SPACE TECHNOLOGY RESEARCH PLANS

Presented by W. Ray Hook
Director for Space
NASA Langley Research Center

ABSTRACT

Development of new technologies is the primary purpose of the Office of Aeronautics and Space Technology (OAST). OAST's mission includes the following two goals: (l) to conduct research to provide fundamental understanding, develop advanced technology and promote technology transfer to assure U.S. preeminence in aeronautics and to enhance and/or enable future civil space missions: and (2) to provide unique facilities and technical expertise to support national aerospace needs.

OAST includes both NASA Headquarters operations as well as programmatic and institutional management of the Ames Research Center, the Langley Research Center and the Lewis Research center. In addition. a considerable portion of OAST's Space R&T Program is conducted through the flight and science program field centers of NASA. Within OAST, the Space Technology Directorate is responsible for the planning and implementation of the NASA Space Research and Technology Program.

The Space Technology Directorate's mission is "to assure that OAST shall provide technology for future civil space missions and provide a base of research and technology capabilities to serve all national space goals." Accomplishing this mission entails the following objectives:

- Identify, develop, validate and transfer technology to:
  - Increase mission safety and reliability
  - Reduce flight program development and operations costs
  - Enhance mission performance
  - Enable new missions
- Provide the capability to:
  - Advance technology in critical disciplines
  - Respond to unanticipated mission needs.

In-space experiments are an integral part of OAST's program and provides for experimental studies, development and support for in-space flight research and validation of advanced space technologies. Conducting technology experiments in space is a valuable and cost effective way to introduce advanced technologies into flight programs. These flight experiments support both the R&T base and the focussed programs within OAST.

SPACE TECHNOLOGY RESEARCH PLANS

OVERVIEW
PLANS

Presented To:
Space Station Freedom Utilization Conference

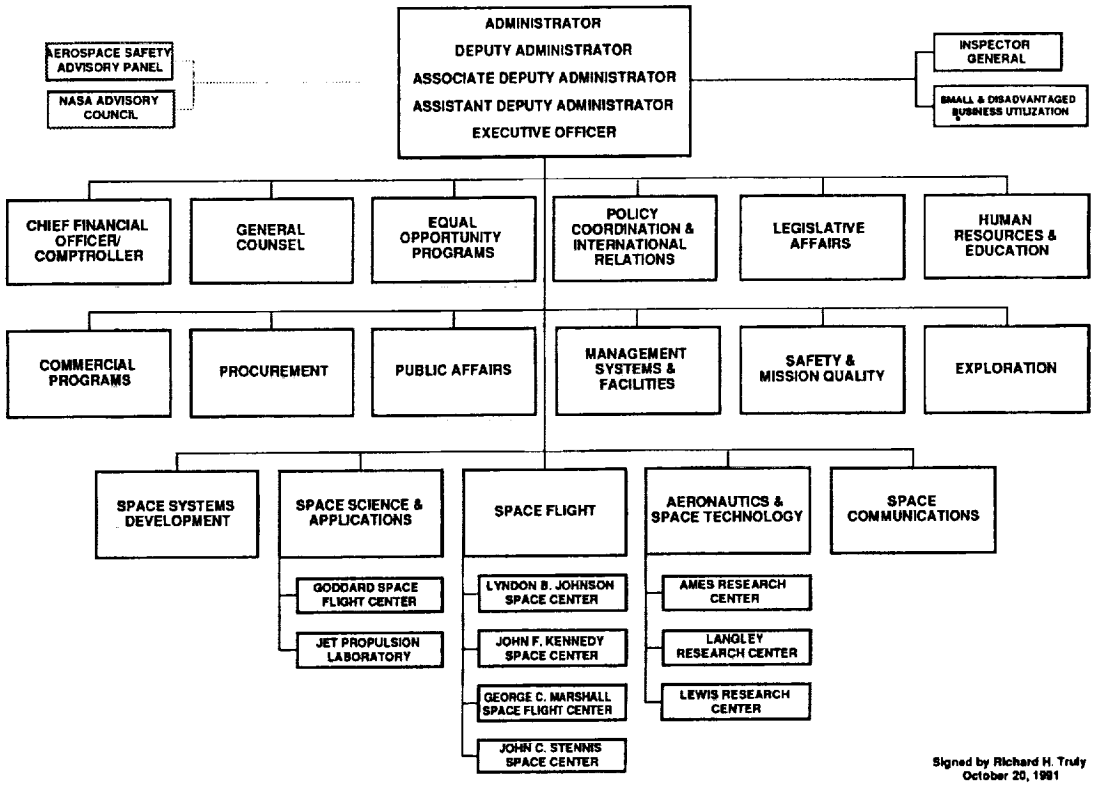
Presented by:
W. Ray Hook
Director, Space Directorate
Langley Research Center

For:
Office of Aeronautics and Space Technology

August 4, 1992

OAST
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



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OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

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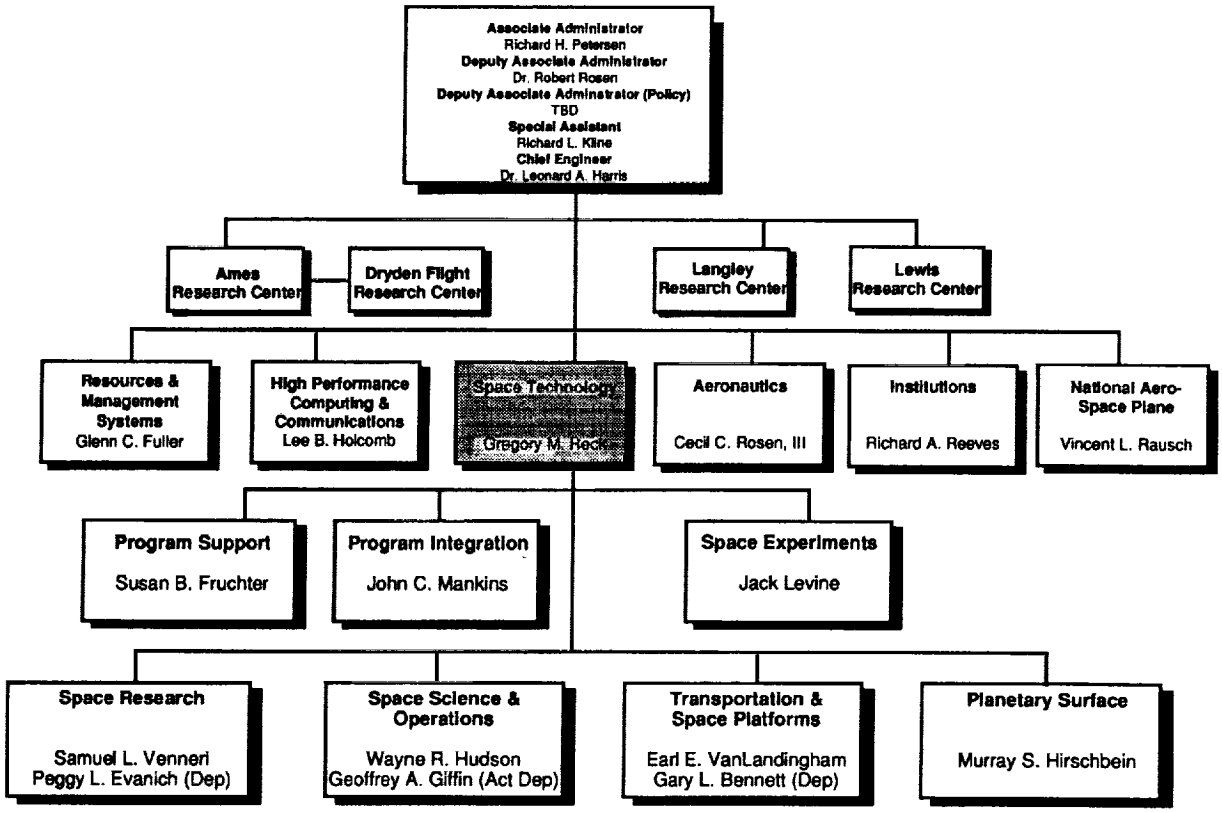


SPACE R&T VISION & MISSION STATEMENT

OAST

VISION

WORLD LEADERSHIP IN SPACE RESEARCH AND TECHNOLOGY DEVELOPMENT TO MAKE IT POSSIBLE TO LOOK BEYOND THE KNOWN, TO CHALLENGE THE LIMITS OF HUMAN CAPABILITY, TO INSPIRE THE GENERATION OF THE 21ST CENTURY, AND TO SECURE THE BENEFITS OF SPACE FOR LIFE ON EARTH

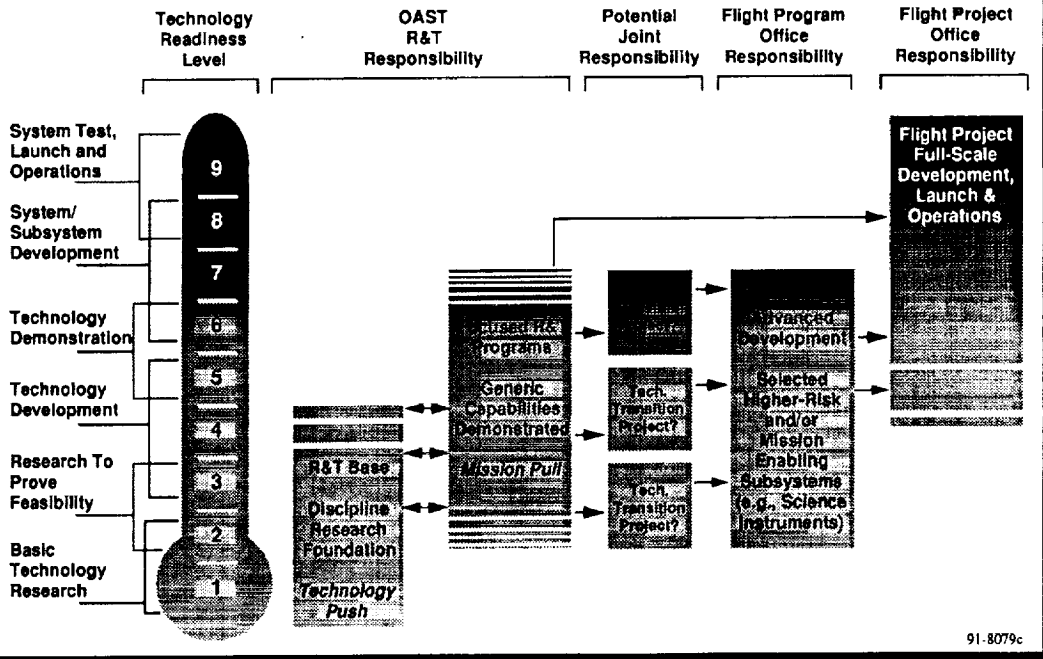
MISSION

OAST SHALL PROVIDE TECHNOLOGY FOR FUTURE CIVIL SPACE MISSIONS AND PROVIDE A BASE OF RESEARCH AND TECHNOLOGY CAPABILITIES TO SERVE ALL NATIONAL SPACE GOALS

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

TECHNOLOGY MATURATION STRATEGY

OAST



INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY

RESEARCH & TECHNOLOGY BASE

DISCIPLINE RESEARCH
Aerothermodynamics
Space Energy Conversion
Propulsion
Materials & Structures
Information and Controls
Human Support
Space Communications

UNIVERSITY PROGRAMS

SPACE FLIGHT R&T
IN SPACE TECHNOLOGY EXPTS

SYSTEMS ANALYSIS

CIVIL SPACE TECHNOLOGY INITIATIVE

SPACE SCIENCE TECHNOLOGY
Science Sensing
Observatory Systems
Science Information
In Situ Science
Technology Flight Expts.

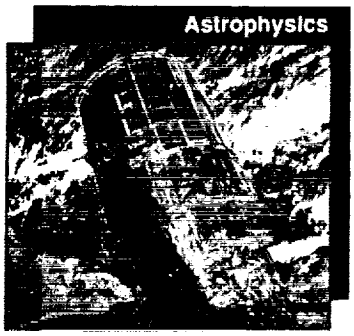
PLANETARY SURFACE TECHNOLOGY
Surface Systems
Human Support
Technology Flight Expts.

TRANSPORTATION TECHNOLOGY
ETO Transportation
Space Transportation
Technology Flight Expts.

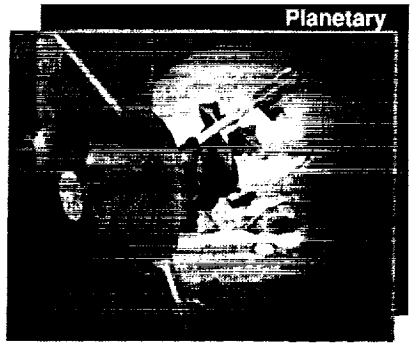
SPACE PLATFORMS TECHNOLOGY
Earth-Orbiting Platforms
Space Stations
Deep-Space Platforms
Technology Flight Expts.

OPERATIONS TECHNOLOGY
Automation & Robotics
Infrastructure Operations
Info. & Communications
Technology Flight Expts.

TECHNOLOGY CONTRIBUTIONS TO SCIENCE SPACECRAFT

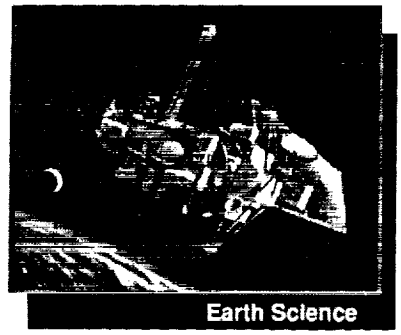


- Hubble - VLSI Data Processing
- Astro - Startracker
- Hubble - Battery Technology
- Hubble - Image Restoration



- Galileo (& Hubble) - CCD Array
- Voyager - Spacecraft Health Monitoring
- Magellan - Radar Ground Processor

- UARS - 205 GHz Limb Sounder Technology
- Shuttle Imaging Radar - SAR Technologies
- TOPEX - Millimeter Accuracy Laser Ranging



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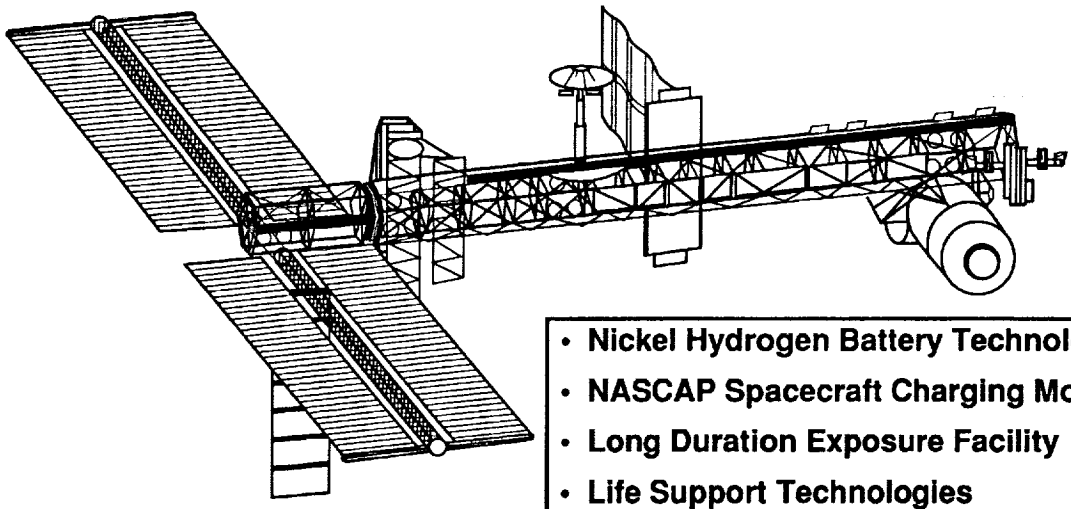
Office of Aeronautics and Space Technology

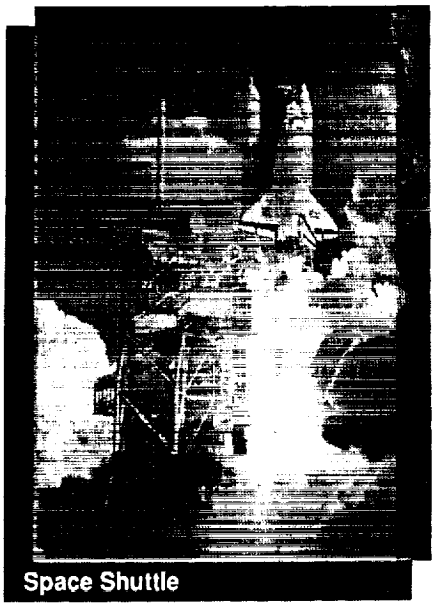
TECHNOLOGY CONTRIBUTIONS TO SPACE PLATFORMS



- Nickel Hydrogen Battery Technology
- NASCAP Spacecraft Charging Model
- Long Duration Exposure Facility
- Life Support Technologies
- Multipropellant Resistojet
- Large Area Solar Cells
- Arcjet Thruster

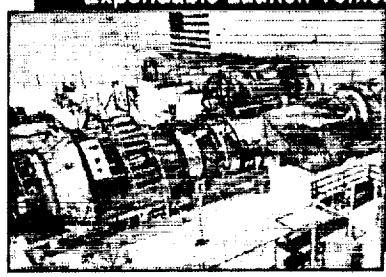
Office of Aeronautics and Space Technology

TECHNOLOGY CONTRIBUTIONS TO TRANSPORTATION


Space Shuttle

- Structural Analysis for Solid Rocket Motor (SRM) Redesign
- Vacuum Plasma Spray Coatings & Chambers
- Health Monitoring (Test Facilities)
- Thermal Protection System
- Bearing Cooling Analysis
- Real Time Data System
- Orbiter Experiments
- Damping Seals
- Modified Tires

Expendable Launch Vehicles



- Advanced Primary Battery

Office of Aeronautics and Space Technology

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UNIVERSITY SPACE ENGINEERING RESEARCH PROGRAM

UNIVERSITY-BASED CENTERS

- ATTRACT AND RETAIN STUDENT AND INDUSTRY SUPPORT
- SUPPORT AND EXPAND THE NATION'S ENGINEERING TALENT BASE
- FOSTER INNOVATIVE, MULTI-DISCIPLINARY RESEARCH

- UNIVERSITY OF ARIZONA
  - Planetary Resources
- UNIVERSITY OF CINCINNATI
  - Propulsion Monitoring Systems
- UNIVERSITY OF COLORADO, BOULDER
  - Space Construction
- UNIVERSITY OF IDAHO
  - VLSI hardware
- MASSACHUSETTS INSTITUTE OF TECHNOLOGY
  - Controlled Structures Technology
- UNIVERSITY OF MICHIGAN
  - Space TeraHertz Sensing Technologies
- NORTH CAROLINA STATE AT RALEIGH & NORTH CAROLINA AGRICULTURAL & TECHNICAL STATE UNIVERSITIES
  - Mars Mission Technologies
- PENNSYLVANIA STATE UNIVERSITY
  - Propulsion
- RENSSELAER POLYTECHNIC INSTITUTE
  - Robotics

91-2118

SPACE R&T PROGRAM

20-YEAR STRATEGIC VISIONS

Space Science

- Technologies Will Be Ready To Enable Low Mass, Facility Class Single Aperture And Interferometric Space-Based Observatories Across The EM Spectrum; To Conduct Cost-Effective, Long Term Remote Sensing; To Make Complex, But Frequent *In Situ* Scientific Studies In Space Laboratories, On The Moon & At The Planets; And, To Enhance Human Understanding Of Extremely Large Science Data Sets

Planetary Surface

- The Technology Will be Completed To Emplace Safe and Permanent, Largely Self-Sufficient Human Outposts On The Moon Or Mars, With Capabilities For Extensive Surface Exploration & Science, And Resource Exploitation Operations

Transportation

- Capabilities Will be In Hand To Enable Safe, Highly Operable Reusable Piloted Vehicles For ETO Transport; Low Cost, Reliable Expendable ETO Vehicles For Small, Medium & Large Payloads (Including Internationally Competitive ELVs); And Long Life, High Performance Space Transfer Systems That Enable Human Exploration Of The Moon and Mars, And Ambitious Deep Space Robotic Missions

Space Platforms

- Technologies Will Be Ready For Long Lived, Earth Orbiting Platforms With Significantly Reduced Masses and Costs, But Increased Payload Capabilities (Manned & Unmanned); And, For Reduced Mass, High Reliability Spacecraft For Long-Duration Deep Space Science & Exploration Mission Applications

Operations

- New Technology Will Make Possible Largely Autonomous Ground, Flight & In-Space Systems That Reduce The Costs Of Civil Space Mission Operations And Infrastructure, While Improving Their Safety & Reliability, Enabling More Complex Capabilities, And Massively Increasing Mission Data Returns

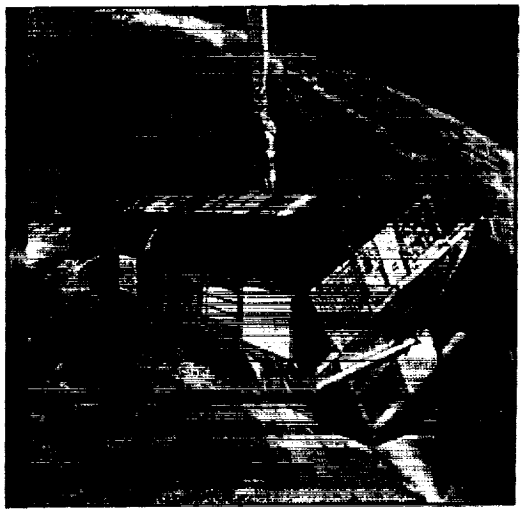
Innovative Discipline Research

- Innovative, High-Leverage Concepts Will Be Validated Analytically & In Laboratory Research That Make Possible "Next Generation" Earth & Space Science, Exploration, Commercial , And Infrastructure Missions

thrust visions — JUNE 22, 1992

SPACE FLIGHT RESEARCH & TECHNOLOGY

PROVIDE FOR EXPERIMENT STUDIES, DEVELOPMENT AND SUPPORT FOR IN-SPACE FLIGHT RESEARCH AND VALIDATION OF ADVANCED SPACE TECHNOLOGIES



- IN-SPACE TECHNOLOGY EXPERIMENT PROGRAM (IN-STEP)
  - DESIGN, DEVELOP AND FLIGHT TEST INDUSTRY, UNIVERSITY AND NASA TECHNOLOGY FLIGHT EXPERIMENTS
- FLIGHT OPPORTUNITIES VIA
  - SPACE SHUTTLE
  - EXPENDABLE LAUNCH VEHICLES
  - SPACE STATION FREEDOM

Past Flight Experiments

Experiment Name	Launch Date	Carrier
Capillary Loop Pump	1/86	STS-61C
Assembly Concept for Construction of Erectable Space Structure	11/85	STS-41D
Superfluid Helium	7/85	STS-51F
Drop Dynamics	4/85	STS-51B
Feature Ident. & Location Exp	10/84	STS-41G
Dynamics Augmentation Exp/ Photogrammetry	8/84	STS-41D
Solar Array Flight Exp	8/84	STS-41D
Solar Cell Calibration Exp	8/84	STS-41D
Long Duration Exposure Facility	4/84	STS-41C
Tribology Experiment	11/83	STS-41A
Thermal Control Exp	8/83	STS-31D
Thermal Canister	11/81	STS-2
Multi-Purpose Furnace System	11/73	Skylab 4
Zero-G Flammability	11/73	Skylab 4
Copper Aluminum Eutetic Exp.	7/73	Skylab 3
Growth of Spherical Crystals	7/73	Skylab 3
Immiscible Alloy Compounds	7/73	Skylab 3
Indium Antimonide Crystal Exp	7/73	Skylab 3
Metal Halide Eutectics Exp.	7/73	Skylab 3
Mixed III-V Crystal Growth	7/73	Skylab 3
Microsegregation in Germanium	7/73	Skylab 3
Radioactive Tracer Diffusion	7/73	Skylab 3
Silver Grids Melted in Space	7/73	Skylab 3

Experiment Name	Launch Date	Carrier
Vapor Growth in II-VI Compounds	7/73	Skylab 3
Whisker Reinforced Composites	7/73	Skylab 3
Astronaut Maneuvering Equip.	4/73	Skylab 1/2
Coronograph Contamination Measurement	4/73	Skylab 1/2
ATM Contamination Experiment	4/73	Skylab 1/2
Exothermic Brazing Experiment	4/73	Skylab 1/2
Foot Control Maneuvering Unit	4/73	Skylab 1/2
Gallinium Arsenide Crystal Growth	4/73	Skylab 1/2
Inflight Aerosol Analysis	4/73	Skylab 1/2
Materials Processing Facility	4/73	Skylab 1/2
Metals Melting Experiment	4/73	Skylab 1/2
Radiation in Spacecraft Exp.	4/73	Skylab 1/2
Spacecraft Surfaces Exp.	4/73	Skylab 1/2
Sphere Forming Experiment	4/73	Skylab 1/2
Thermal Control Coating Exp.	4/73	Skylab 1/2
Planetary Atmosphere Exps. Test	6/71	Scout
Orbiting Frog Otolith Experiment	11/70	Scout
Space Electric Rocket Test	2/70	Thorad-Agena
Horizon Definition Research Project	8/66	Scout
Pegasus	2/65	Saturn 1
Flight Investigation Reentry Environment	4/64	Atlas-Antares
Scout Reentry Heating Project	3/62	Scout
Radio Attenuation Measurement	8/61	Hybrid RAM

SPACE EXPERIMENTS PROGRAM

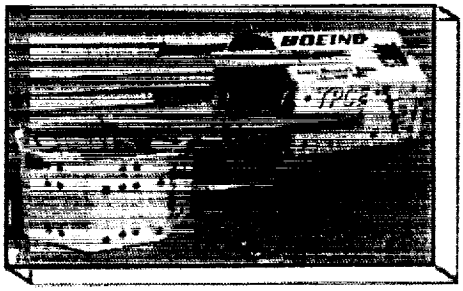
OAST — SCOPE

- IN-SPACE EXPERIMENTS ARE AN INTEGRAL PART OF OAST'S PROGRAM
  - TO OBTAIN DATA THAT CAN NOT BE ACQUIRED ON THE GROUND
  - TO VALIDATE/DEMONSTRATE CERTAIN ADVANCED TECHNOLOGIES
    - FEASIBILITY/PROOF OF CONCEPT
    - SENSOR/COMPONENT QUALIFICATION
- FLIGHT EXPERIMENTS SUPPORT BOTH THE R&T BASE AND THE FOCUSSED PROGRAMS

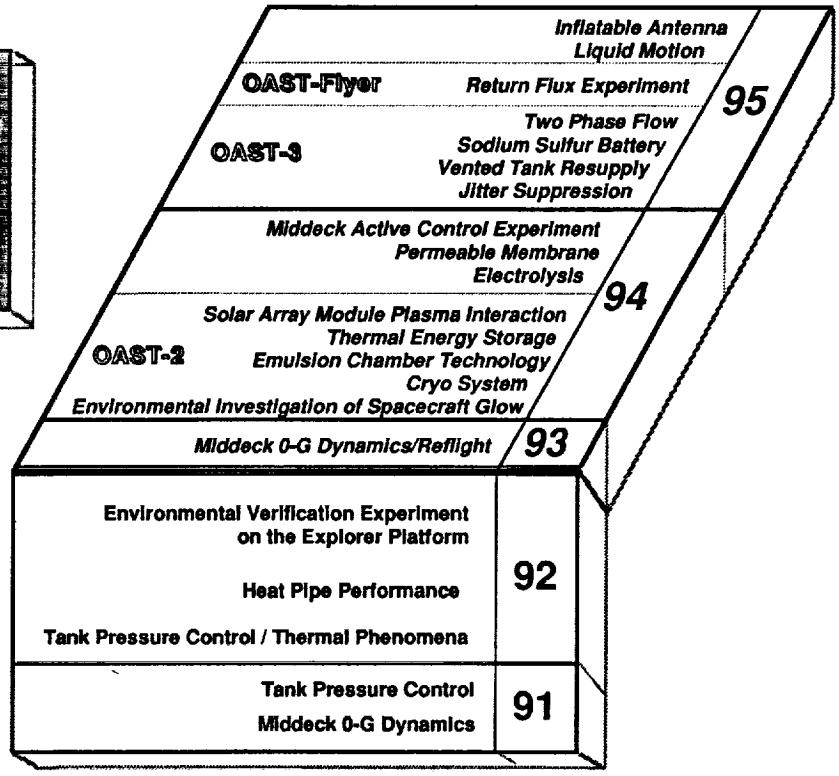
CONDUCTING TECHNOLOGY EXPERIMENTS IN SPACE IS A VALUABLE AND COST EFFECTIVE WAY TO INTRODUCE ADVANCED TECHNOLOGIES INTO FLIGHT PROGRAMS

IN-SPACE TECHNOLOGY EXPERIMENTS

Tank Pressure Control



MODE



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MIDDECK 0-GRAVITY DYNAMICS EXPERIMENT (MODE)

MASSACHUSETTS INSTITUTE OF TECHNOLOGY / LaRC

OBJECTIVE:

- TO MEASURE MECHANICAL DYNAMICS OF A JOINTED TRUSS STRUCTURE AND THE SLOSH DYNAMICS OF FLUIDS IN LOW GRAVITY

ACCOMPLISHMENTS:

- COMPLETED STRUCTURAL AND FLUID DYNAMICS TEST OBTAINING 300 MILLION DATA POINTS
  - FOUND NEW MODAL RESONANCES THAT HAD NOT BEEN PREDICTED FROM MODELS DERIVED FROM GROUND BASED DATA
  - FOUND GREATER VISCOSITY EFFECTS THAN MODELS PREDICTED

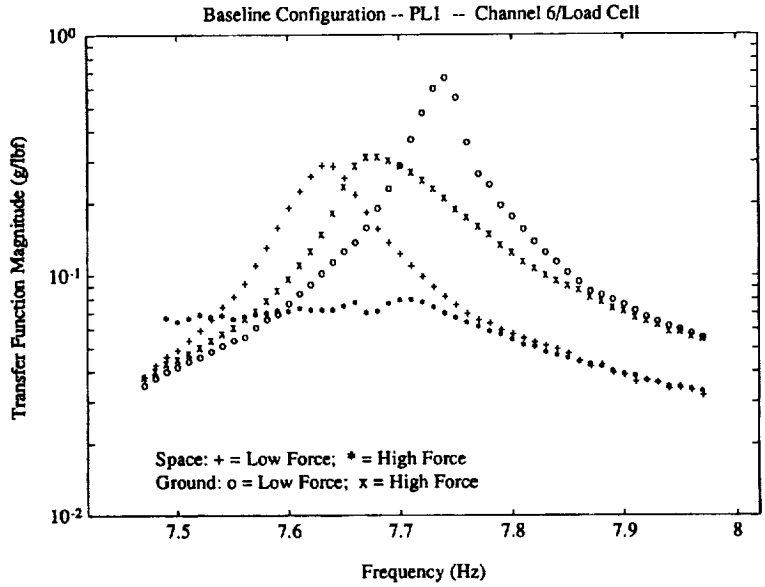
BENEFITS:

- ADVANCES DESIGN CAPABILITIES FOR:
  - PRECISION CONTROLLED LARGE SPACE STRUCTURES
  - LARGE FLUID MASS FRACTION SPACECRAFT

FIRST FLIGHT STS-48 (MIDDECK)
SEPTEMBER 1991
TOTAL COST: $2.1M
TOTAL WEIGHT: 135 LBS.

92-8043

GROUND VS. FLIGHT RESULTS FOR STA TORSION MODE



TANK PRESSURE CONTROL EXPERIMENT (TPCE) BOEING AEROSPACE CO. AND LeRC

OBJECTIVES

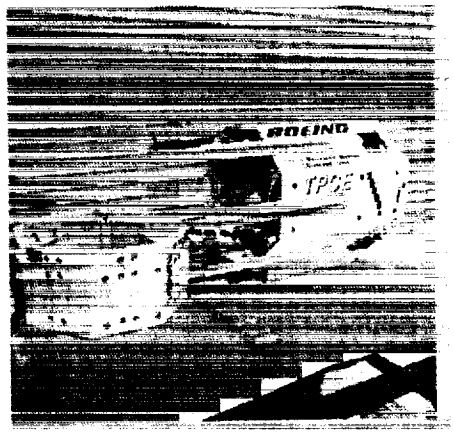
- INVESTIGATE JET MIXING AS A MEANS OF PRESSURE CONTROL OF CRYOGENIC FLUIDS

ACCOMPLISHMENTS:

- VERIFIED THAT JET-INDUCED FLUID MIXING TECHNOLOGY IS AN EFFECTIVE PRESSURE CONTROL TECHNIQUE FOR CRYOGENIC TANKS IN LOW GRAVITY
- OBTAINED EXCELLENT VIDEO DATA ON THE FLUID DYNAMICS OF JET MIXING FOR COMPARISON WITH DROP TOWER RESULTS AND NUMERICAL PREDICTIONS
- OBTAINED EXTENSIVE LOW-GRAVITY TEMPERATURE/PRESSURE DATA FOR DETERMINATION OF FLUID MIXING TIMES

BENEFITS:

- CONTINUOUS OR PERIODIC MIXING
  - MAKES FLUID STATE MORE PREDICTABLE
  - REDUCES POTENTIAL FOR SUDDEN PRESSURE CHANGES (WEIGHT & SAFETY IMPACT)
- DATA BASE INCREASES CONFIDENCE IN SIZING MIXERS FOR CRYOGENIC APPLICATIONS

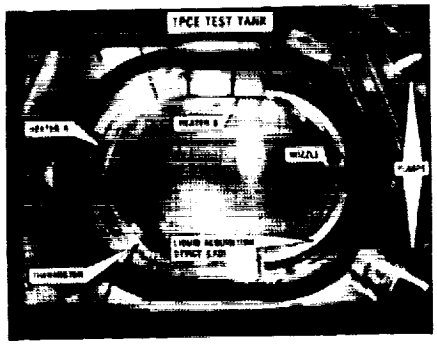


FIRST IN-STEP EXPERIMENT
FLOWN IN A G.A.S. CANISTER ON STS. 43
AUGUST, 1991
TOTAL COST: $1.7M
TOTAL WEIGHT: 186 LB

TANK PRESSURE CONTROL EXPERIMENT (TPCE)
STS-43 AUGUST 1991

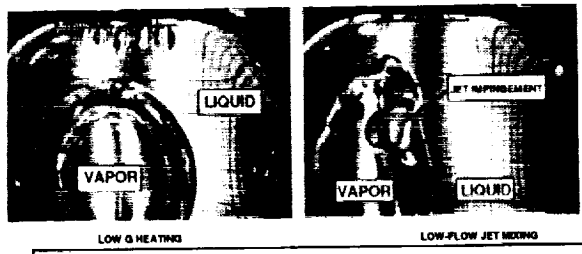
DESCRIPTION

- LOW-G FLUID MXING EXPERIMENT ON STS
- FREON IN A PLEXIGLASS TANK IS THERMALLY STRATIFIED BY HEATERS CAUSING THE PRESSURE TO RISE
- THEN MIXED BY AN AXIAL JET MIXER TO EQUILIBRATE
- TEMPERATURE, PRESSURE, AND VIDEO DATA



RESULTS

38 TEST RUNS WITH 4 HOURS OF EXCELLENT VIDEO



LOW G HEATING — LOW-FLOW JET MIXING

PRELIMARY CONCLUSIONS

- FLOW PATTERN WITH CLOSED GEYSER, SHOWN ABOVE, PROVIDES EFFECTIVE PRESSURE CONTROL AND IS MOST EFFICIENT
- THERMAL EQUILIBRATION TIMES AND PRESSURE REDUCTION TIMES IN GENERAL AGREEMENT WITH CERTAIN MODELS
- LOW ENERGY JETS PROVIDE EFFECTIVE AND EFFICIENT PRESSURE CONTROL

ORBITAL ACCELERATION RESEARCH EXPERIMENT (OARE)

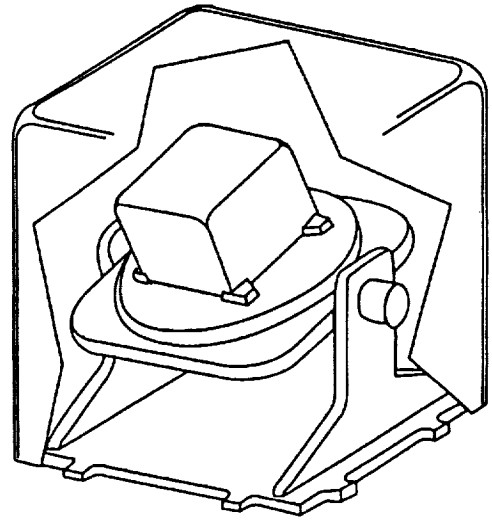
LANGLEY RESEARCH CENTER

OBJECTIVE:

- ACCURATE MEASUREMENT OF AERODYNAMIC ACCELERATION ALONG THE ORBITER'S PRINCIPAL AXES IN THE FREE MOLECULAR FLOW REGIME AND THROUGH THE TRANSITIONAL FLOW REGIME DURING REENTRY

APPROACH:

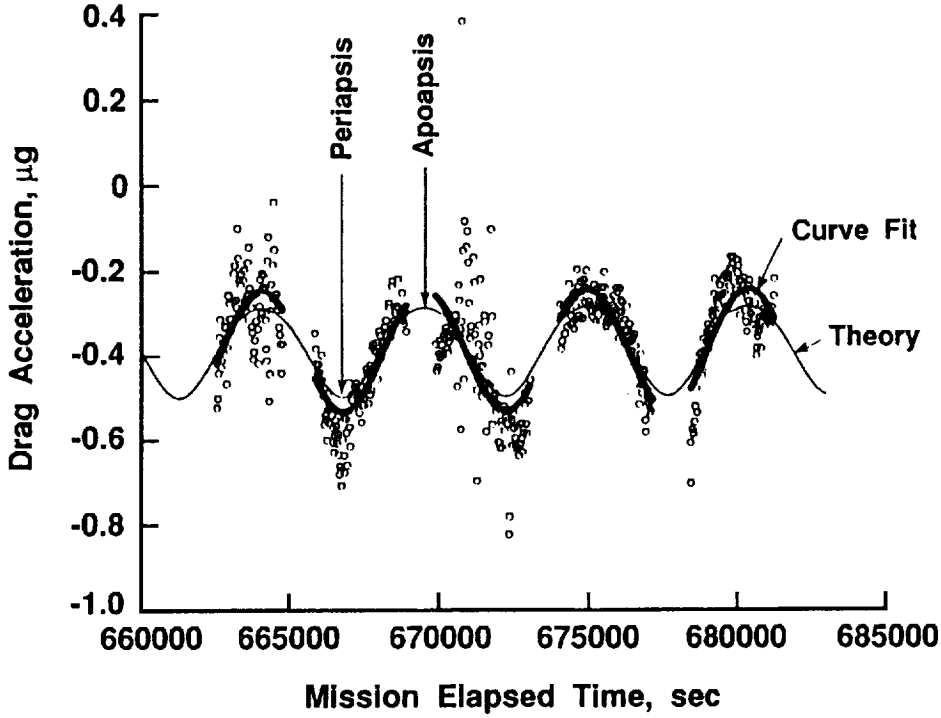
- MEASURES LINEAR ACCELERATIONS (10-9g) IN THE PRESENCE OF ORBITER STRUCTURAL VIBRATION NOISE
- UTILIZES THREE AXIS ELECTROSTATIC ACCELEROMETERS WITH ON-ORBIT CALIBRATION CAPABILITY
- INSTALLED ON THE KEEL BRIDGE FITTING IN THE PAYLOAD BAY
- OPERATIONAL ON OV-102 FLIGHTS 6/92 (STS-50), 6/93 (STS-58)



APPLICATION:

- DETERMINATION OF ORBITAL DRAG WHICH PROVIDES DESIGN SPECIFICATIONS FOR ORBIT MANAGEMENT AND MAINTENANCE SYSTEM FOR THE SSF
- PROVIDES AERODYNAMIC DESIGN DATA FOR ADVANCED AEROMANEUVERING SPACE TRANSFER VEHICLES
- EXPAND KNOWLEDGE OF MICROGRAVITY ENVIRONMENT NEEDED FOR THE CONDUCT OF MICROGRAVITY EXPERIMENTS

OARE SENSES PERIODIC ORBITAL DRAG VARIATION

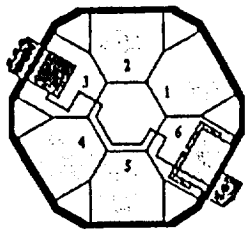


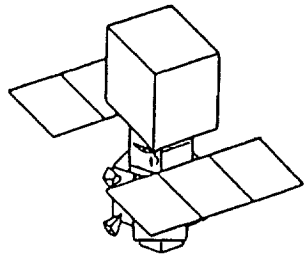
ENVIRONMENTAL VERIFICATION EXPERIMENT FOR THE EXPLORER PLATFORM (EVEEP)

GODDARD SPACE FLIGHT CENTER

OBJECTIVE:

- VERIFY ACCURACY OF CONTAMINATION MODELING PROGRAMS





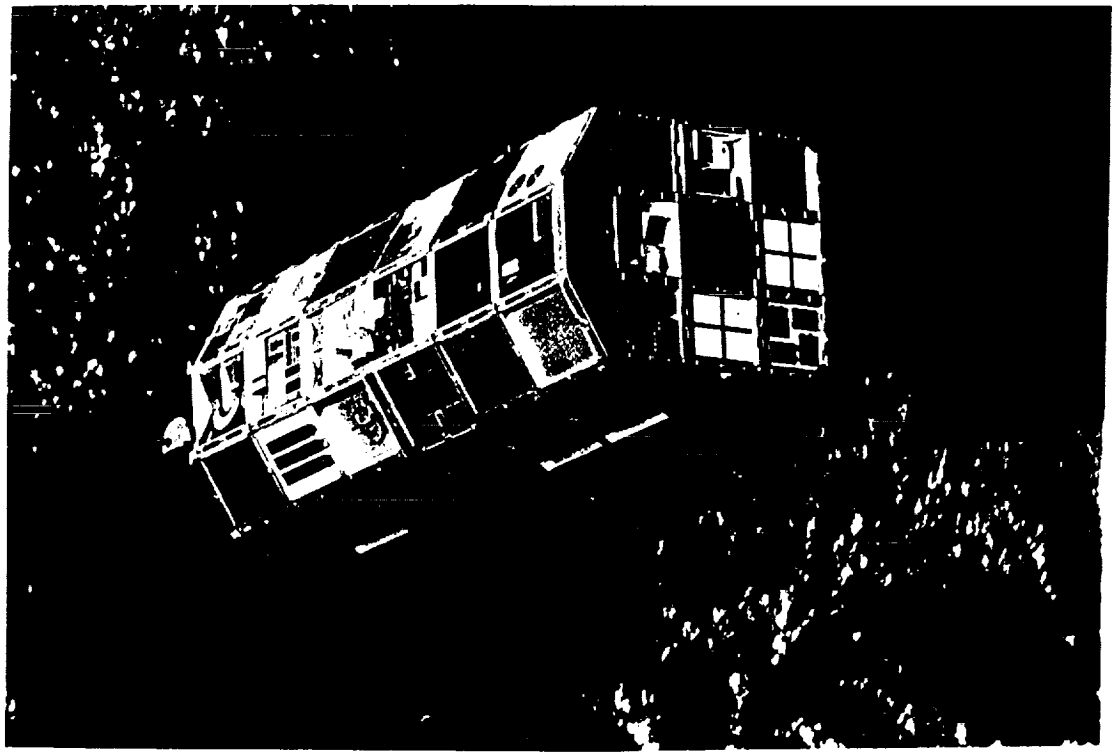
APPROACH:

- FLY TQCM'S ON SPACECRAFT FOR WHICH DETAILED CONTAMINATION MODELS EXIST (EUVE/EXPLORER PLATFORM)
- FLY BOTH TEFLON-COATED AND UNCOATED TQCM'S IN SUN AND SHADE ORIENTATIONS
- FLIGHT DATE: 6/92 DELTA II (EXPLORER PLATFORM)

APPLICATION:

- FLIGHT RESULTS WILL BE USED TO IMPROVE UNDERSTANDING OF SYNERGISTIC EFFECTS OF UV RADIATION AND ATOMIC OXYGEN ON MATERIALS (TEFLON) AND THE UNDERSTANDING OF VOLATILE MATERIAL DEPLETION MECHANISMS

LDEF IN ORBIT



MAJOR RESULTS OF LDEF FLIGHT EXPERIMENTS

- Meteoroid and debris impacts are not random but affected by meteor showers and space operations
- LDEF data being used to upgrade Meteoroid Model SP-8013 for distribution, velocity, directionality, and surface degradation
- LDEF ionizing radiation studies show induced radioactivity not a significant hazard for Space Station Freedom
- LDEF ionizing radiation data being used to establish crew shielding requirements for Space Station Freedom
- No LDEF systems-level failures attributed to natural LEO environment
- LDEF data established long-term degradation rates for polymeric materials, coatings, composites, and reactive metals in the LEO environment
- LDEF verified that some coatings and materials are resistant to atomic oxygen and UV in the LEO environment

SPACE EXPERIMENTS PROGRAM

OAST
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

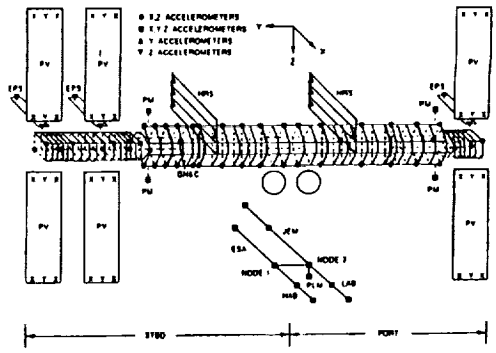
SSF PLANNING

- PURPOSE
  - TO ENSURE THAT ADEQUATE SSF RESOURCES WILL BE AVAILABLE FOR OAST USE
- APPROACH
  - DEVELOP TRAFFIC MODEL BASED ON PROJECTED USE
  - DEVELOP REQUIREMENTS FOR DESIGN AND DEVELOPMENT
  - SUPPORT SSF UTILIZATION ACTIVITIES AS REQUIRED
  - SUPPORT BY LaRC, SPACE STATION FREEDOM OFFICE
- STATUS
  - OAST HAS BEEN ALLOCATED 12% OF THE U.S. SHARE OF ALLOCATABLE RESOURCES ON SSF
  - COMPLETED FIRST ANNUAL INPUT TO THE SSF "PARTNER UTILIZATION PLAN" BASED ON TRAFFIC MODEL
- MAJOR NEAR TERM ACTIVITY
  - USE RESULTS OF NEXT A.O. TO PREPARE NEXT YEAR'S INPUT TO "PARTNER UTILIZATION PLAN"

MODAL IDENTIFICATION EXPERIMENT
LANGLEY RESEARCH CENTER

OBJECTIVE:

- CHARACTERIZE THE STRUCTURAL DYNAMICS OF SPACE STATION FREEDOM AND REFINE MODELING TECHNIQUES FOR FUTURE LARGE SPACE STRUCTURES



APPROACH:

- UTILIZING SPACE STATION FREEDOM HARDWARE TO THE LARGEST EXTENT POSSIBLE WITH THE ADDITION OF OAST SUPPLIED INSTRUMENTATION TO FIT RESEARCH NEEDS, MEASURE SYSTEM MODES IN RESPONSE TO EXCITATION

APPLICATION:

- ON-ORBIT VERIFICATION OF FUTURE LARGE, FLEXIBLE SPACE STRUCTURES FOR SCIENCE AND EXPLORATION

OAST ANNOUNCEMENT OF OPPORTUNITY

SPACE EXPERIMENTS PROGRAM

- PURPOSE

  TO SOLICIT PROPOSALS FOR EXPERIMENTS IN THE TECHNOLOGY CATEGORIES

  - SPACE MATERIALS, COATINGS, AND ENVIRONMENTAL EFFECTS
  - CRYOGENIC FLUID HANDLING
  - HUMAN SUPPORT
  - SPACE POWER
  - IN-SPACE CONSTRUCTION, REPAIR, AND MAINTENANCE
  - SCIENCE SENSORS AND SENSOR COOLING
  - VIBRATION ISOLATION
  - SPACE COMMUNICATION

- APPROACH
  - APPROXIMATELY FIFTY PROPOSALS SELECTED BY RIGOROUS REVIEW PROCESS FOR PHASE A
  - DOWN-SELECTION TO PHASE B, LEADING TO NON-ADVOCATE REVIEW
  - NEW EXPERIMENTS READY FOR FLIGHT STARTING 1997
  - ANY SUITABLE CARRIER UTILIZED, INCLUDING SSF, SHUTTLE, ELV

- STATUS
  - EXPECTED RELEASE IN AUGUST