# NASA Space Research & Technology Overview (ITP)

**Presentation to:**

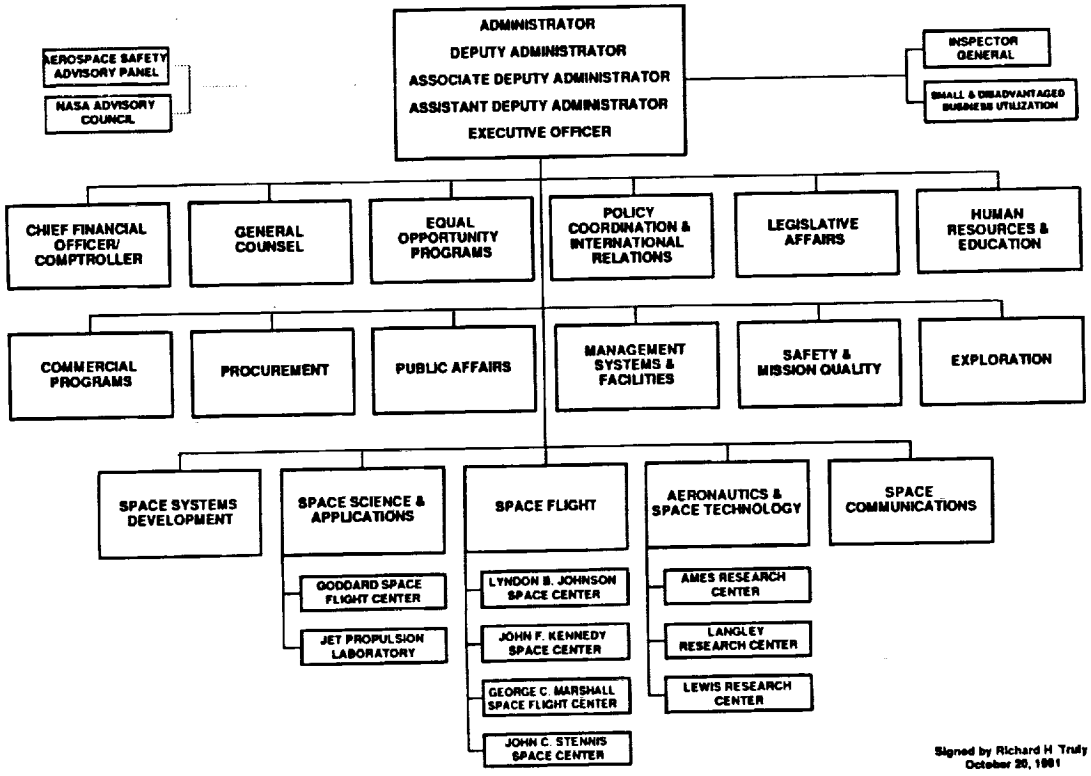
**Civil Space Technology Development Technology Transfer Workshop**

**Gregory M. Reck**
**Director for Space Technology**
**Office of Aeronautics and Space Technology**

**March 17, 1992**

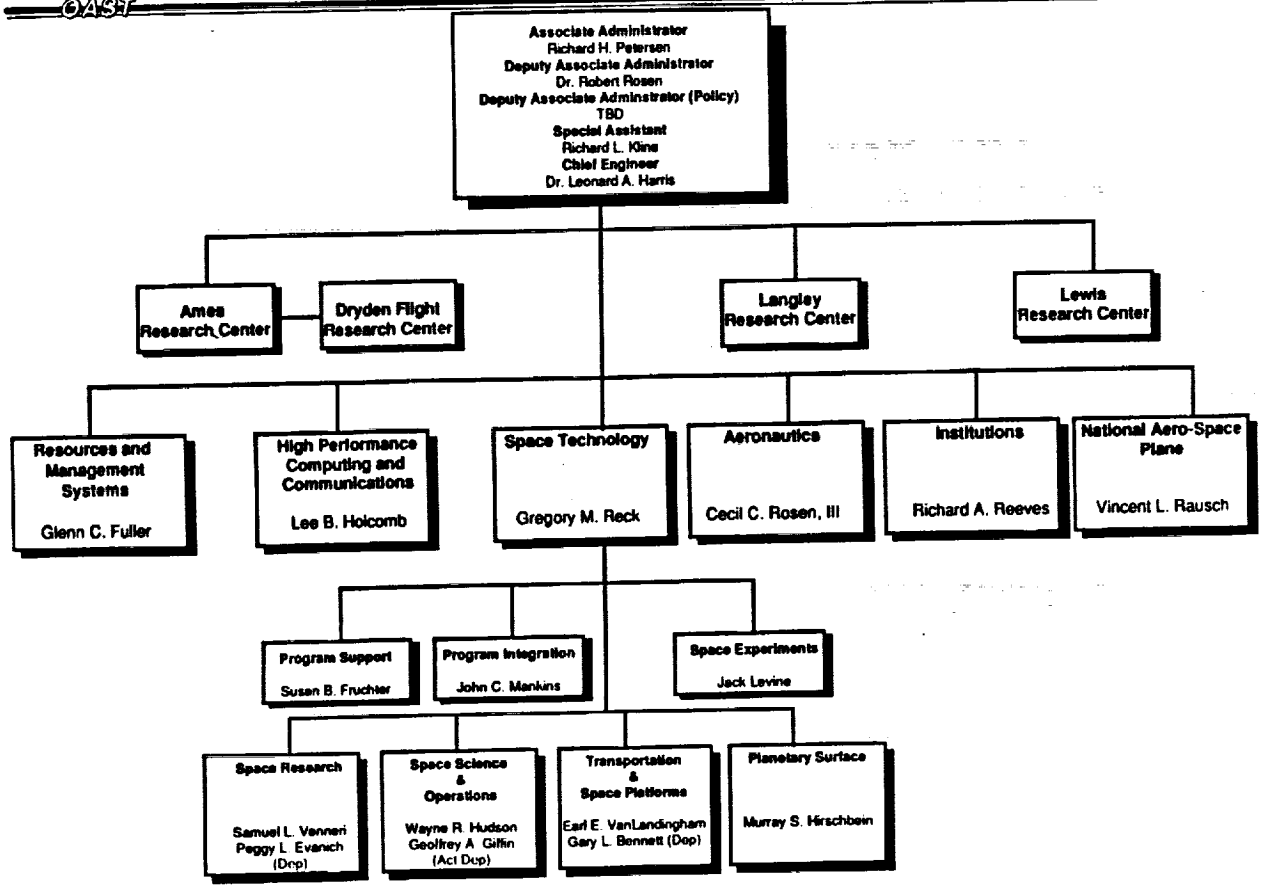
OAST

## NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



# OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

OAST




# OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

## FY 1992 BUDGET

OAST

($,M)

| APPROP. | AERO | TRANSAT. | SPACE | TOTAL |
|---|---|---|---|---|
| R&D | 574.2 | 5.0 | 309.3* | 888.5 |
| R&PM | 273.1 | 16.1 | 138.4 | 427.6 |
| CofF | 42.3 | - | - | 42.3 |
| SUBTOTAL | 889.6 | 21.1 | 447.7 | 1358.4 |
| RES. OPS. SUPP. | | | | 210.1 |
| TOTAL | | | | 1568.5 |

* SPACE EXCLUDES MISSION STUDIES ($5.0M)

92-1038
Rev 2/26/92

# SPACE R&T MISSION STATEMENT

OAST

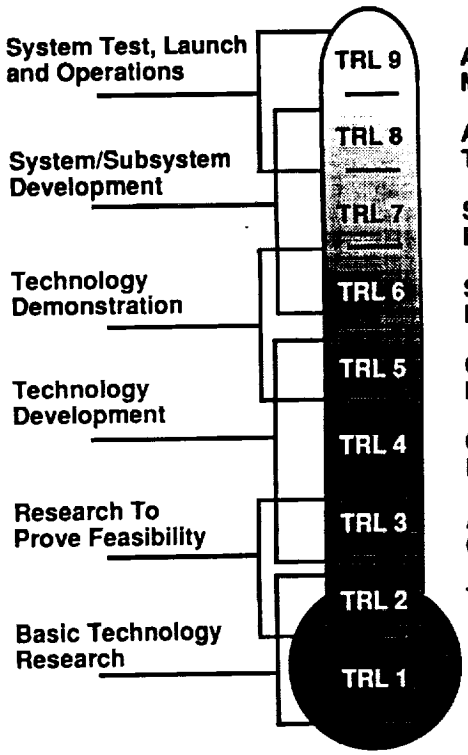
***OAST SHALL PROVIDE TECHNOLOGY FOR FUTURE CIVIL SPACE MISSIONS AND PROVIDE A BASE OF RESEARCH AND TECHNOLOGY CAPABILITIES TO SERVE ALL NATIONAL SPACE GOALS***

- *IDENTIFY, DEVELOP, VALIDATE AND TRANSFER TECHNOLOGY TO:*
  - INCREASE MISSION SAFETY AND RELIABILITY
  - REDUCE PROGRAM DEVELOPMENT AND OPERATIONS COST
  - ENHANCE MISSION PERFORMANCE
  - ENABLE NEW MISSIONS
- *PROVIDE THE CAPABILITY TO:*
  - ADVANCE TECHNOLOGY IN CRITICAL DISCIPLINES
  - RESPOND TO UNANTICIPATED MISSION NEEDS

LBF4194B

# TECHNOLOGY READINESS LEVELS

OAST




TRL 9 — ACTUAL SYSTEM "FLIGHT PROVEN" THROUGH SUCCESSFUL MISSION OPERATIONS

TRL 8 — ACTUAL SYSTEM COMPLETED AND "FLIGHT QUALIFIED" THROUGH TEST AND DEMONSTRATION (Ground or Flight)

TRL 7 — SYSTEM PROTOTYPE DEMONSTRATION IN A SPACE ENVIRONMENT

TRL 6 — SYSTEM/SUBSYSTEM MODEL OR PROTOTYPE DEMONSTRATION IN A RELEVANT ENVIRONMENT (Ground or Space)

TRL 5 — COMPONENT AND/OR BREADBOARD VALIDATION IN RELEVANT ENVIRONMENT

TRL 4 — COMPONENT AND/OR BREADBOARD VALIDATION IN LABORATORY ENVIRONMENT

TRL 3 — ANALYTICAL & EXPERIMENTAL CRITICAL FUNCTION AND/OR CHARACTERISTIC PROOF-OF-CONCEPT

TRL 2 — TECHNOLOGY CONCEPT AND/OR APPLICATION FORMULATED

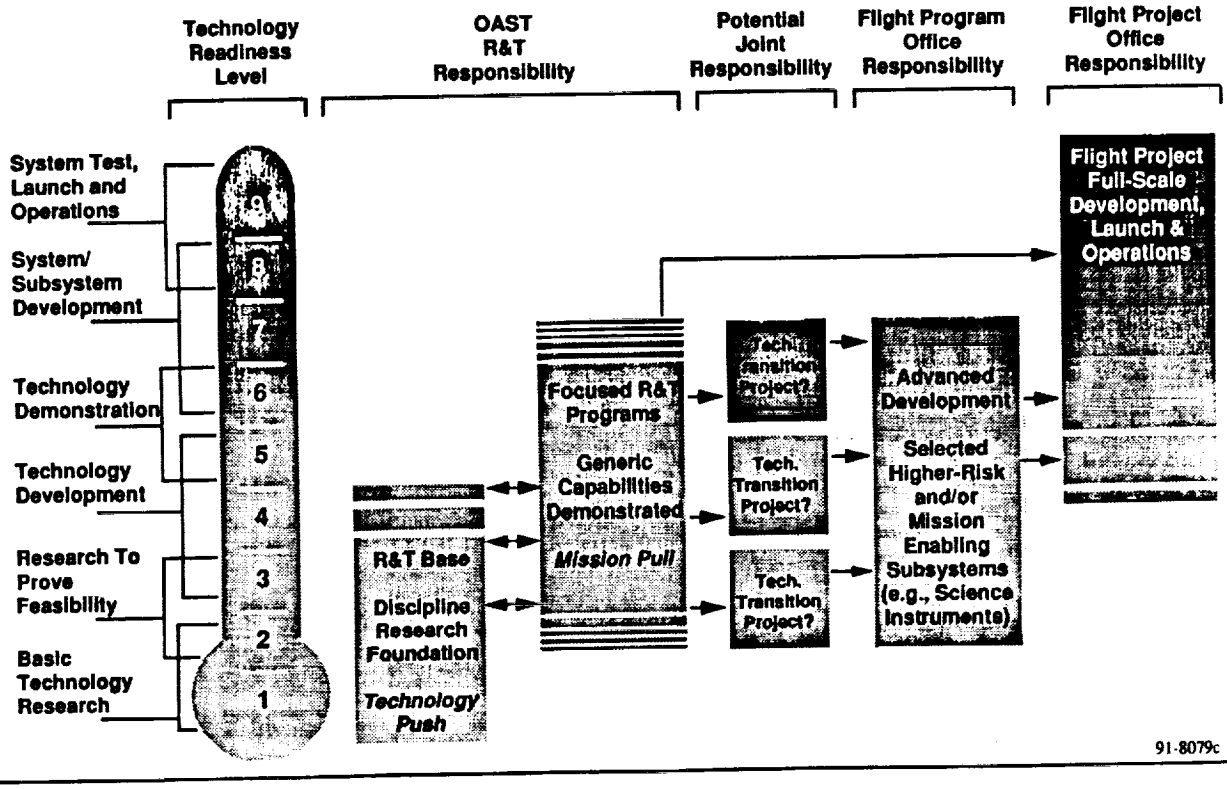
TRL 1 — BASIC PRINCIPLES OBSERVED AND REPORTED

91-8080A

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**

**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.

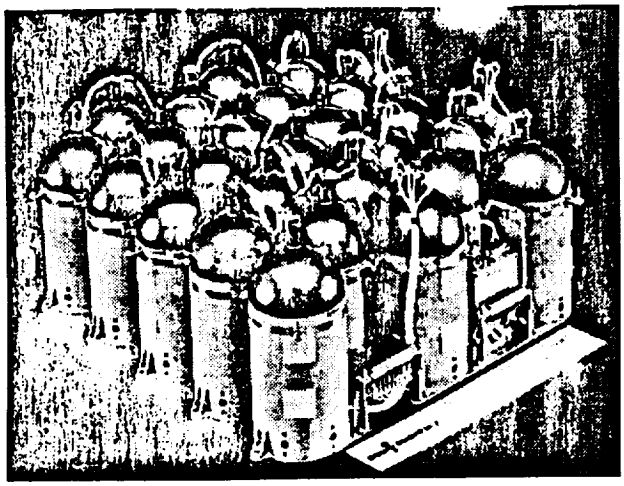
**SPACE PLATFORMS TECHNOLOGY**
- Earth-Orbiting Platforms
- Space Stations
- Deep-Space Platforms
- Technology Flight Expts.

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

LBF40319

# DISCIPLINE RESEARCH

## CONCEIVE, DEVELOP AND VALIDATE NEW TECHNOLOGY CONCEPTS AND APPROACHES FOR ENHANCING OR ENABLING FUTURE SPACE MISSIONS, INCLUDING REVOLUTIONARY IMPROVEMENTS IN SPACE CAPABILITY



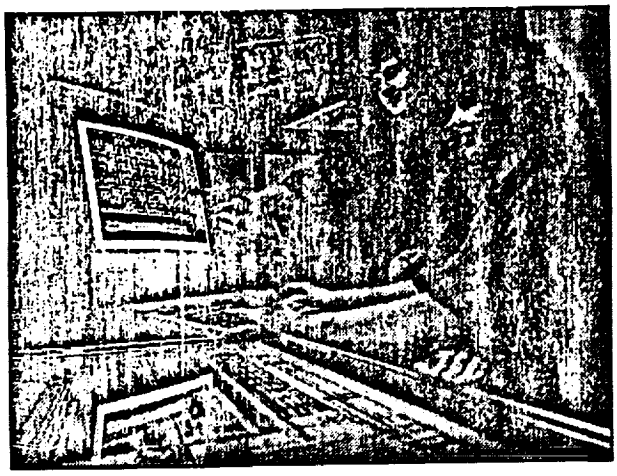
- DISCIPLINE RESEARCH TECHNOLOGY
  - AEROTHERMODYNAMICS
  - SPACE ENERGY CONVERSION
  - PROPULSION
  - MATERIALS & STRUCTURES
  - INFORMATION & CONTROLS
  - HUMAN SUPPORT
  - ADVANCED COMMUNICATIONS

*Office of Aeronautics and Space Technology*

91-8064

# UNIVERSITY PROGRAMS

## BROADEN THE CAPABILITIES OF THE NATION'S ENGINEERING COMMUNITY TO PARTICIPATE IN THE U.S. CIVIL SPACE PROGRAM THROUGH UNIVERSITY-BASED RESEARCH AND EDUCATION



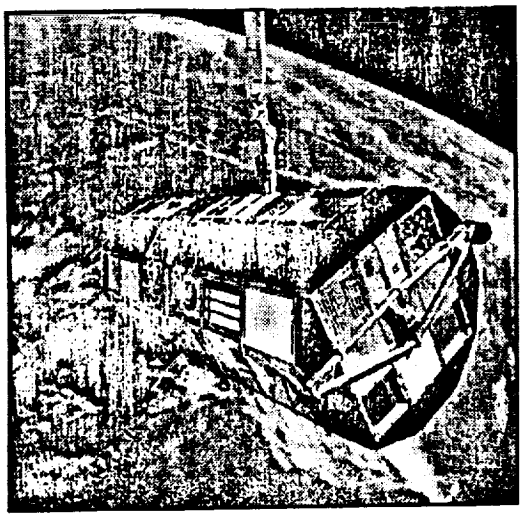
- UNIVERSITY SPACE ENGINEERING RESEARCH CENTERS
  - FOSTER CREATIVE AND INNOVATIVE CONCEPTS OF FUTURE SPACE SYSTEMS
  - EXPAND THE NATION'S ENGINEERING TALENT BASE FOR RESEARCH AND DEVELOPMENT
- UNIVERSITY INVESTIGATORS RESEARCH
  - SPONSOR INDIVIDUAL RESEARCH ON HIGHLY INNOVATIVE SPACE TECHNOLOGY CONCEPTS AND APPROACHES
- UNIVERSITY ADVANCED DESIGN
  - FOSTER INTERDISCIPLINARY ENGINEERING DESIGN EDUCATION

*Office of Aeronautics and Space Technology*

91-8061

# SPACE FLIGHT RESEARCH & TECHNOLOGY

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

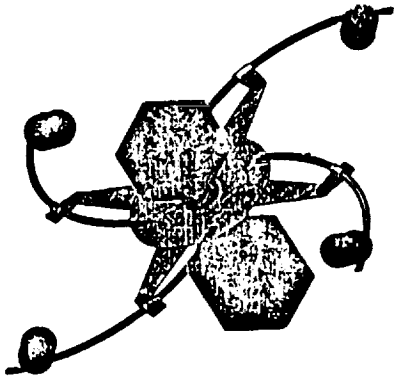


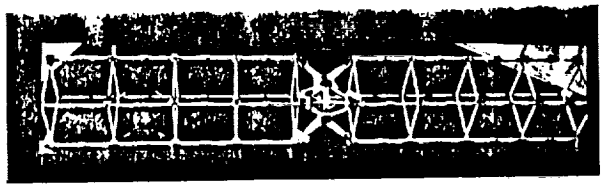
- IN-SPACE TECHNOLOGY EXPERIMENT PROGRAM (IN-STEP)
  - DESIGN, DEVELOP AND FLIGHT TEST INDUSTRY, UNIVERSITY AND NASA TECHNOLOGY FLIGHT EXPERIMENTS
- FLIGHT OPPORTUNITIES VIA
  - SPACE SHUTTLE
  - EXPENDABLE LAUNCH VEHICLES
  - SPACE STATION FREEDOM

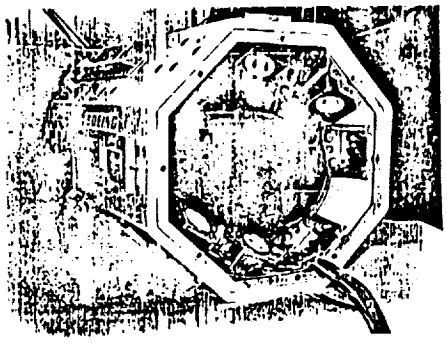
91-8063

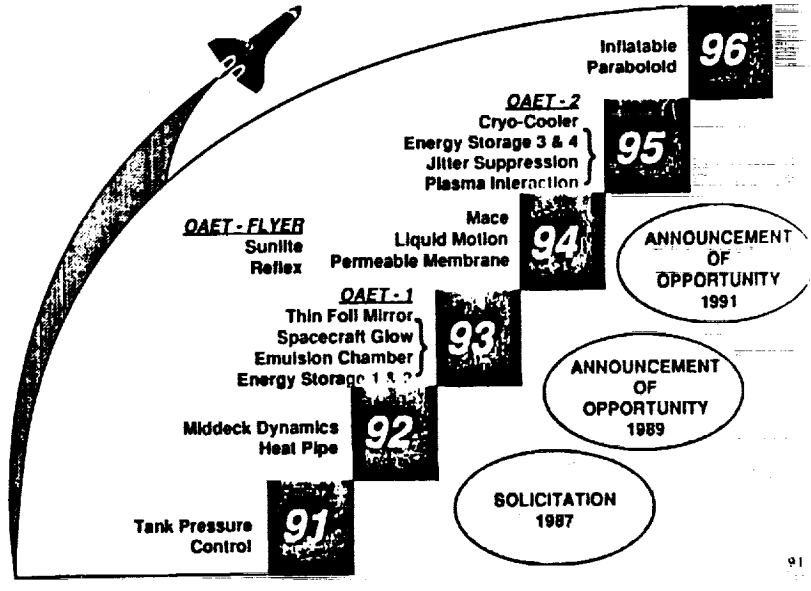
*Office of Aeronautics and Space Technology*

# IN-SPACE TECHNOLOGY EXPERIMENTS



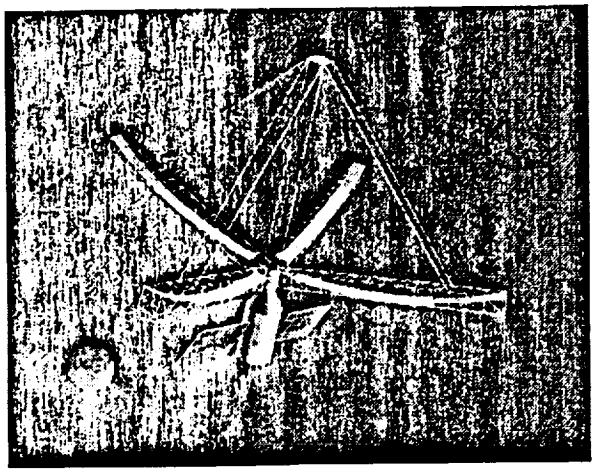






# SYSTEMS ANALYSIS

## CONDUCT INTERDISCIPLINARY SYSTEM STUDIES TO IDENTIFY AND PRIORITIZE NEW TECHNOLOGY REQUIREMENTS AND OPPORTUNITIES AND DEVELOP MODELING AND ANALYSIS TOOLS



- **FOCUSED PROGRAMS**
  - **IDENTIFY CRITICAL TECHNOLOGY ISSUES OF FUTURE MISSION CONCEPTS**
    - **TRANSPORTATION**
    - **SPACE SCIENCE**
    - **SPACE PLATFORMS**
    - **SPACE EXPLORATION**
    - **OPERATIONS**
- **BREAKTHROUGH**
  - **IDENTIFY BENEFITS OF HIGHLY INNOVATIVE SPACE TECHNOLOGY IDEAS AND SPACE APPLICATIONS OF NEW TECHNOLOGY FRONTIERS**
- **EXTERNAL**
  - **SUPPORT SPACE COMMERCIALIZATION**
  - **IMPROVE USE OF INDUSTRY INDEPENDENT R&D (IRAD)**
  - **PLAN FOR MULTI-AGENCY PROGRAMS**

***Office of Aeronautics and Space Technology***

91-8065

**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.

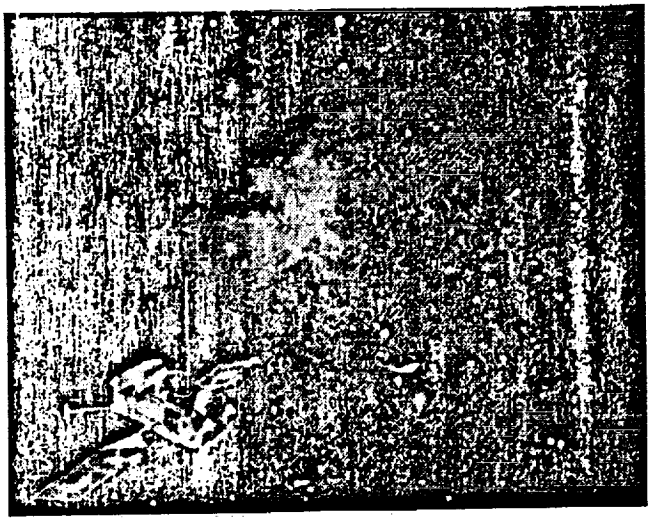
**SPACE PLATFORMS TECHNOLOGY**
Earth-Orbiting Platforms
Space Stations
Deep-Space Platforms
Technology Flight Expts.

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

LBF40319

# SCIENCE TECHNOLOGY

## DEVELOP ADVANCED INSTRUMENT, OBSERVATION, INFORMATION, AND IN SITU MEASUREMENT TECHNOLOGIES TO MAXIMIZE THE RETURN FROM NASA SPACE AND EARTH SCIENCE MISSIONS OVER THE NEXT TWENTY YEARS



- EXPAND CAPABILITY AND REDUCE COSTS THROUGH DISCIPLINARY ADVANCEMENTS WHICH INCREASE SCIENCE INFORMATION RETURN AND SPACECRAFT PERFORMANCE
  - INSTRUMENT
  - OBSERVATION
  - DATA & INFORMATION
  - IN SITU MEASUREMENT
- ENABLE THE NEXT GENERATION OF SPACE SCIENCE MISSIONS
  - ASTROPHYSICS
  - SOLAR SYSTEM EXPLORATION
  - SPACE PHYSICS
  - EARTH SCIENCE
  - LIFE SCIENCES/MICROGRAVITY

91-8046

*Office of Aeronautics and Space Technology*

# PLANETARY SURFACE TECHNOLOGY

## PROVIDE KEY TECHNOLOGIES FOR ROBOTIC AND MANNED PLANETARY SURFACE EXPLORATION SYSTEMS INCLUDING CAPABILITIES FOR AN OUTPOST ON THE MOON AND EXPLORATION OF THE PLANET MARS

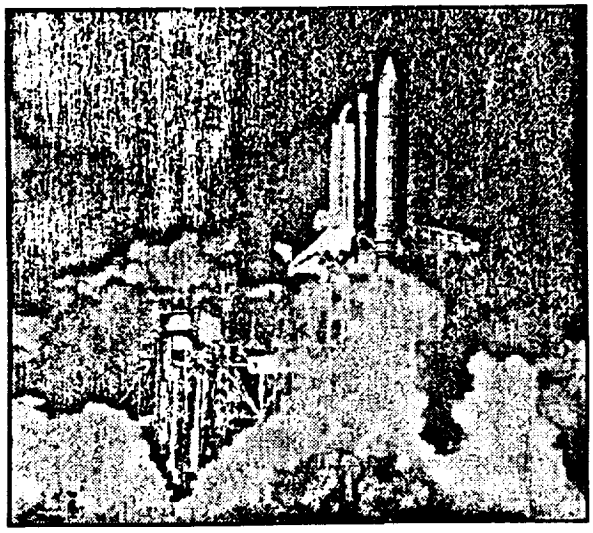
- INCREASE RELIABILITY AND REDUCE RISK; REDUCE DEVELOPMENT AND OPERATIONS COST; AND ENABLE NEW AND INNOVATIVE CAPABILITIES IN THE AREAS OF:
  - ADVANCED SURFACE SYSTEM OPERATIONS ON THE MOON AND MARS
  - TECHNOLOGIES FOR HUMAN SUPPORT DURING VERY LONG DURATION PILOTED MISSIONS IN DEEP-SPACE AND ON PLANETARY SURFACES

91-8050A
rev 8/23/91

*Office of Aeronautics and Space Technology*

# TRANSPORTATION TECHNOLOGY

## PROVIDE TECHNOLOGIES THAT SUBSTANTIALLY INCREASE OPERABILITY, IMPROVE RELIABILITY, PROVIDE NEW CAPABILITIES, WHILE REDUCING LIFE CYCLE COSTS



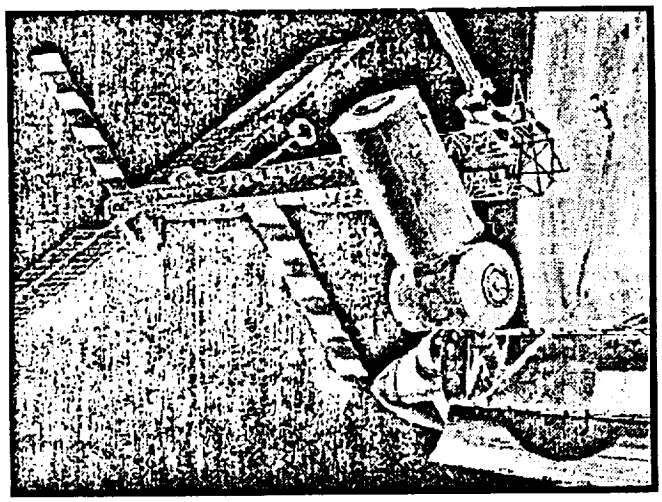
- ENHANCE SAFETY, RELIABILITY, AND SERVICEABILITY OF CURRENT SPACE SHUTTLE
- PROVIDE TECHNOLOGY OPTIONS FOR NEW MANNED SYSTEMS THAT COMPLEMENT THE SHUTTLE AND ENABLE NEXT GENERATION VEHICLES WITH RAPID TURNAROUND AND LOW OPERATIONAL COSTS
- SUPPORT DEVELOPMENT OF ROBUST, LOW-COST HEAVY LIFT LAUNCH VEHICLES
- DEVELOP AND TRANSFER LOW-COST TECHNOLOGY TO SUPPORT COMMERCIAL ELV's AND UPPER STAGES
- IDENTIFY AND DEVELOP HIGH LEVERAGE TECHNOLOGIES FOR IN-SPACE TRANSPORTATION, INCLUDING NUCLEAR PROPULSION, THAT WILL ENABLE NEW CLASSES OF SCIENCE AND EXPLORATION MISSIONS

*Office of Aeronautics and Space Technology*

91-8048

# SPACE PLATFORMS TECHNOLOGY

## DEVELOP TECHNOLOGIES TO INCREASE ON-ORBIT MISSION EFFICIENCY AND DECREASE LIFE CYCLE COSTS FOR FUTURE MANNED AND UNMANNED SCIENCE, EXPLORATION & COMMERCIAL MISSIONS.



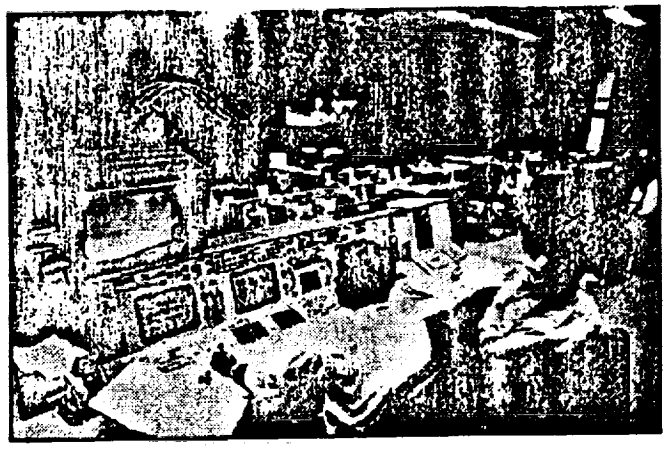
- DEVELOP TECHNOLOGIES THAT WILL DECREASE LAUNCH WEIGHT AND INCREASE THE EFFICIENCY OF SPACE PLATFORM FUNCTIONAL CAPABILITIES
- DEVELOP TECHNOLOGIES THAT WILL INCREASE HUMAN PRODUCTIVITY AND SAFETY OF MANNED MISSIONS
- DEVELOP TECHNOLOGIES THAT WILL INCREASE MAINTAINABILITY AND REDUCE LOGISTICS RESUPPLY OF LONG DURATION MISSIONS
- IDENTIFY AND DEVELOP FLIGHT EXPERIMENTS IN ALL TECHNOLOGY AND THRUST AREAS THAT WILL BENEFIT FROM THE UTILIZATION OF SSF FACILITIES

*Office of Aeronautics and Space Technology*

91-8052

# OPERATIONS TECHNOLOGY

**DEVELOP AND DEMONSTRATE TECHNOLOGIES TO REDUCE THE COST OF NASA OPERATIONS, IMPROVE THE SAFETY AND RELIABILITY OF THOSE OPERATIONS, AND ENABLE NEW, MORE COMPLEX ACTIVITIES TO BE UNDERTAKEN**



- THE OPERATIONS THRUST SUPPORTS THE FOLLOWING MAJOR ACTIVITIES:
  - IN-SPACE OPERATIONS
  - FLIGHT SUPPORT OPERATIONS
  - GROUND SERVICING AND PROCESSING
  - PLANETARY SURFACE OPERATIONS
  - COMMERCIAL COMMUNICATIONS
- THE FOLLOWING TECHNOLOGY AREAS ARE INCLUDED:
  - AUTOMATION & ROBOTICS
  - INFRASTRUCTURE OPERATIONS
  - INFORMATION & COMMUNICATIONS
  - FLIGHT EXPERIMENTS

*Office of Aeronautics and Space Technology*

91-8055

# INTEGRATED TECHNOLOGY PLAN PROCESS

OASF

- INTERNAL NEEDS
  - AGENCY PROGRAM OFFICES REQUESTED TO DEFINE AND PRIORITIZE MISSION TECHNOLOGY NEEDS AS RECOMMENDED BY AUGUSTINE
- EXTERNAL NEEDS
  - SSTAC/ARTS MEMBERS REQUESTED TO PROVIDE INPUTS ON OVERALL CIVIL SPACE TECHNOLOGY NEEDS
  - COMSTAC RECOMMENDATIONS ON ELVs, COMMUNICATIONS ADVISORY GROUP RECOMMENDATIONS AND OTHER KEY TECHNOLOGY ASSESSMENTS UNDER EVALUATION
- DEVELOPMENT OF INTEGRATED TECHNOLOGY PLAN
  - TEAMS FORMED TO PREPARE TECHNOLOGY PLANS
  - APPLIED DECISION RULES FOR BASE AND FOCUSED PROGRAMS
- EXTERNAL REVIEW
  - SSTAC/ARTS CONDUCTED REVIEW WITH PARTICIPATION BY ASEB, OTHER EXTERNAL EXPERTS IN JUNE
- STRUCTURE FOR ANNUAL PLANNING AND REVIEW PROCESS ESTABLISHED

SBF-0169b

National Aeronautics and
Space Administration

Washington, D.C.
20546

RECEIVED
DEC 11 2 23 PH '91

DEC 10 '91

Attn of: OP

TO: R/Associate Administrator for
Aeronautics and Space Technology

FROM: O/Associate Administrator for Space Communications

SUBJECT: Space Technology Needs Update for FY 1994 Program

This responds to your memorandum, same subject, dated November 15, 1991. We have reviewed our needs and find that the technology areas previously identified to you on April 1, 1991, are still valid. The following general technology areas are all high priority for Code O.

1. High Data Rate Communications. This includes optical and millimeter wave radio frequencies for both space-to-ground and space-to-space applications to handle the high volumes of data transported in future programs. An example of space-to-space communication might be future communications cross links between our tracking and data relay satellites.

2. Advanced Data Systems. This includes development of advanced data storage, data compression, and information management systems, which are required to meet the sophisticated needs of future planetary and exploration programs.

3. Advanced Navigation Techniques. This includes development of new techniques for navigation and their application to cruise, approach, and in-orbit navigation for manned and unmanned planetary missions.

4. Mission Operations. This includes incorporation of artificial intelligence, expert systems, neural networks, and increased automation in mission operations. Other work includes development of test beds to check out advanced software, coordination of distributed software, and automated performance analysis of networked computing environments.

We will be pleased to assist you if further definition of our requirements is needed.

Charles F. Force

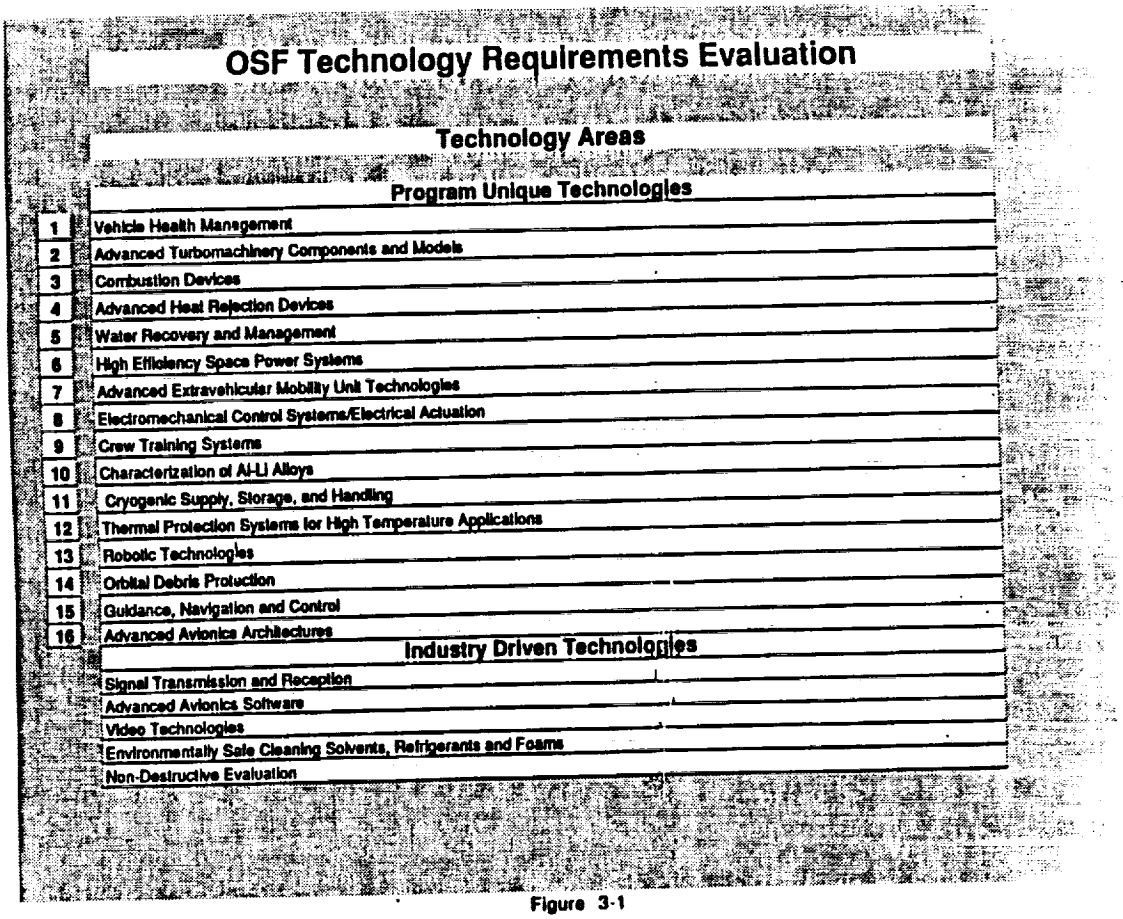



Figure 3-1

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

# EXTERNAL TECHNOLOGY NEEDS SOURCES

OAST

- BOEING AEROSPACE & ELECTRONICS
- GENCORP-AEROJET
- GENERAL ELECTRIC-PHILADELPHIA
- GENERAL ELECTRIC-VALLEY FORGE
- GRUMMAN
- HUGHES
- MARTIN MARIETTA
- MCDONNELL DOUGLAS
- RCA
- SPACE SYSTEMS/LORAL
- SPARTA
- STANFORD TELECOM
- TRW
- UNITED TECHNOLOGIES CORPORATION
- *PLUS — DIRECT INPUTS FROM SSTAC/ARTS MEMBERS, EARLIER NRC SURVEY DATA*

SEPTEMBER 9, 1991
JCM-6430

# EXTERNAL TECHNOLOGY PERSPECTIVES SUMMARY

OAST

## SPACE SCIENCE

Precision Space Structures and Pointing Accuracy

## PLANETARY SURFACE

Regnerative Life Support Systems
Radiation Protection for Long Missions
Utilization of In Situ Materials/Propellants
Artificial Intelligence Techniques
Robotic & Microrobotic Systems
Advanced EMUs
Surface Rover Technologies (Pressurized and Unpressurized)
Nuclear Electric Power
High-Efficiency Lunar Radiators & Thermal Energy Storage
Power Beaming
Human Health Maintenance
Reduced Gravity Countermeasures/Artificial Gravity
Bioprocess-Grade Fluid Management Systems

## SPACE PLATFORMS

Composite Lightweight Structures
Micrometeoroid and Debris Protection
Long-Life Structures and Mechanisms
Regnerative Life Support Systems
Advanced EMUs
Expanded Atomic Oxygen Database
High-Efficiency, Radiation-Resistant, Lightweight PV Arrays
High-Efficiency Power Processing Units
Lightweight Batteries

## TRANSPORTATION

Economical Launch Systems (Manned and Unmanned)
Software Productivity Enhancers
Integrated Vehicle Health Monitoring and Maintenance
Advanced Cryogenic (Oxygen/Hydrogen) Engines
Fault-Tolerant Advanced Avionics with Open Architectures
High-Performance/Composite Lightweight Structures
Long-Life Structures and Mechanisms
High-Performance, Storable Space Thrusters
High-Power Electric Propulsion
Nuclear Thermal Propulsion for Manned Interplanetary Missions
Cryogenics Long-Duration Storage and Management
Gun-Type Launch Systems
Aerobraking (Thermal Protection Systems)
Integrated RCS/Auxiliary Propulsion
Lightweight, Fuel-Efficient Airbreather Propulsion Systems

## OPERATIONS

Data Management System Architecture and Software
Systems Integration technologies (Software, etc.)
Artificial Intelligence Techniques
Safe Robotic Systems
Advanced Communications (e.g., Laser &
Millimeter Wave Technology)

JUNE 24, 1991
JCM-7660d

# USER PRIORITIZED TECHNOLOGY NEEDS - UPDATE

OAST

- **OFFICE OF SPACE SCIENCE & APPLICATIONS**
  - WOODS HOLE REVISIONS TO OSSA STRATEGIC PLAN HAVE BEEN INCLUDED
- **OFFICE OF SPACE EXPLORATION**
  - REVISIONS RECEIVED IN FEBRUARY 1992
- **OFFICE OF SPACEFLIGHT**
  - SOME ADJUSTMENT IN EMPHASIS
- **OFFICE OF SPACE OPERATIONS**
- **EXTERNAL (INDUSTRY) NEEDS**

LBF40389a

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

# RESEARCH & TECHNOLOGY STRATEGY

OAST

## FLIGHT PROGRAMS FORECAST

- **5-YEAR FORECAST INCLUDES**

**'93 THRU '97: LIMITED NEW STARTS**

COMPLETION OF INITIAL SSF
SOME SHUTTLE IMPROVEMENTS
INITIAL EOS & EOSDIS
SELECTED SPACE SCIENCE STARTS
NLS DEVELOPMENT
INITIAL SEI ARCHITECTURE SELECTION
EVOLVING GEO COMMERCIAL COMMSATS
MINOR UPGRADES OF COMMERCIAL ELVS

- **10-YEAR FORECAST INCLUDES**

**'98 THRU '03: MULTIPLE NEW STARTS TO BE LAUNCHED IN 2003 THRU 2010**

SSF EVOLUTION/INFRASTRUCTURE
FINAL SHUTTLE ENHANCEMENTS
ADVANCED LEO EOS PLATFORMS/FULL EOSDIS
MULTIPLE SPACE SCIENCE STARTS
NLS OPERATIONS/EVOLUTION
EVOLVING LAUNCH/OPERATIONS FACILITIES
INITIAL SEI/LUNAR OUTPOST START
DSN EVOLUTION (KA-BAND COMMUNICATIONS)
NEW GEO COMMERCIAL COMMSATS
NEW COMMERCIAL ELVS

- **20-YEAR FORECAST INCLUDES**

**'04 THRU '11 MULTIPLE OPTIONS FOR NEW STARTS TO BE LAUNCHED IN 2009 THRU 2020**

SSF-MARS EVOLUTION
BEGINNING OF AMLS/PLS DEVELOPMENT
MULTIPLE SPACE SCIENCE STARTS
DSN EVOLUTION (OPTICAL COMM)
INITIAL MARS HLLV DEVELOPMENT
EVOLVING LUNAR SYSTEMS
MARS SEI ARCHITECTURE CHOSEN
LARGE GEO COMMSATS
NEW COMMERCIAL ELVS

LBF40305
(JCM-7692)

## OSSA TECHNOLOGY NEEDS
## Grouped According to Urgency & Commonality

REVISED
NOVEMBER 15, 1991

| | HIGHEST PRIORITY | | 2nd-HIGHEST PRIORITY | | | 3rd HIGHEST PRIORITY | | | |
|---|---|---|---|---|---|---|---|---|---|
| Near Term | Detectors: IR Si & Ge arrays, multiplexers, CCD, optical, Xe, non-cryo IR, high purity Ge, sensor readout electronics & tunnel sensors (SE, SL, SZ, SS) | Cryogenic Systems -- Optics, coolers, shielding, electronics (SZ, SE, SL, SS) | High Frame Rate, High Resolution Video (SN, SL) | 2.5 - 4m, 100K Lightweight, PSR (SZ) | Fluid Diagnostics (SN) | Real-Time Radiation Monitoring (SB) | Solar Arrays/Cells (SL, SZ, SE) | Telerobotics (SN) | High Transmission UV Filters (SZ) |
| | Submm & Microwave Tech: -- SIS 1.2 Thz Heterodyne Rec. -- Active SAR integrated circuits -- Passive submm 600 GHz diodes (SZ, SE) | Vibration Isolation Technology (SN, SZ, SB) | Telescience, Telepresence, & AI (SN, SL, SB) | Automated Biomedical Analysis (SB) | Rad Hard Parts & Detectors (SZ, SL) | Solid/Liquid Interface Characterization (SN) | Laser Light Scattering (SN) | High Temperature Materials For Furnaces (SN) | K band Transponders (SZ) |
| | Efficient, Quiet Refrigerator/Freezer (SB) | Extreme Upper Atmosphere Instrument Platforms (SS) | Batteries -- Long life time -- High energy density (SL, SZ) | Real-Time Environmental Control & Monitoring (SB) | Space Qualified maser & ion Clocks (SZ) | Field Portable Gas Chromatographs (SB) | Advanced Furnace Technology (SN) | 3-D packaging for 1 MB Solid State Chips (SZ) | Rapid Subject/ Sample Delivery & Return Capability (SB) |
| | Lasers: Long-life, Stable & Tunable (SE, SZ, SL, SB) | Mini/microsystems -- Instrumentation, rovers descent imager, camera, RTG ascent vehicle/landet, S/C subsystems (SL) | Low-drift Gyros, Trackers, Actuators (SZ) | Combustion Diagnostics (SN) | Plasma Wave Antennas/ Thermal (SS) | High Temperature Electronics (SL) | Non-Contact Temperature Measurement (SN) | Ultra-high Gigabit/sec Telemetry (SZ) | Microbial Decontamination Methods (SB) |
| | Data -- High Volume, High Density, High Data Rate, On-board Storage & Compression (SE, SL, SN, SZ) | Interferometer-specific Tech: -- picometer metrology -- active delay lines -- control-structures interact. (SZ, SL, SB | Microphonics Technology, FET development (SZ) | Auto S/C Monitoring & Fault Recovery (SL) | Improved EVA Suit/PLSS (EMU) (SB) | Thermal Control System (SZ) | Special Purpose Bioreactor Simulator Syst. (SB) | Animal & Plant Reproduction Aids (SB) | |
| | Controlled Structures/ Large Antenna Structure Arrays/Deployable (SE, SZ, SS, SB) | Parallel Software Environment for Model & Data Assimilation, Visualization Computational Techniques (SE, SL, SZ) | X-ray Optics Tech: -- imaging system -- low cost optics -- Bragg concentrators -- coated apertures (SZ) | SETI Technologies -- Microwave & Optical/Laser Detection (SB) | Regenerative Life Support (SB) | Auto Rendezvous Auto Sample Transfer, Auto Landing (SL) | Non-Destructive Monitoring Capability (SB) | Non-Destructive Cosmic Dust Collection (SB) | |
| | Interspacecraft Ranging & Positioning Precision Sensing Pointing & Control (SS, SZ, SL) | Large Filled Apertures -- lightweight & stable optics -- Cryo optical ver., fab., test. -- Deformable mirrors -- 15-25m PSR (SL, SZ, SE) | Sample Acquisition, Analysis and Preservation (SB, SL) | 32 Ghz TWT Optical Communication (SL, SS) | High Resolution Spectrometer (SB) | Spacecraft Thermal Protection (SL) | Partial-g/ µg Medical Care Delivery Systems (SB) | Dust Protection/ Jupiter's Rings (SL) | |
| Far Term | 50-100Kw Ion Propulsion (NEP) (SL) | | Radiation Shielding for Crews (SB) | SIS 3 Thz Heterodyne Receiver (SZ) | Human Artificial Gravity Systems (SB) | CELSS Support Technologies (SB) | | | |

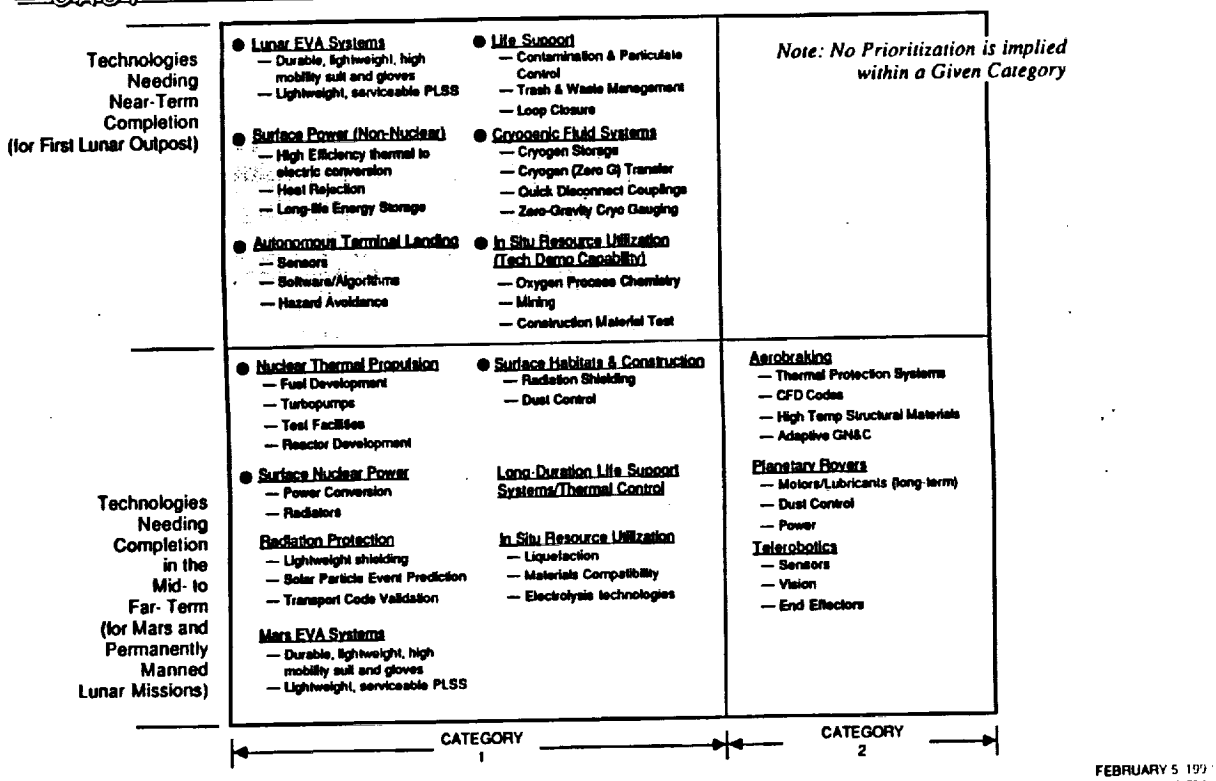
SB: Life Sciences
SE: Earth Sciences & Applications
SL: Solar System Exploration
SN: Microgravity Science & Applications
SS: Space Physics
SZ: Astrophysics

SPACE RESEARCH AND TECHNOLOGY PROGRAM

DRAFT

# SEI TECHNOLOGY NEEDS (for FY 1994 planning)

OAST




FEBRUARY 5 199
JCM 704

● Near-Term Investment Recommended by OEXP

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

# DECISION RULES: R&T BASE

OAST

## GENERAL RULES

- USE EXTERNAL REVIEWS TO AID IN ASSURING PROGRAM TECHNICAL QUALITY
- PROVIDE STABILITY BY COMPLETING ON-GOING DISCRETE EFFORTS

## DISCIPLINE RESEARCH

- ASSURE ADEQUATE SUPPORT TO MAINTAIN HIGH-QUALITY IN-HOUSE RESEARCH IN AREAS CRITICAL TO FUTURE MISSIONS
  - PROVIDE CAPABILITIES FOR AD HOC SUPPORT R&T FOR FLIGHT PROGRAMS
- PROVIDE GROWTH IN R&T BASE AREAS NEEDED FOR FUTURE FOCUSED PGMS
  - COORDINATE WITH ANNUAL FOCUSED PROGRAM PLANNING
- CREATE ANNUAL OPPORTUNITIES FOR THE INSERTION OF NEW R&T CONCEPTS
  - GOAL: PROVIDE APPROXIMATELY 15-20% "ROLL-OVER" PER YEAR
- SUPPORT TECHNOLOGY PUSH FLIGHT EXPERIMENTS WHERE SPACE VALIDATION IS REQUIRED.

## FLIGHT PROGRAMS

- MAINTAIN COMPETITIVELY-SELECTED STUDIES/IMPLEMENTATION OF IN-HOUSE AND INDUSTRY/UNIVERSITY SMALL-SCALE FLIGHT EXPTS, ORIENTED ON NASA'S TECHNOLOGY NEEDS

## UNIVERSITY PROGRAMS

- EVALUATE TO FOCUS PARTICIPATION IN NASA SPACE R&T BY U.S. UNIVERSITIES AND COLLEGES - USING COMPETITIVE SELECTION

LBF40318
(JCM 6803)

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

# R&T Base Discipline Programs Content

OAST

| | BASE CAPABILITIES | | | ADVANCED TECHNOLOGIES | | | "BREAKTHROUGH" TECHNOLOGIES | | |
|---|---|---|---|---|---|---|---|---|---|
| Aerothermo-dynamics | Hypersonic Flowfield Sim. | Hypersonic Vehicle Synth. | — | Flt. Environ. Instrument'n | Configuration Design/Optimiz. | — | — | — | — |
| | Fundamental Data Bases | — | — | Aerothermo. Design Tools | — | — | — | — | — |
| Space Communications | Travelling Wave Tubes (TWTs) | — | — | KaBand TWT | Digital Switching Processors | Ground Terminals | Laser Comm. Components | — | — |
| | MMICs | — | — | Solid State MMIC Systems | Direct Broadcast (Audio) | — | Mobile Comm. Systems (Personal) | — | — |
| Space Energy Conversion | Photovoltaic Perf. Validation | Solar Dynamics Design/Analysis | — | Adv. Solar Cells (GaAs, In-P) | Adv. Batteries (Rechg/Life) | Thermoelectric Conv. Systems | Laser Power Components | Alkali Metal T-E Conversion | Diamond Film Pwr Electronics |
| | Electrochemical Diagn./Models | — | — | Concentrators and Arrays | Solar Dynamics Conv. Systems | Power Mgt. & Distribution | Adv. Fuel Cells (Li/CO2) | Liquid Sheet Radiators | — |
| Human Support | -Extravehicular Activity Suit | — | — | EVA Gloves | EMU Components | Life Support Models | Visualization Research | AI Computer Associates | — |
| | Human Modeling (Cogn./Physical) | — | — | PLSS Components | Interactive EVA Displays | Life Support Sensors/Cntrls | Virtual Reality Environments | — | — |
| Information and Controls | Electro-optic Mat's/Sensors | — | — | Advanced AI Research | Computational Controls | — | Micromachines | Photonics | Multiple Interactive Robots |
| | — | — | — | — | Software Develop. Tools | — | Neural Networks | High-Temp Superconductors | — |
| Materials and Structures | Materials Synthesis | Space Durable Materials | Sp. Environ. Effects (Mat's) | Optics | High Precision Struct. | Durable Polymers | Intermetallics & Metal Matrix | Computational Materials | Adaptive Materials |
| | High Temp. TPS | Advanced Space Struct. Concepts | Tribology | Mechanisms | Lg./Deployed Struct. | High Temp. Veh. Struct. | Computational Chemistry | "Smart" Materials | — |
| | | | | Extreme TPS | Debris Shielding | | | | |
| Propulsion | Combustion Models/Diagn. | Internal Pump Flow CFD | — | Ion Thrusters | Water Resistojets | H-O Engines | High Energy Density Propell. | Laser Rocket Propulsion | Superconduct Bearings |
| | Engine Analysis Expert Systems | Cryo. Fluid Modeling | — | Hydrogen Arcjets | Iridium-Rhenium Engine Liners | Propulsion Health Mgt. | Electrodeless Thrusters (ECR) | Fission/Fusion Propulsion | — |
| | | | | MPD Thrusters | | | | | |

NOVEMBER 13, 1991
JCM 6800v

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

# DECISION RULES: FOCUSED PROGRAMS

OAST

## GENERAL

- ANNUALLY ASSESS AND FUND PROJECTS IN ORDER OF PRIORITY AGAINST MISSION-DERIVED INVESTMENT CRITERIA
  - EXTERNAL REVIEW WILL BE USED TO AID IN ASSURING QUALITY
  - REVIEW WITH USER OFFICES WILL BE USED TO AID IN ASSURING RELEVANCE AND TIMELINESS
- PROVIDE STABILITY BY COMPLETING ON-GOING DISCRETE EFFORTS
- START A MIX OF TECHNOLOGY PROJECTS WITH SHORT-, MID- AND LONG-TERM OBJECTIVES EACH YEAR
- ASSURE BALANCED INVESTMENTS TO SUPPORT THE FULL RANGE OF SPACE R&T USERS
- FUND NEW TECHNOLOGY PROJECTS THAT HAVE PASSED INTERNAL REVIEWS AS REQUIRED (E.G., NON-ADVOCATE REVIEW FOR MAJOR EXPERIMENTS)

## MAJOR FLIGHT EXPERIMENTS

- SUPPORT COMPETITIVELY-SELECTED IMPLEMENTATION OF IN-HOUSE AND INDUSTRY MAJOR TECHNOLOGY FLIGHT EXPTS IN ACCORDANCE WITH MISSION-DERIVED PRIORITIZATION CRITERIA
- FUND MAJOR FLIGHT EXPERIMENTS WHERE ADEQUATE GROUND-BASED R&T IS UNDERWAY OR HAS BEEN COMPLETED

LBF40287a
(JCM 6804)

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

# INVESTMENT PRIORITIZATION CRITERIA

OAST

**MISSION NEED**

Engineering Leverage
- Performance (Including Reliability) Leverage of the Technology to A System
- Importance of That Technology/System Performance To A Mission And Its Objectives

Cost Leverage
- Projected Cost Reduction For A Given System/Option
- Projected Cost Reduction for A Mission of That Savings

Breadth Of Application
- Commonality Across Missions/Systems Options
- Commonality Across Systems in Alternative Mission Designs

**PROGRAMMATICS & TIMING**

Timeliness Of Planned Deliverables
- Timing of the Mission Need for Technology Readiness
- Projected Duration of R&T Needed To Bring Technology to Readiness

Criticality Of Timely R&T Results To Mission Decisions
- Timing of Mission Planning Need for Technology Results
- Importance of Technology To Mission Objectives/Selection

Uncertainty in Planned R&T Program Success/Schedule

**SPECIAL ISSUES**

- Readiness to Begin A Focused Technology Project
- Commitment To An Ongoing R&T Program
- Interrelationships To Other Government Program(s)
- Projected "National Service" Factors

LBF40285
(JCM-6684a)

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

# Strategic Plan ITP: CSTI Element Categorization

OAST

| | HIGHEST PRIORITY ◊◊◊ | | | 2nd-HIGHEST PRIORITY ◊◊ | | | 3rd-HIGHEST PRIORITY ◊ | | |
|---|---|---|---|---|---|---|---|---|---|
| Space Science Technology | Submillimeter Sensing | Direct Detectors | Active µwave Sensing | Sample Acq., Analysis & Preservation | Passive Microwave Sensing | ---- | Optoelectrncs Sensing & Processing | Probes and Penetrators | ---- |
| | Cooler and Cryogenics | Sensor Electronics Micropracision CSI | Laser Sensing Telescope Optical Systems | Data Archiving and Retrieval | Data Visualization and Analysis | ---- | Precision Instrument Pointing | Sensor Optical Systems | ---- |
| Planetary Surface Technology | Radiation Protection | Regenerative Life Support (Phys-Chem.) | Space Nuclear Power (SP-100) | High Capacity Power | Planetary Rovers | Surface Habitats and Construction | Exploration Human Factors | ---- | Artifical Gravity |
| | ---- | ---- | Extravehicular Activity Systems | Surface Solar Power and Thermal Mgt. | In Situ Resource Utilization | Laser-Electric Power Beaming | Medical Support Systems | ---- | ---- |
| Transportation Technology | ETO Propulsion | Nuclear Thermal Prop. | Aeroassist/ Aerobraking | Transfer Vehicle Avionics | ETO Vehicle Avionics | ETO Vehicle Structures & Materials | Autonomous Rendezvous & Docking | COHE | Auxiliary Propulsion |
| | Cryogenic Fluid Systems | Aeroassist Flight Expt Advanced Cryo. Engines | Low-Cost ETO Transport | Nuclear Electric Propulsion | CONE | ---- | Autonomous Landing | TV Structures and Cryo Tankage | HEAb |
| Space Platforms Technology | Platform Structures & Dynamics | Platform Power and Thermal Mgt. | Zero-G Life Support | Platform Materials & Environ. Effects | Station-Keeping Propulsion | ---- | Spacecraft On-Board Propulsion | Earth-Orbiting Platform Controls | Advanced Refrigerator Systems |
| | ---- | ---- | Zero-G Advanced EMU | Platform NDE-NDI | Deep-Space Power and Thermal | ---- | Spacecraft GN&C | Debris Mapping Experiment | ---- |
| Operations Technology | Space Data Systems | High-Rate Comm. | Artificial Intelligence | Ground Data Systems | Optical Comm Flight Expt | Flight Control and Operations | Space Assembly & Construction | Space Processing & Servicing | Photonics Data Systems |
| | ---- | CommSat Communicat'ns | TeleRobotics | Operator Syst./Training | Flt. Telerobotic Servicer/DTF-1 Navigation & Guidance | CommSat Communicat'ns Flight Expts | ---- | Ground Test and Processing | ---- |

LBF40343 FINAL

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

# FY 1992 Program ITP: CSTI Element Categorization

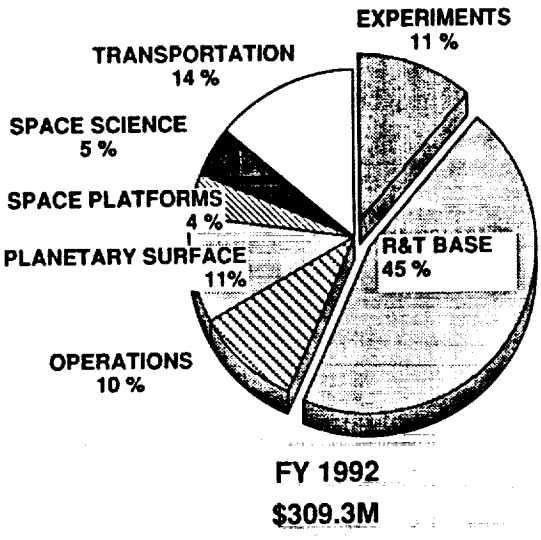
OAST

| | HIGHEST PRIORITY ◊◊◊ | | | 2nd-HIGHEST PRIORITY ◊◊ | | | 3rd-HIGHEST PRIORITY ◊ | | |
|---|---|---|---|---|---|---|---|---|---|
| Space Science Technology | Submillimeter Sensing | Direct Detectors | Laser Sensing | --- | --- | --- | --- | --- | --- |
| | Cooler and Cryogenics | Microprecision CSI | --- | --- | --- | --- | --- | --- | --- |
| Planetary Surface Technology | Radiation Protection | Regenerative Life Support (Phys-Chem.) | Space Nuclear Power (SP-100) | High Capacity Power | --- | --- | --- | --- | --- |
| | --- | --- | Extravehicular Activity Systems | --- | --- | Laser Electric Power Beaming | --- | --- | --- |
| Transportation Technology | ETO Propulsion | --- | --- | --- | --- | --- | --- | --- | --- |
| | --- | Advanced Cryogenic Engines | Nuclear Thermal Propulsion | Nuclear Electric Propulsion | --- | --- | --- | --- | --- |
| Space Platforms Technology | Platform Structures & Dynamics | Platform Power & Thermal Mgt. | --- | --- | --- | --- | --- | --- | --- |
| | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Operations Technology | Space Data Systems | --- | Artificial Intelligence | --- | --- | --- | --- | --- | --- |
| | --- | --- | TeleRobotics | --- | --- | --- | --- | --- | --- |

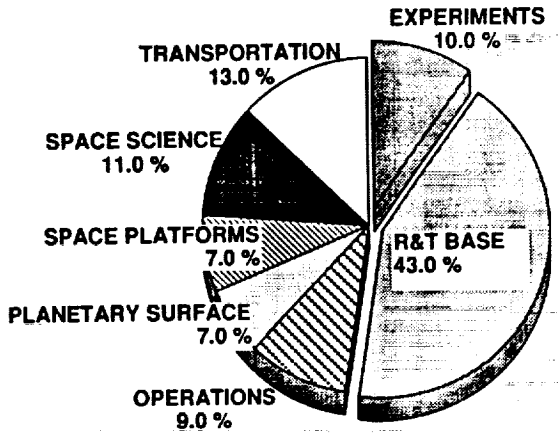
LBF40363a

# SPACE RESEARCH & TECHNOLOGY PROGRAM

OAST




FY 1992
$309.3M

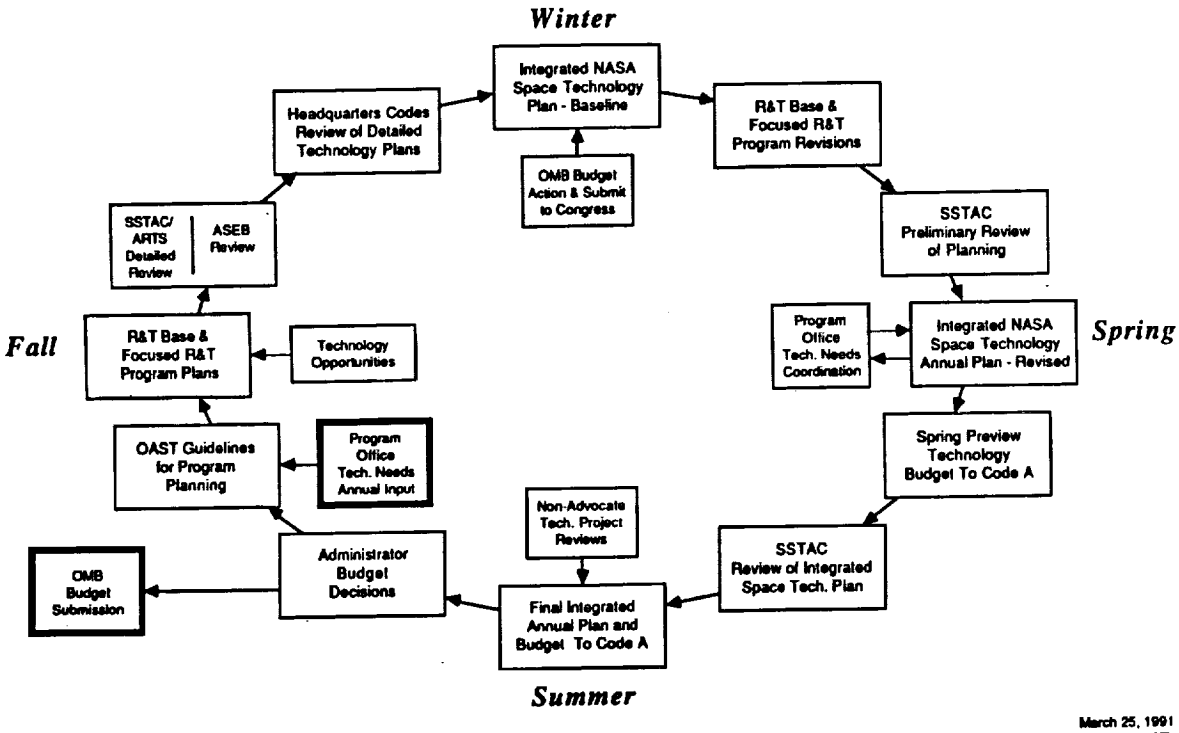



FY 1993
$332.0M

LBF 40423c

# SPACE TECHNOLOGY PLANNING CYCLE

OAST




March 25, 1991
JCM-7207b

## WHY SHOULD SPACE TECHNOLOGY BE A NATIONAL PRIORITY?

OAST

- OVER THE PAST 29 YEARS, U.S. LEADERSHIP HAS ERODED AS THE SPACE ACTIVITIES OF OTHER NATIONS HAVE EXPANDED IN SCOPE AND QUALITY
- OVER THE SAME PERIOD, U.S. SPACE PROGRAMS HAVE ENCOUNTERED COST, SCHEDULE AND TECHNICAL DIFFICULTIES
- IN ADDITION, THE U.S. STABLE OF VEHICLES AND TELECOMMUNICATIONS SATELLITES ARE BEING CHALLENGED ON THE WORLD MARKET
- FINALLY, THE TECHNOLOGIES WE MUST HAVE TO ACHIEVE PREEMINENCE IN SPACE FOR THE 21ST CENTURY DO NOT YET EXIST
- A WELL MANAGED AND FOCUSED PROGRAM WILL PROVIDE BENEFITS FOR THE NATION AND THE SPACE PROGRAM

*Ref: SSTAC ITP Review*

# BENEFITS FOR THE NATION

OAST

- IMPROVING NATIONAL COMPETITIVENESS
  - COMMERCIAL SPACE MARKETS
  - BROAD RANGE OF CRITICAL TECHNOLOGIES
- STIMULATING QUALITY SCIENCE AND ENGINEERING EDUCATION
  - EXCITING AND MEANINGFUL UNDERGRADUATE AND GRADUATE OPPORTUNITIES
  - INVOLVES GOVERNMENT, INDUSTRY AND ACADEMIA
  - SUPPLIES INDUSTRY AND ACADEMIA, NOT JUST NASA
  - ATTRACTS BEST AND BRIGHTEST INTO TECHNICAL FIELDS
- DEVELOPING BROADLY APPLICABLE NEW TECHNOLOGIES
  - NASA MISSION TECHNOLOGIES APPLICABLE TO COMMERCIAL AND DOD
  - ALL FUTURE NATIONAL SPACE ENDEAVORS ENHANCED BY NASA SPACE R&T

*Ref: SSTAC ITP Review*

# BENEFITS FOR FUTURE U.S. SPACE ENDEAVORS

OAST

- IMPROVING THE QUALITY OF FUTURE U.S. FLIGHT PROGRAMS
  - PROVIDES NEW CAPABILITIES WITH MINIMUM COST OR SCHEDULE RISK
  - REDUCES ERROR IN COST PROJECTIONS
- TWO-FOLD REDUCTION IN THE COST OF ACCESS TO SPACE
  - COST REDUCTION WITHOUT REDUCING SCOPE
  - REDUCED SPACECRAFT SIZE
  - INCREASED AUTONOMY
- INCREASING SAFETY AND RELIABILITY
  - ACHIEVING SAFETY AND RELIABILITY WITH CURRENT TECHNOLOGY CAN BE COSTLY
  - NEW TECHNOLOGIES CAN SIGNIFICANTLY REDUCE THESE COSTS
- ENABLING NEW SPACE MISSIONS
- SUSTAINING NASA EXPERTISE

*Ref: SSTAC ITP Review*

# REVIEW TEAM RECOMMENDATIONS

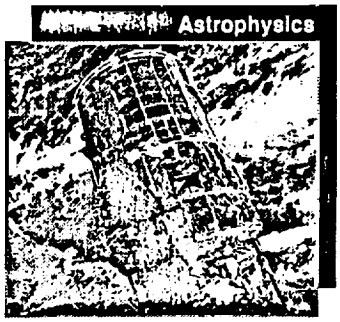
OAST

**ACCEPT RECOMMENDATION 8 OF THE AUGUSTINE REPORT AND INITIATE PLANNING FOR THE NEEDED FUNDING GROWTH TO TRIPLE THE CURRENT LEVEL OF INVESTMENT IN ADVANCED SPACE RESEARCH AND TECHNOLOGY**

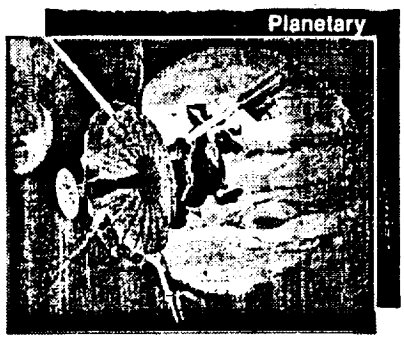
- CONTINUE TO IMPROVE THE INTEGRATED TECHNOLOGY PLAN
- DEVELOP NATIONAL TEAMS
- DEVELOP NATIONAL TESTBEDS
- REVITALIZE SPACE R&T FACILITIES
- INCREASE THE USE OF TECHNOLOGY FLIGHT DEMONSTRATIONS
- IMPROVE TECHNOLOGY TRANSFER

LBF40492

## TECHNOLOGY CONTRIBUTIONS TO SCIENCE SPACECRAFT

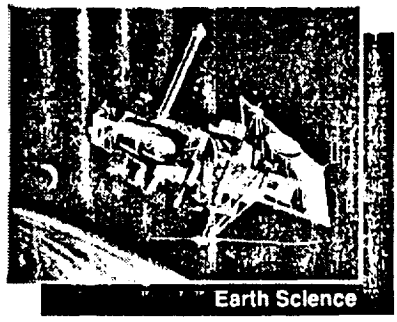



- Hubble - VLSI Data Processing
- Astro - Startracker
- Hubble - Battery Technology
- Hubble - Image Restoration




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

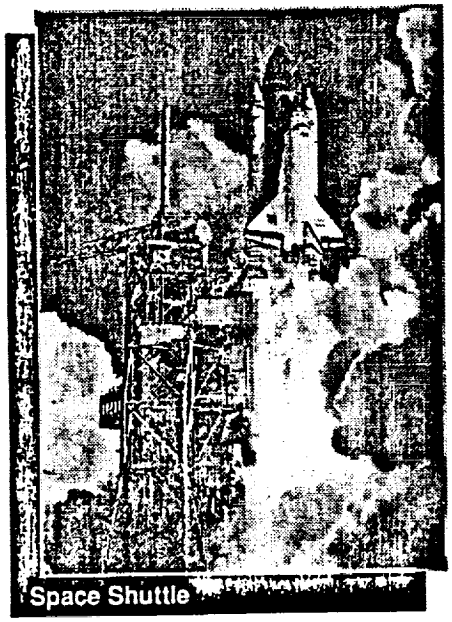
- UARS - 205 GHz Limb Sounder Technology
- Shuttle Imaging Radar - SAR Technologies
- TOPEX - Millimeter Accuracy Laser Ranging



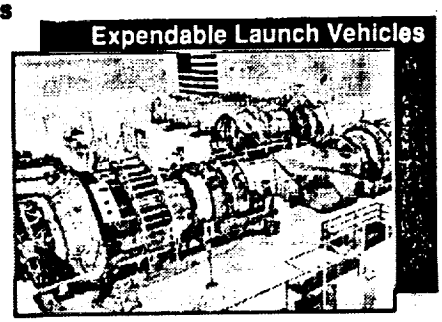

*Office of Aeronautics and Space Technology*

92-8013

## TECHNOLOGY CONTRIBUTIONS TO TRANSPORTATION




- 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

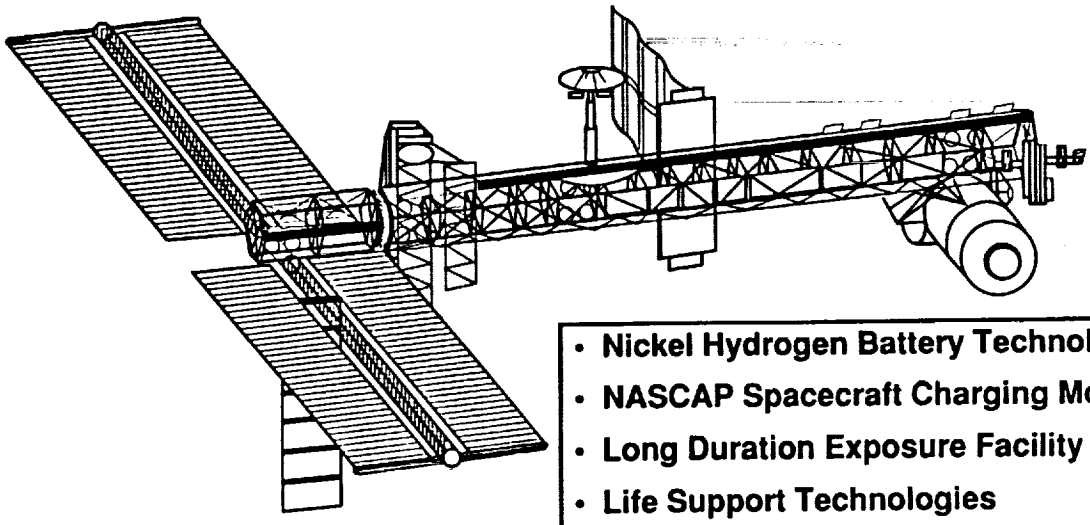



- Advanced Primary Battery

*Office of Aeronautics and Space Technology*

92-8023a

## 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*

92-8024

# SCIENCE TECHNOLOGY

## INSTRUMENT

- IR Detectors
- Active Microwave
- Optoelectronics
- Submillimeter Detectors
- High Energy Detectors
- Passive Microwave
- Laser Sensors
- Sensor Readouts

## OBSERVATION

- Cryocoolers
- Micro Precision CSI
- Precision Pointing
- Telescope Systems
- Sensor Optics

## IN SITU MEASUREMENT

- Sample Acquisition, Analysis, and Preservation
- Probes and Penetrators

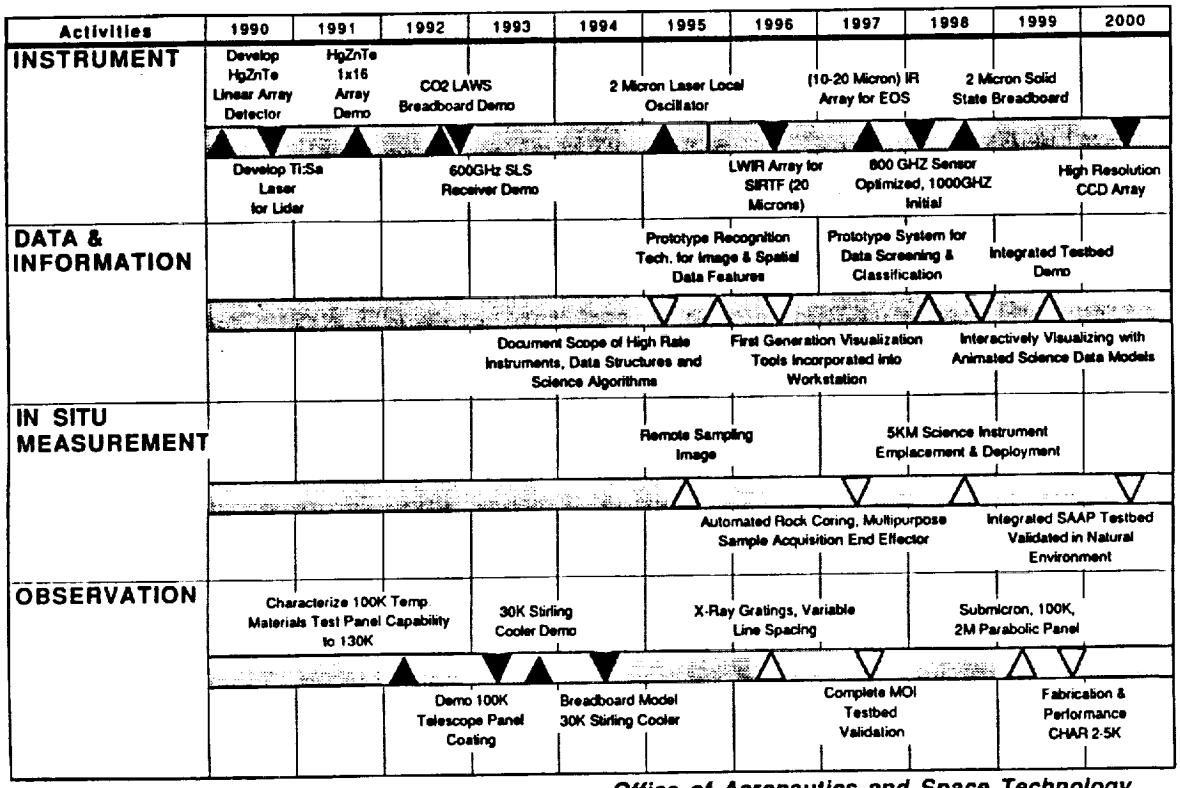
## DATA & INFORMATION

- Data Archives
- Information Visualization

*Office of Aeronautics and Space Technology*

91-8047

# SPACE SCIENCE MILESTONES




▲ Indicates Funded
△ Indicates NonFunded

*Office of Aeronautics and Space Technology*