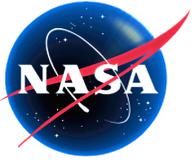


# **NEW MILLENNIUM PROGRAM**

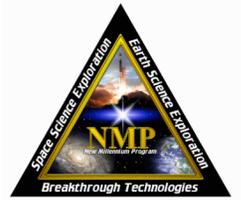
## **An Overview of NASA's New Millennium Program**

**American Society of Mechanical Engineers  
Western Michigan University  
March 17, 2005**

**John F. Stocky  
Chief Technologist  
New Millennium Program  
Jet Propulsion Laboratory  
California Institute of Technology**



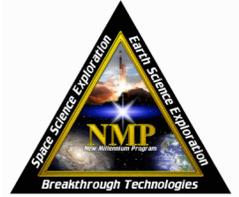
# An Overview of NASA's New Millennium Program



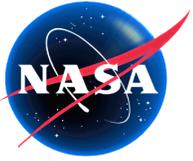
- **Why is the New Millennium Program needed?**
- **What is the New Millennium Program?**
- **What does the New Millennium Program try to accomplish?**
- **What is going on now?**
- **What is coming in the future?**



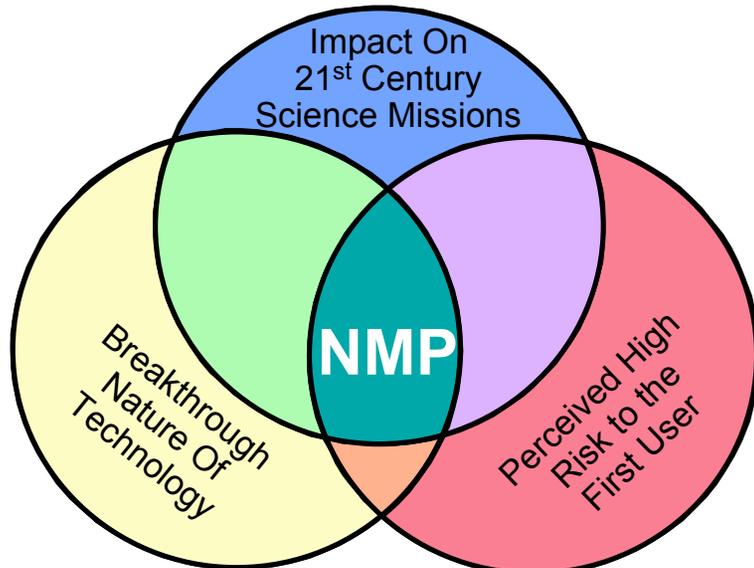
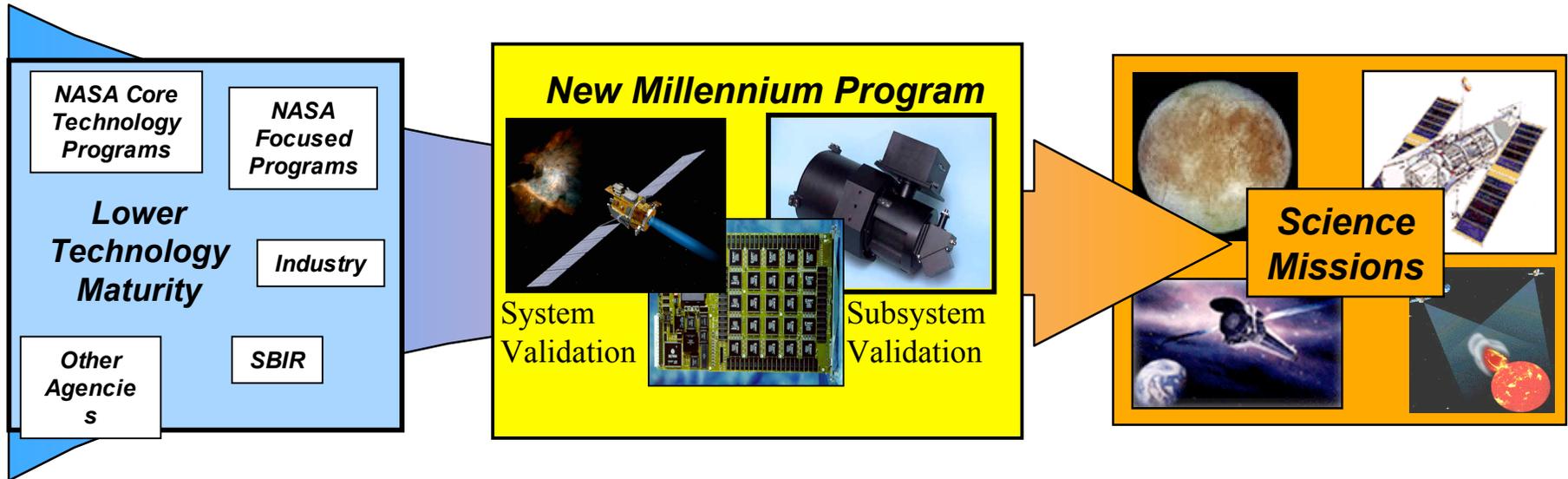
# Why Is the New Millennium Program Needed?



- **Advanced technology programs seldom are able to carry the technology advances they initiate beyond tests with breadboard hardware in a laboratory environment.**
  - **Address many topics and funds are limited**
  - **Testing with more “flight-like” hardware in “relevant” environments is expensive**
- **Flight project managers are risk adverse**
  - **Only willing to accept “unproven” hardware if it is essential to their mission**
  - **Want equipment that has flown on other missions successfully**
- **The resulting gap means that innovation on flight spacecraft proceeds slowly**
- **New Millennium Program is intended to bridge that gap and hasten the infusion of technological innovation**



# Flight Validation of Breakthrough Technologies to Benefit Future Space and Earth Science Missions

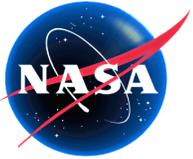


## Breakthrough technologies

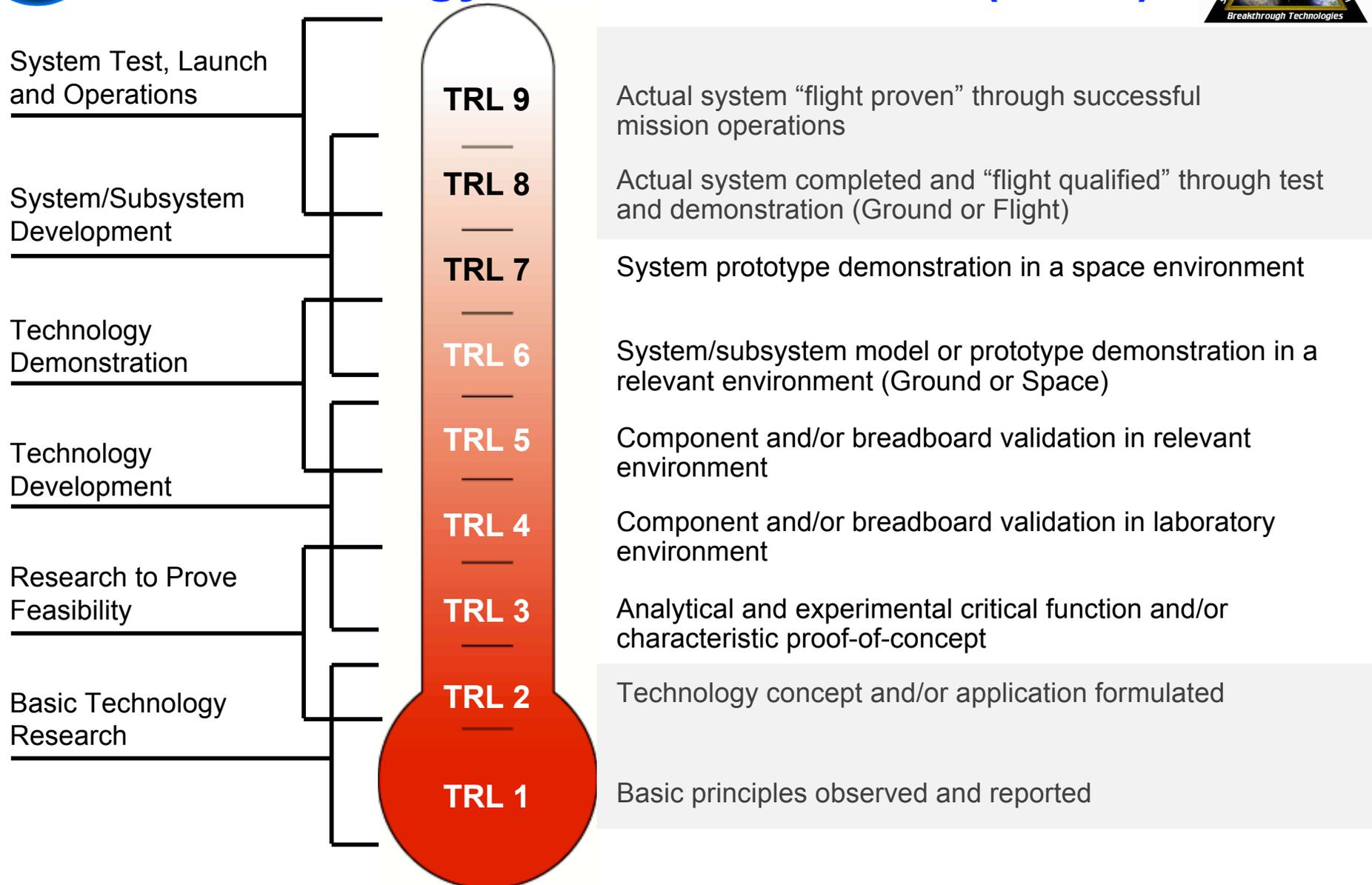
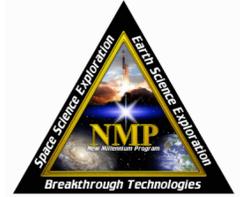
- Enable new capabilities to meet Earth and Space Science needs
- Reduce costs of future missions

## Flight validation

- Mitigates risks to first users
- Enables rapid technology infusion into future missions



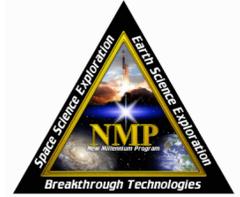
# New Millennium Program Technology Readiness Levels (TRLs)



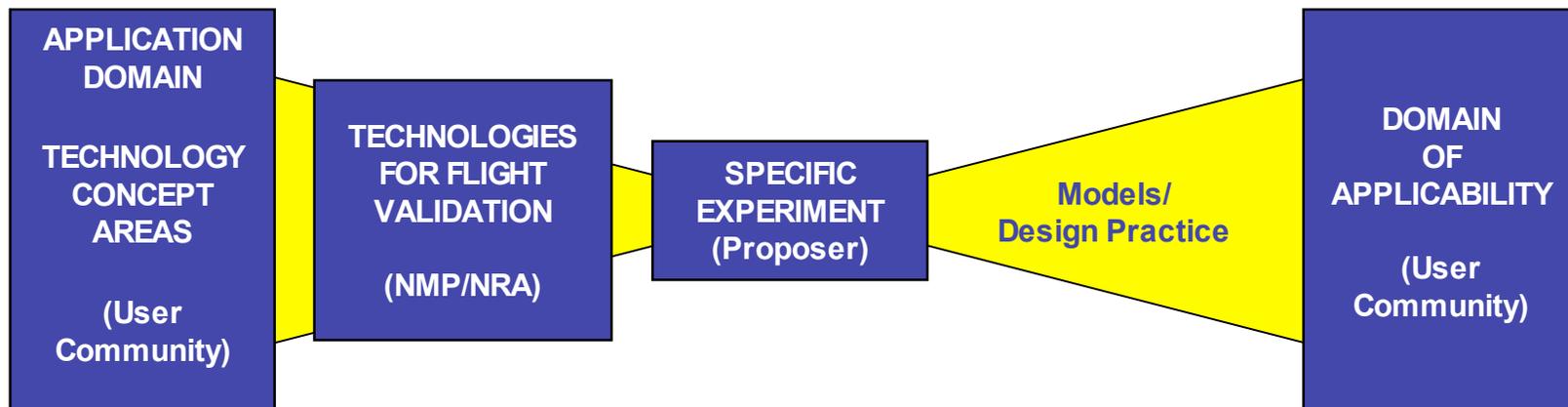


# New Millennium Program

## What Is Technology Validation?

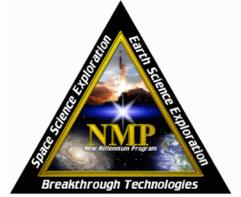


- **Validation, for the New Millennium Program,**
  - Empirical evidence that the physics associated with the technology advance are understood
- **Validation characteristics**
  - **Clear definition of the technology advance being validated**
  - **A model of the technology advance**
    - Model provides ability to predict and to scale to a variety of operational applications
  - **Combines data from ground and in-space tests**
    - Ground and in-space data combined validate or improve the model and our understanding
    - Data establish a pre-determined level of performance

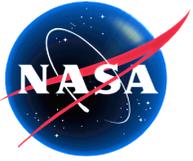




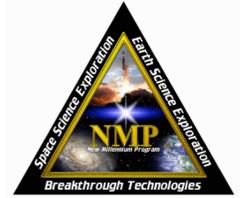
# What is the New Millennium Program?



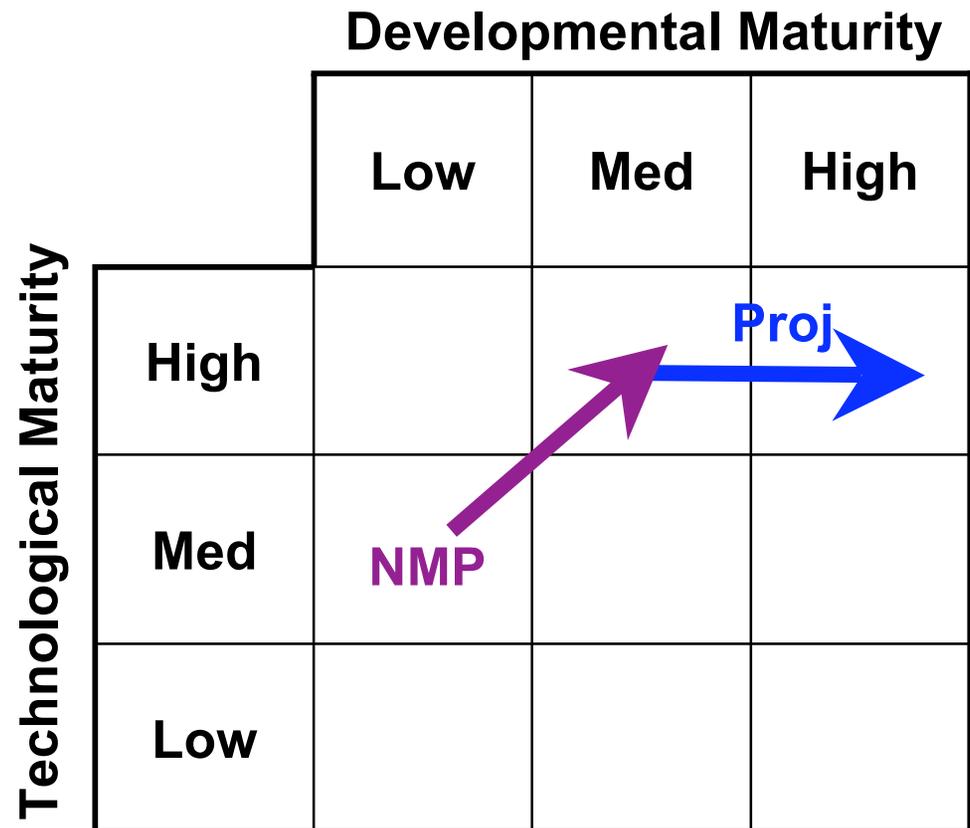
- **New Millennium Program was created to provide opportunities for in-space validation of advanced technologies**
  - **Three criteria:**
    - Is a “Breakthrough” technology advance
    - Has user interest
    - Requires in-space testing
  - **Result: mitigates the risk of first use**



# New Millennium Program Technology Maturity vs. Development Maturity



- **Technological Maturity**
  - Refers to our ability to understand how to design, build, and operate a device to achieve a desired capability and performance by implementing a specific approach
- **Developmental Maturity**
  - Refers to the degree to which a specific design to achieve a desired capability and performance has been qualified for space flight

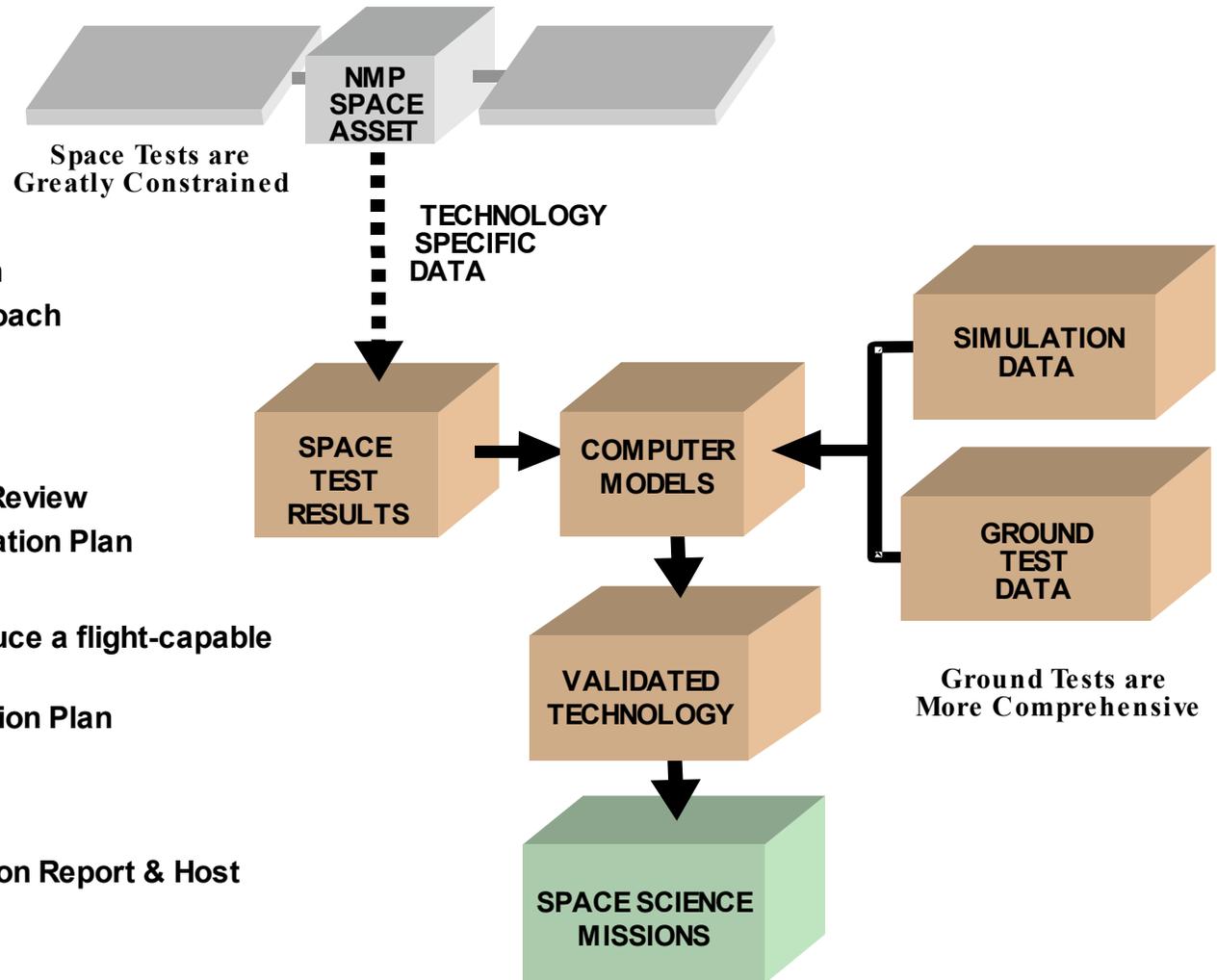




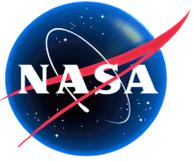
# New Millennium Program Technology Validation Is a Comprehensive Effort



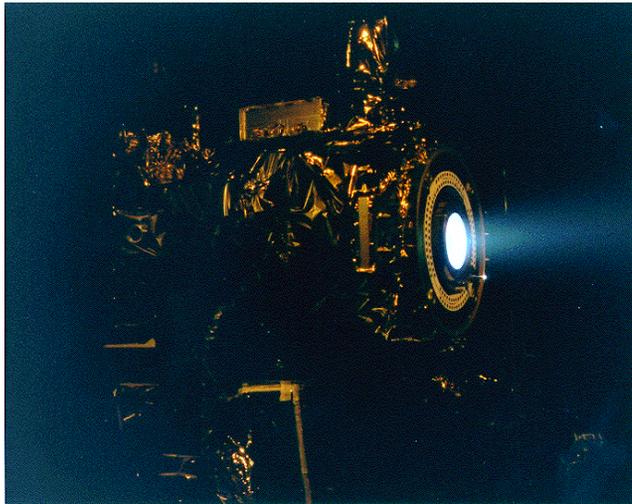
- **TRL 4 at end of Concept Definition Phase**
  - Site visit and demonstration
  - Overview of validation approach
- **TRL 5 at end of Formulation Refinement**
  - Technology Review Board
  - Confirmation Assessment Review
  - Approved Technology Validation Plan
- **Implementation Phase**
  - Demonstrate ability to produce a flight-capable article
  - **Execute Technology Validation Plan**
    - Ground Tests
    - In-Space Tests
    - Achieve TRL 6
  - **Publish Technology Validation Report & Host Workshop**







# DS1 and DS2



## DS1

### 12 Advanced Technology Experiments

- Solar Electric Propulsion
- Fully depleted SOI
- Mini-camera & Spectrometer
- Ion-Electron Spectrometer
- Remote Agent
- Conc. Solar Array
- Multi-Func Stru
- AutoNav
- Pwr. Switching
- Small DS X-ponder
- Ka S-S Amp
- Beacon Monitor

**Launch — October, 1998**

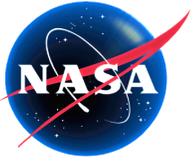
## DS2

### Validate design principles and practices for direct-entry Impactors (up to 60,000 g)

#### Mission

- Launch 1/99 on Mars Polar Lander
- Deploy at Mars approach
- No data

### Follow-on experiment to complete validation



## DS3 & DS4

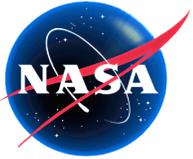


### DS3

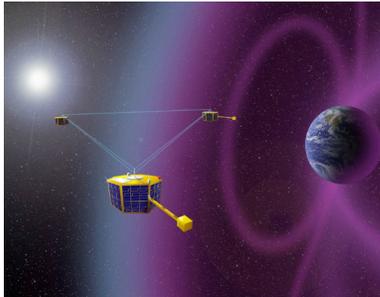
- **Project designed to validate the technologies necessary for precision formation flying**
- **Proved to be premature**
  - The necessary technological capability was not sufficiently mature to support an in-space experiment
- **Became a focused technology program within NASA's Origins program**

### DS4

- **Project designed to validate the advanced technologies necessary for a comet rendezvous and sample return mission**
- **Was made a NASA Project called Champollion**
- **Eventually cancelled due to cost growth.**

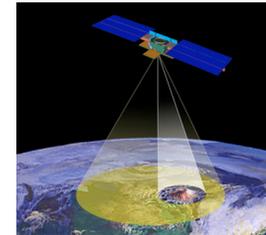


## ST5 and ST6



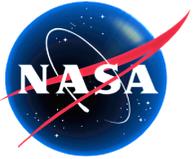
### ST5

- **Validate the technological capability to conduct scientific investigations from multiple spacecraft**
  - Three small spacecraft (25 kg)
  - '06 Launch to Polar Earth orbit
  - Measure the time varying curl of the Earth's magnetic field to validate the measurement concept
- **Validate the capability to develop small spacecraft capable of making science-quality measurements**

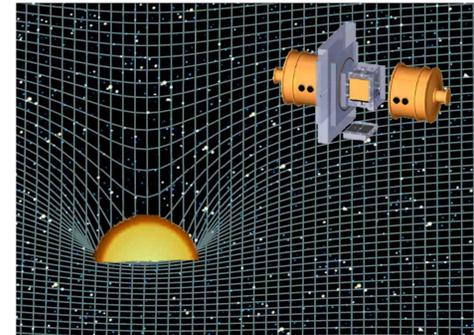


### ST6

- **First NMP subsystem-level validation project**
- **Originally selected 3 exp'ts**
  - Inertial Stellar Compass
    - Low mass, low power IMU
  - Autonomous Sciencecraft Exp't
    - On-board science planning
  - Autonomous Rendezvous Exp't
    - Cancelled
- **ASE validated on EO1 during FY04**
- **ISC will be hosted on USAF TechSat-2 ('06 Launch)**



# EO1 and ST7

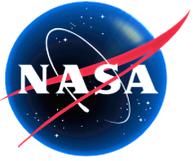


## EO1

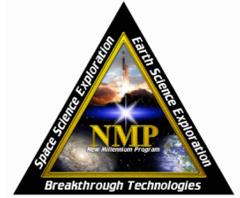
- **Launched 11/01**
- **Validated 10 advanced technologies**
  - Formation Flying GN&C
  - Pulsed Plasma Thruster
  - Adv. Rec. Processor
  - Adv. Land Imager
  - Hyperspectral Imager
  - Flex Solar Array
  - C-C Radiator
  - Fiber Optic Data Bus
  - Atmospheric Corrector
  - X-Band phased array antenna
- **Instruments have been in demand for Earth Observation**
- **Used in conjunction with AURA to perform coordinated observations**
- **Hosted ST6 ASE Validation Exp't**

## ST7

- **Disturbance Reduction System Validation Exp't**
- **Spacecraft follows a proof mass**
  - Validates ability to control a S/C such that it deviate from a purely gravitational trajectory by less than  $3 \times 10^{-14} \text{ m/s}^2 / \sqrt{\text{Hz}} \times (1 + [f/3 \text{ mHz}]^2)$  over a frequency range of 1 mHz to 30 mHz
- **Capability needed by LISA (US/European) mission to detect gravitational waves**
- **Launch in 2008**

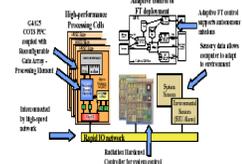
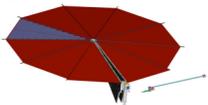


# ST8 and ST9

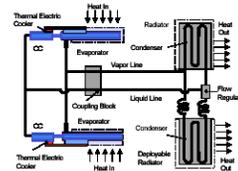


## ST8

- **Subsystem Technology Validation Project**
- **Four Experiments Selected**
  - SAILMAST Validation Exp't
  - COTS-Based High Throughput Computing Architecture
  - Next Generation Ultraflex
  - Miniature Loop Heat Pipe
- **In Formulation Refinement Phase**
- **Expected launch date FY'09**

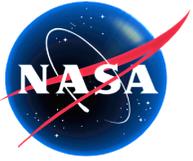


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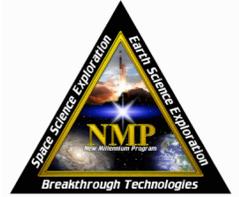


## ST9

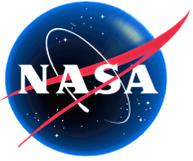
- **System Technology Validation Project**
- **Five Candidate Experiments**
  - Solar Sail
  - Large space Telescopes
  - Precision Formation Flying
  - Terrain-Guided Automatic Landing System
  - Aerocapture
- **In Concept Definition Phase**
  - At the end of the Concept Definition Study, one will be selected to develop an in-space validation experiment
- **Expected launch date FY'10**



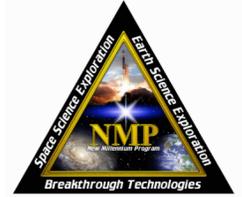
# What Is Coming in the Future?



- **Just now beginning:  
ST10 will be the New Millennium Program's next  
technology validation project**
  - **Third subsystem validation project**
  - **Initial activities**
    - Work with science and user communities to identify candidate areas in which to solicit validation experiments
      - Have high payoff potential
      - Require in-space tests to be validated
    - **NASA selects the 3 to 5 areas in which a formal solicitation will be made**
- **Continue bringing the ongoing projects to launch**
  - **ST5, ST6, ST7, ST8, ST9**



# New Millennium Program



- **Bridges the gap between advanced technology programs and operational science missions for high-payoff technology advances**
  - **Hastens the infusion of innovation by mitigating the cost and schedule risks associated with the first operational use of a technology advance**
- **Addresses the difficulties of simultaneously increasing technological maturity and developing flight hardware and software**
  - **Accepts higher risks**
  - **Operates in a lower cost environment**
  - **Develops special processes and procedures**
    - Provide experienced guidance and support
    - Identify difficulties early to contain costs