NASA's New Millennium Program: Validation of Advanced Technologies in Space

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Introduction

- New Millennium Program (NMP) is a space flight test program providing:
  - Flight validation of new technologies
  - Reduced risk and cost to NASA's Earth Observing and Space Science missions in the use of new technology.

- This talk will describe:
  - NMP process for technology selection.
  - Check List for the "strength of the validation".
NMP Program Overview

FORMULATION

Users
Code S Themes
Code Y
Technologists

Technology
Maturation and
Readiness
Assessment

Technology
Selection and
Project Formulation

IMPLEMENTATION

Partnering

Validation and
Infusion
Plan

Access-to-Space
Carrier Options

Validation
Flight:
System/Subsystem

FLIGHT/INFUSION

Flight
Validation Project

Technology
Infusion
Report and
Workshop

Earth and
Space Sciences
Missions

SPACE-FLIGHT VALIDATION OF ADVANCED TECHNOLOGIES
### NMP Flight History and Prospects

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- **DS1**: 10/9
- **DS2**: 01/9
- **EO1**: 11/0
- **ST5**
- **EO3**
- **ST6**
- **ST7**
- **ST8**

*One Flight Per Year*

*Two Flights Per Year*
Hallmark of NMP

- Technology maturation from TRL4 to TRL7:
  - Phase A Readiness Evaluation:
    - Sub-System Technologies: \(~\$0.5\text{M for 6 months}\)
    - System Technologies: \(~\$1\text{M for 6 months}\)

- Validate the best technology for NASA through open and fair competition:
  - Advanced technologies solicited via NRA call.

- Reduce flight cost by validating only critical pieces of technology.

- Low-cost flights:
  - Piggy-back approaches
NMP Technology Selection Process: Domain of Applicability

- Specific Experiment (Point Solution) must address a significant portion of the Domain of Applicability.

- The keys are:
  - Technology Scaling
  - Validated Computer Models
  - Well-Understood Design Practice
Each new technology has a different TRL and maturation path that is established early in the project with agreement of the NMP.
NMP Matures Technologies
Starting at TRL3/TRL4

TRL 9 Actual system flight proven through successful mission operations.
TRL 8 Flight System completed and qualified through test and demonstration.
TRL 7 System prototype demonstrated in a space environment.
TRL 6 System prototype demonstrated in a relevant environment.
TRL 5 Component and/or breadboard validated in relevant environment.
TRL 4 Component and/or breadboard validated in laboratory environment.
TRL 3 Critical function or characteristic demonstrated (POC = proof-of-concept).
TRL 2 Technology concept and/or application formulated.
TRL 1 Basic principles observed and reported.

• Issues in the use of TRLs:
  • TRL3 Proof-of-Concept Conundrum
  • H/W vs S/W TRL Definitions
  • Design Cycle Maturity vs Technology Maturity
  • Relevant Environment Definition and Characterization
  • Legalistic Use of TRLs
Flight Validation

- Space Tests are Greatly Constrained

NMP SPACE ASSET

TECHNOLOGY SPECIFIC DATA

SPACE VALIDATION RESULTS

MODELS

SIMULATION DATA

GROUND TEST DATA

EARTH AND SPACE SCIENCE MISSIONS

VALIDATION RESULTS

Ground Tests are More Comprehensive

- VALIDATION LINKS THESE ELEMENTS:
  - Ground Test
  - Computer Models
  - Space Test Results
Timeliness of the Flight Validation

Technology validation must occur in a critical time period in order to maximally impact missions.
Strength of the Technology Validation: Check List

• TRL UNDERSTANDING
  • Separation of design cycle maturity from technology maturity.
  • Establish the TRL for each technology and its maturation pathway.
  • Identification TRL graduation points (readiness gates)

• INTEGRATED TEST PLAN:
  • Plan for comparing ground test and computer model predictions with space test results.
  • Look for statistical approaches. (Can it be done more than once?)

• SCALABILITY:
  • Size of the domain of applicability and user community.

• TIMELINESS:
  • Impact of technology validation on science and/or earth observing missions?
CONCLUSIONS

- Well-in Hand:
  - Technology Selection Process
    - Strong Customer (Code S and Y) interactions
    - Six-month technology trial period
  - Validation vs Demonstration
    - Technology Scalability
    - Domain of Applicability
  - Design Maturity vs Technology Maturity

- Needs Work
  - S/W TRL definitions
  - Low-cost access to space
    - Partnerships
    - Piggy-back approaches
  - Relevant Environment Characterization