Technology Selection and Validation: New Millennium Flight Projects

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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

Basic Principles
Observed & Reported
Conceptual Design
Formulated
Conceptual Design
Tested Experimentally
Critical
Hardware Tested
Pre-Prototype
Tested
Prototype
Developed to Qualify
Engineering Model
Tested in Space
Operational

New Millennium

Operations Applications
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

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<th>IPDT</th>
<th>Member Organizations</th>
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<tr>
<td>Microelectronics</td>
<td>USAF Research Lab, Boeing, Georgia Tech, GSFC, Hughes, Honeywell, Irvine Sensors, JPL, APL, GRC, Lockheed-Martin, MIT/LL, 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.</td>
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<td>Telecommunications</td>
<td>Boeing, GSFC, JPL, APL, Lockheed-Martin, Raytheon</td>
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<td>Modular and Multifunctional Systems</td>
<td>GSFC, Honeybee Robotics, JPL, LaRC, L’Garde, MIT, ARC, NOAA, Primex, SSG Inc., Univ. of Arizona, Univ. of Colorado, USAF Research Lab, Yardney, GRC, Lockheed-Martin Astronautics, NRL</td>
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<td>In-Situ Instrument and Micro Electro-mechanical Systems</td>
<td>DARPA, USAF Research Labs, Ball Aerospace, JPL, APL, LANL, National Science Foundation, U. S. Navy Postgraduate School, Sandia National Lab, Southwest Research Institute, Stanford Univ., Univ. of So. Calif./Information Sciences Institute</td>
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<td>Instrument Technologies and Architectures</td>
<td>Ball Aerospace, GSFC, ITT Aerospace, JPL, APL, Lockheed-Martin, MSFC, MIT/LL, LaRC, NRL, NOAA, Orbital Sciences Corp., Raytheon, SSG Inc., TRW, Univ. of Wisconsin, NJIT</td>
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- NASA Goddard Space Flight Center
- NASA Jet Propulsion Laboratory
- Johns Hopkins University Applied Physics Laboratory
- NASA Glen Research Center
- Massachusetts Institute of Technology/Lincoln Lab
- NASA Langley Research Center
- NASA Ames Research Center
- National Oceanic and Atmospheric Administration
- Naval Research Laboratory
- Los Alamos National Laboratory
- NASA Marshall Space Flight Center
- 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**

Breakthrough Technology Domain

Flight Validation Domain
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

1. **Identify and Capture Candidate Concepts**
   - See Fig. 6, and Fig. 7, Steps 1-5.

2. **Establish Teams to Study Concepts**
   - See Fig. 7, Steps 6-10.

3. **Study Concepts and Select One**
   - See Fig. 7, Steps 11-14.

4. **Formulate, Implement, Fly and Disseminate Results**
   - See Fig. 7, Steps 15-21.
NMP Pre-project Planning Process:
Technology Identification and Capture of Flight Validation Mission Concepts

Inform Non NASA Technical Community
(Other Government Agencies, Universities, Industry)

Opportunities for Involvement in Future NMP Missions:
Figures 7b, 7c

1. Compile Capability Needs and Specification Inventory (Theme Tech., NMP Assist.)

Input Technology
- NASA Strategic Plan
- Science Roadmaps
- Tech Pull Roadmaps

Input Emerging NASA Push Technology (Focused Technologies)
- NASA Tech. Inventory

2. Compile Flight Validation Candidate Technology Inventory (NMP)
   - Workshop
   - Technology List
   - Breakthru Tech.
   - Justification
   - Risk Identification
   - TRL level
   - Generic Nature

3. Combine Candidate Technologies w/ Capability Needs (NMP)
   - NMP Tech. Pool

4. Obtain Concurrence from Theme and Push Technologists (NMP)
   - Concurrence

5. Capture Candidate Concepts (NMP)
   - NMP Web Site

Key:
() Organization
- Output
- Constraint
NMP Process for Establishing Teams to Study Candidate Flight Validation Projects

1. Input Emerging Opportunities (NMP)
2. Input Programmatic Priorities/Constraints (HQ) Science Dir.

3. 6. Select Several Concepts (NMP Report - Approach - Bundling - Number of Flights - Risk Reduction
4. 7. Authorize Study of Concepts (HQ) Authority to proceed
5. 8. Establish Solicitation Guidelines (NMP) Prepare Announcement
7. 10. Review (HQ) Peer Concept Selection

8. 11. Assign Project Implementing Center (HQ)
9. 12. Study Concepts (NMP)
10. 13. Review (HQ)
11. 14. Select One Concept (HQ)
NMP Process for Flight Project Formulation, Implementation, Operation and Dissemination of Results

15. Solicit Spacecraft Provider (NMP)
16. Formulate Project (NMP)
17. Approve (HQ)
18. Implement Project (NMP)
19. Solicit Science Team (NMP)
20. Fly Project (NMP)
21. Disseminate Results (NMP)
Workshops
Risk Retirement
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**Validation Flight Launch Schedule**
Deep Space 1
System Level Validation of 12 Breakthrough Technologies

Ion Propulsion System
Hughes, Moog, LeRC, SAI, JPL

Small Deep Space Transponder

Motorola

Low Power Electronics
Georgia Tech., USC, MIT LL

Ka-Band
Solid State
Power Amplifier
Lockheed Martin, JPL

Multiphysical Structure
AFRL, Lockheed Martin

Miniature Integrated Camera Spectrometer
SSG, Rockwell, UofA, JPL

Plasma Experiment for Planetary Exploration
SwRI, LANL

Power Activation & Switching Module
Lockheed Martin

Remote Agent Architecture
ARC, CMU, TRW, JPL

BMD, AEC, Able Tech, LeRC
Entech

Biscon Monitor Operation
JPL, U of Colorado

Autonomous Onboard Optical Navigation
JPL
Deep Space 2
Technologies for surface penetrators and network science

Launch: January 3, 1999
Probe Entry: December 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.

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

Drill and Soil Acquisition System
JPL, Caltech, MicroMo Electronics

Lithium Ion Batteries
Yardney, Technical Products, JPL

Motor: Drill Assembly
Aftbody
Forebody
Earth Observer 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

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

Hyperion:
TRW, JPL, GSFC

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 Constellation Trailblazer 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

**Virtual Platforms**
For Science Missions

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

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

**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