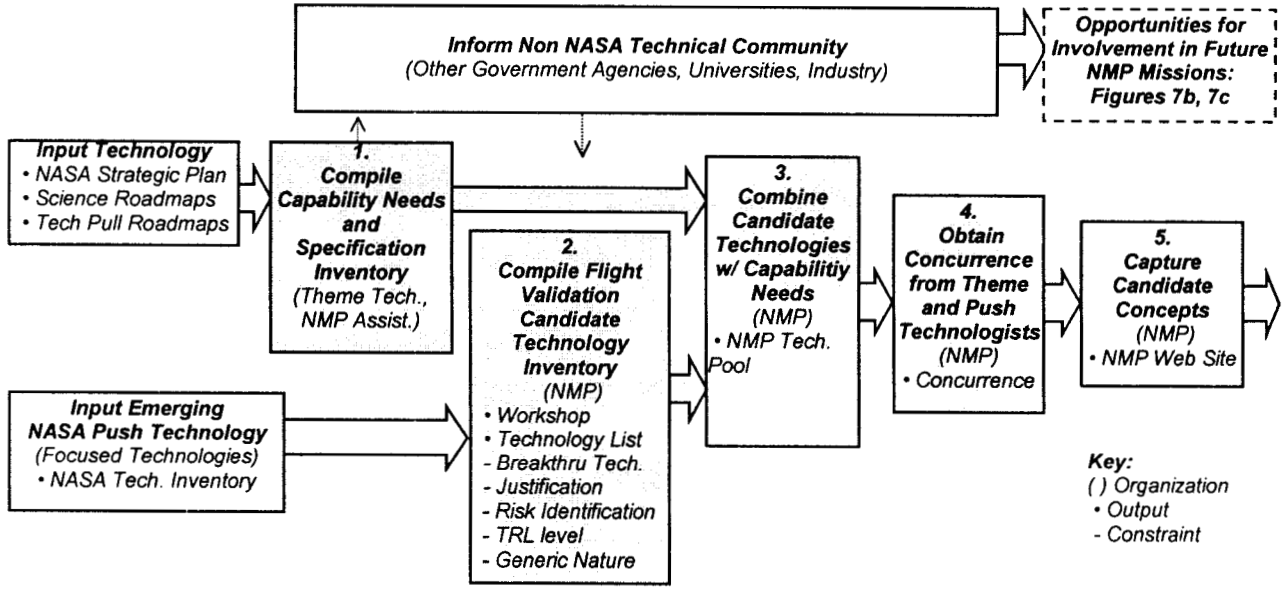
Justification Factors for Selecting a Technology for Space Flight Validation

- Environmental (Ground Test Impossible)
  - Persistent effects (zero gravity)
  - Transient effects (cosmic rays, temperature)
  - External interaction (planetary atmospheres, solar wind)
  - Reliability hazards (micrometeorites, atomic oxygen, dust accumulation)
- Pradigm shift
  - Procedural changes (new design/operation procedures)
  - Advanced technology
- Interdependency (system/subsystem complexity leading to contamination or noise sources)

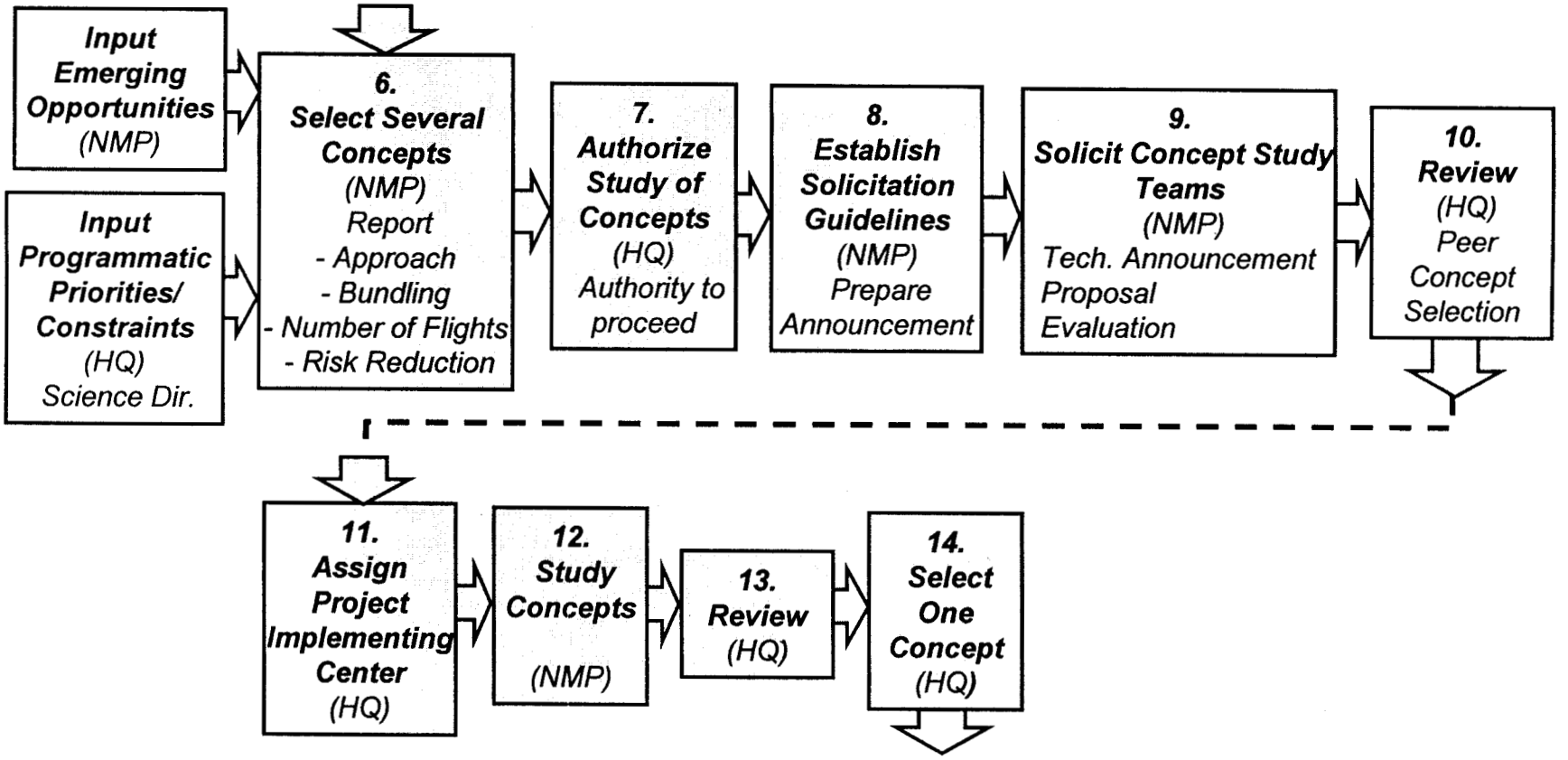
Four Basic Steps in NMP Planning/Implementation Processes for Technology Validation Flights



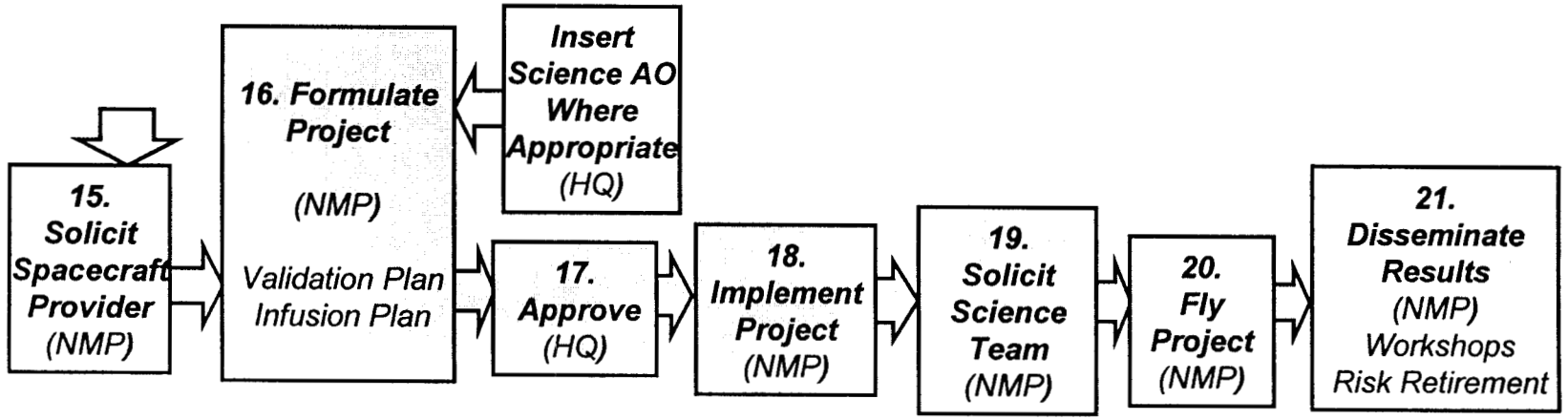
NMP Pre-project Planning Process:
Technology Identification and Capture of Flight Validation Mission Concepts



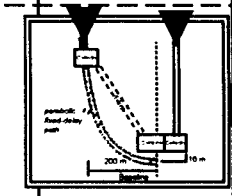
NMP Process for Establishing Teams to Study Candidate Flight Validation Projects



NMP Process for Flight Project Formulation, Implementation, Operation and Dissemination of Results



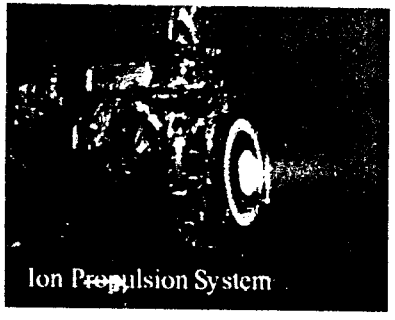
Validation Flight Launch Schedule

FY	98	99	00	01	02	03
DS1	 ▼ 10/98					
DS2	 ▼ 01/99					
EO1			▼ 08/00			
ST3					~06/05	
ST5						
EO3						

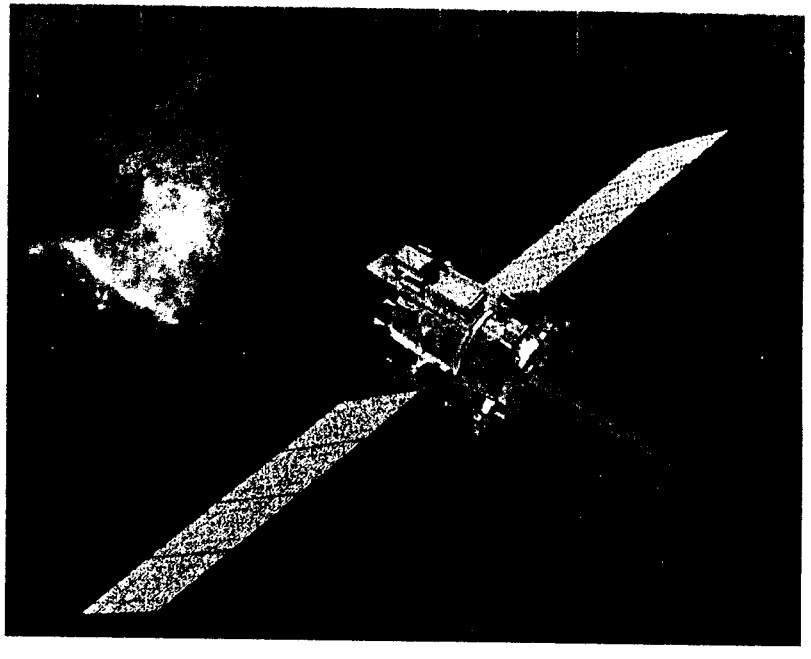
Deep Space 1

System Level Validation of 12 Breakthrough Technologies

NMP

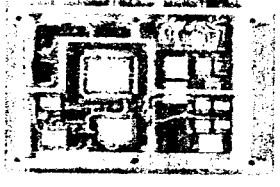


Hughes, Moog, LeRC, SAI, JPL



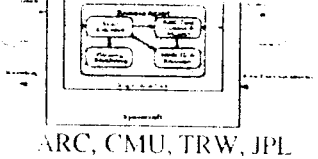
BMDO, AEC-Able Teestar, LeRC
Entech

Small Deep Space Transponder



Motorola

Remote Agent Architecture



ARC, CMU, TRW, JPL

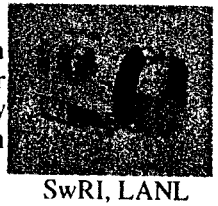
Low Power Electronics

Georgia Tech., USC, MIT LL

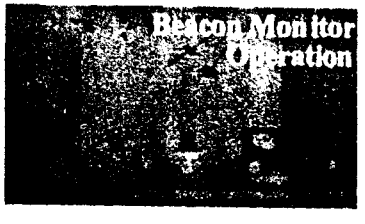
Miniature Integrated Camera Spectrometer

SSG, Rockwell, UofA, JPL

Plasma Experiment for Planetary Exploration



SwRI, LANL



JPL, U of Colorado

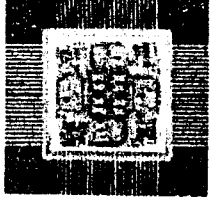
Ka-Band Solid State Power Amplifier

Lockheed Martin, JPL

Multifunctional Structure

AFRL, Lockheed Martin

Power Activation & Switching Module



Lockheed Martin

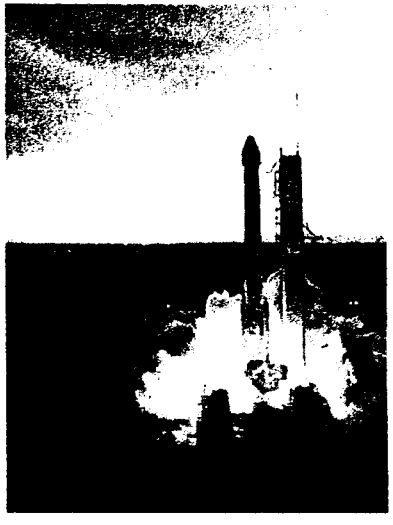
Autonomous Onboard Optical Navigation

JPL

Deep Space 2

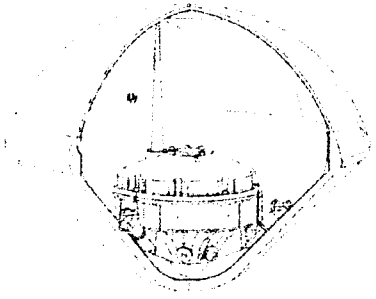
Technologies for surface penetrators and network science

NMP



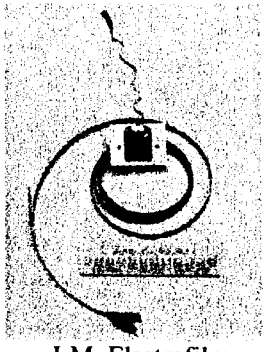
Launch: January 3, 1999

Single-Stage, Passive Aeroshell Entry System



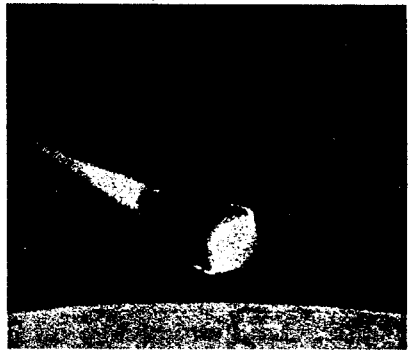
ARC, Eglin AFB, JPL, LaRC, Poco Graphics, GRC, SNL

Flexible Interconnect

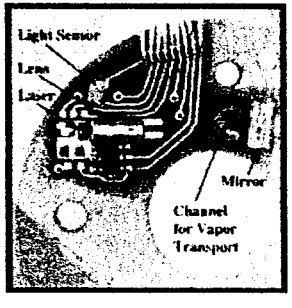


LM, Electrofilm Manufacturing Co., Pioneer Circuits Inc.

Probe Entry: December 3, 1999



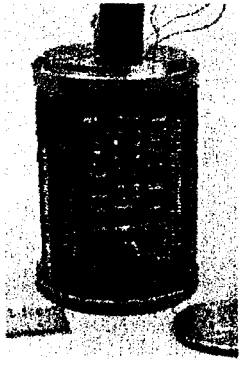
Landed Operations:
Primary Mission: 2 Sols (extended mission battery dependent)



Miniaturized Tunable Diode Laser Subsurface Water Detection

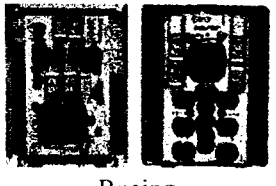
JPL, Caltech

Advanced Microcontroller

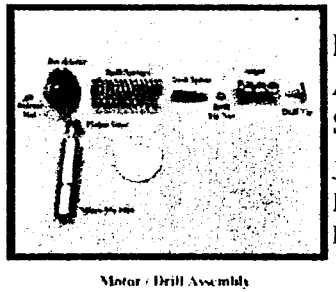


AFRL, Mission Research Corp., Tech Assoc., Boeing, GE, LaRC, U of Tenn.

Power Microelectronics



Boeing

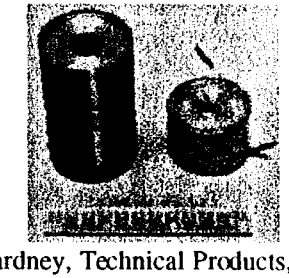


Motor / Drill Assembly

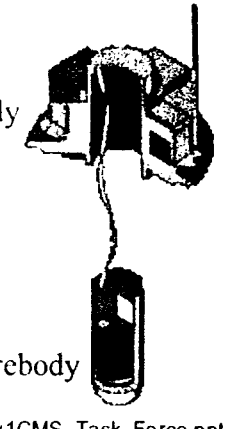
Drill and Soil Acquisition System

JPL, Caltech, MicroMo Electronics

Lithium Ion Batteries



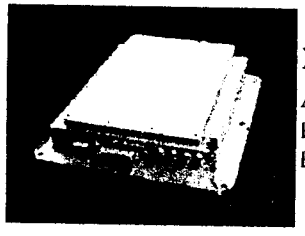
Yardney, Technical Products, JPL



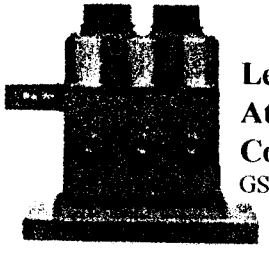
Earth Observer 1

Validation of 9 Breakthrough Technologies

NMP

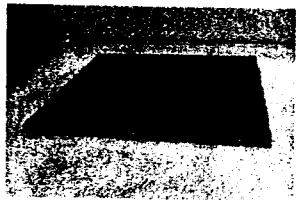


X-Band Phased Array Antenna:
Boeing, GSFC & Lewis Research Center

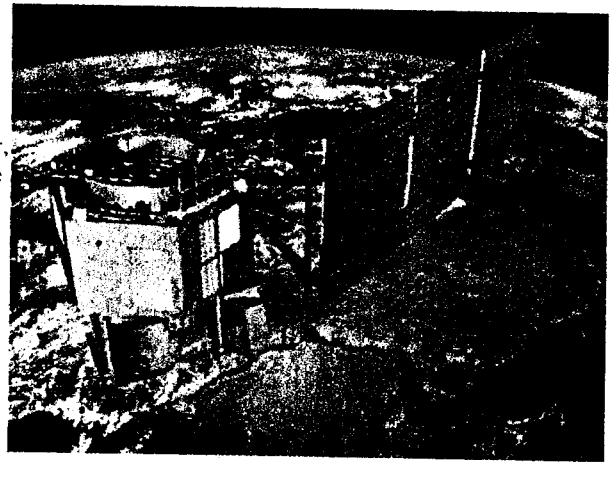


Leisa Atmospheric Corrector:
GSFC

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



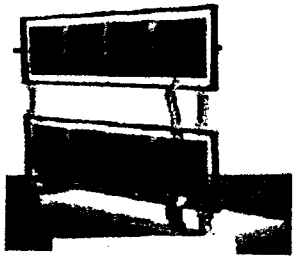
Carbon-Carbon Radiator:
Air Force Research Lab, Amoco Polymers, BF Goodrich, GSFC, Langley Research Center, Lockheed Martin, Naval Surface Warfare Center, & TRW



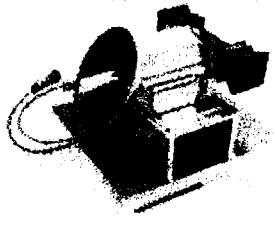
Spacecraft
GSFC, Litton, SWALES

Hyperion:
TRW, JPL, GSFC

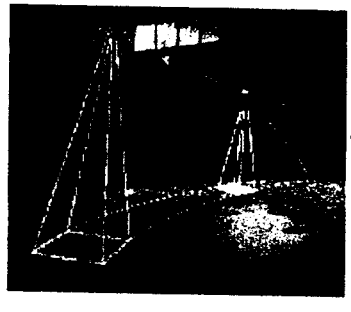
Wideband Advanced Recorder Processor:
GSFC, Litton, MIT Lincoln Lab, Swales, & TRW



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

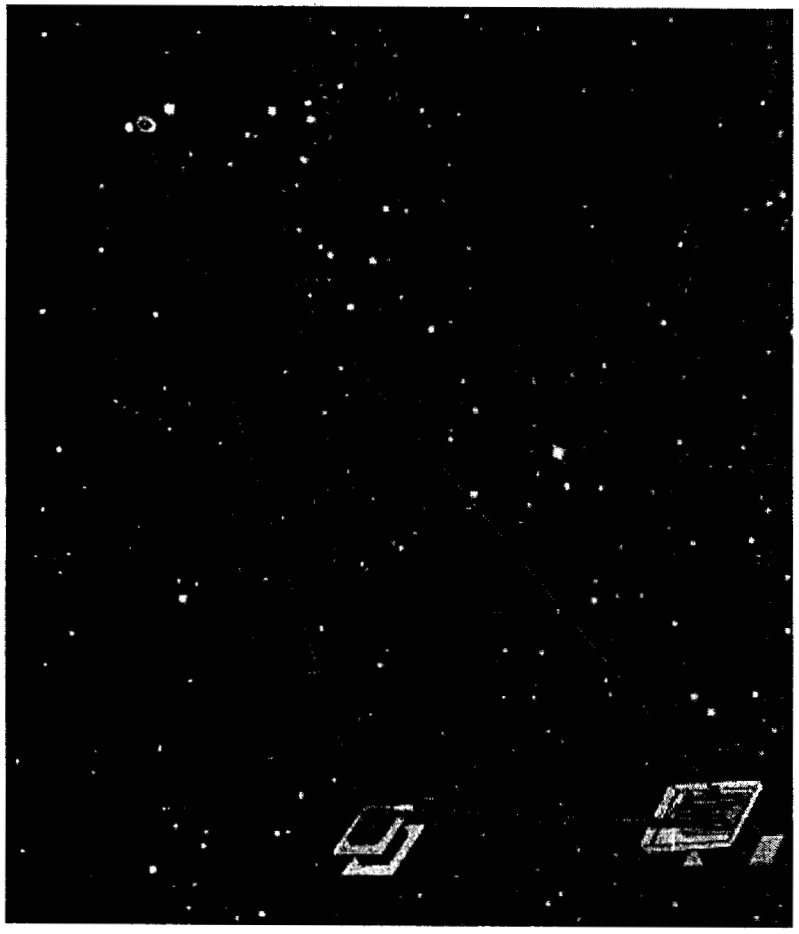


Pulsed Plasma Thruster:
GSFC, Lewis Research Center & PRIMEX



Enhanced Formation Flying
GSFC, JPL

ST3: Two Spacecraft Interferometer



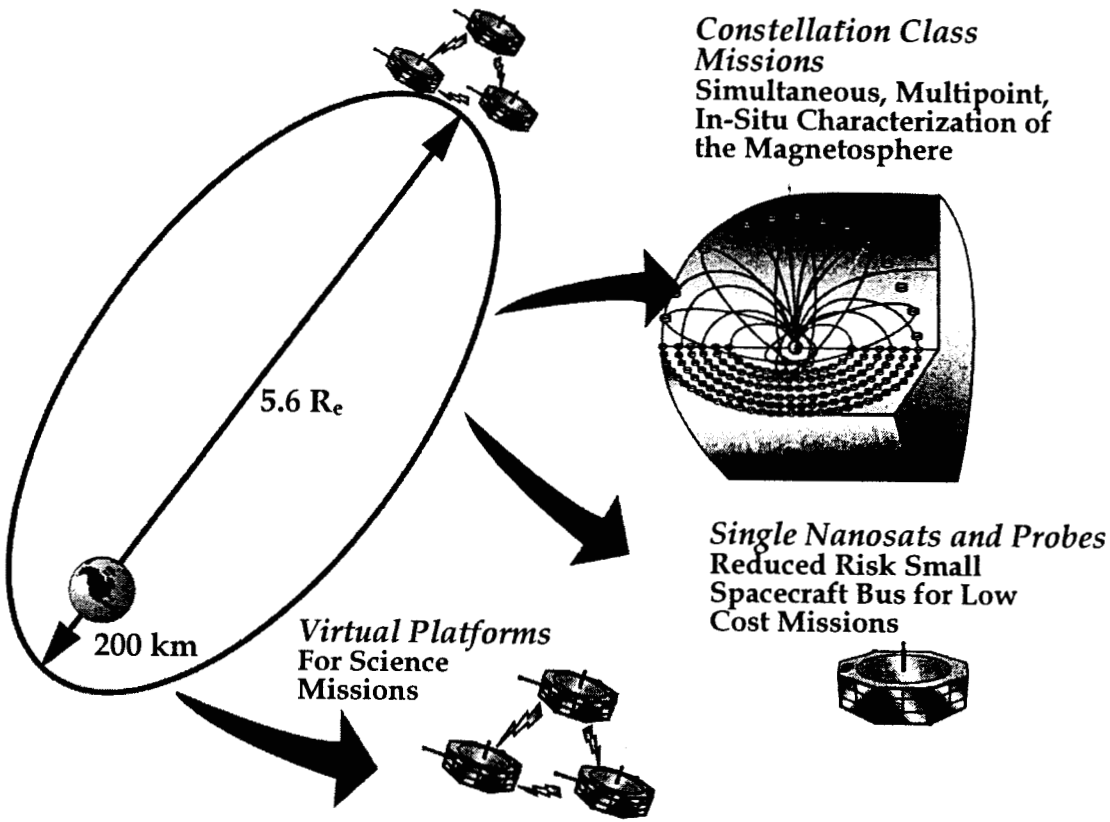
- S/C separation from 50 m to 1 km
  - Observation baselines of 40 to 200 m
  - 8th magnitude stellar targets
- Parabola is locus of constant delay
- Combiner contains 20 m fixed delay line
- Combiner can operate as a 1 m monolithic interferometer
  - No collector, bypass fixed delay
- Both S/C maintain fixed orientation relative to each other during baseline changes
- Launch planned for 2005

ST5 :Nanosat ConstellationTrailblazer Concept

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



TECHNOLOGY VALIDATION INFUSION

Summary

- NMP plays a critical role in reducing risk associated with using breakthrough technologies in future NASA science missions
- Integrated Product Development Teams (IPDT's) pioneered innovative teaming relationship between NASA, industry, academia, other government agencies and FFRDC's in technology planning and selection for NMP technology validation flights
- NMP technology selection and validation processes have evolved to be consistent with planning activities of NASA strategic enterprises
- New NMP technology selection has been successfully implemented on ST5 and EO3 procurements