SPACE RESEARCH & TECHNOLOGY OVERVIEW

- ORGANIZATION
- OBJECTIVES AND STRUCTURE
- PROGRAM ELEMENTS AND MILESTONES
- PLANNING AND RESOURCES
- ACCOMPLISHMENTS
- CENTER ROLES
## OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY
### FY 1992 BUDGET

<table>
<thead>
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<th>APPROP.</th>
<th>AERO ($,M)</th>
<th>TRANSAT. ($,M)</th>
<th>SPACE ($,M)</th>
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* SPACE EXCLUDES MISSION STUDIES ($5.0M)

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## SPACE R&T MISSION STATEMENT

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
INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

RESEARCH & TECHNOLOGY STRATEGY

- 5-YEAR FORECAST INCLUDES
  - '93 THRU '97: COMPLETION OF INITIAL SSF
  - SOME SHUTTLE IMPROVEMENTS
  - INITIAL EOS & EOSDIS
  - SELECTED SPACE SCIENCE STARTS
  - NLS DEVELOPMENT
  - INITIAL SEI ARCHITECTURE SELECTION
  - EVOLVING GEO COMMERCIAL COMMATS
  - MINOR UPGRADES OF COMMERCIAL ELVS

- 10-YEAR FORECAST INCLUDES
  - '98 THRU '03: SSF EVOLUTION/INFRASTRUCTURE
  - FINAL SHUTTLE ENHANCEMENTS
  - MULTIPLE ADVANCED LEO EOS PLATFORMS
  - MULTIPLE SPACE SCIENCE STARTS
  - 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 COMMATS
  - NEW COMMERCIAL ELVS

- 20-YEAR FORECAST INCLUDES
  - '04 THRU '11
    - SSF-MARS EVOLUTION
    - BEGINNING OF AM/SPS DEVELOPMENT
    - MULTIPLE SPACE SCIENCE STARTS
    - DSN EVOLUTION (OPTICAL COMM)
    - INITIAL MARS HLV DEVELOPMENT
    - EVOLVING LUNAR SYSTEMS
    - MARS SEI ARCHITECTURE CHOSEN
    - LARGE GEO COMMATS
    - NEW COMMERCIAL ELVS

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

TECHNOLOGY MATURATION STRATEGY

Technology Readiness Level

The figure illustrates the progression of technology maturation, starting from basic technology research and extending through technology development, proof of feasibility, system and subsystem development, technology demonstration, and finally to system test, launch, and operations. Each step represents an increasing level of readiness and responsibility, culminating in flight project office responsibility.

Flight Program Office

The flight program office is responsible for full-scale development, launch, and operations. This stage involves the integration of all components and systems, ensuring they meet the required performance and safety standards.

Flight Project Office

The flight project office oversees the day-to-day operations and maintenance of the mission, ensuring it stays on schedule and within budget.

Flight Project Full-Scale Development, Launch & Operations

This is the final stage, where the project is fully operational, functioning as intended, and providing the intended benefits.

Potential Joint Responsibility

This represents areas where multiple stakeholders or offices may have joint responsibility, ensuring a coordinated approach to technology maturation and mission success.
INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY

RESEARCH & TECHNOLOGY BASE

CIVIL SPACE TECHNOLOGY INITIATIVE

DISCIPLINE RESEARCH

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

UNIVERSITY PROGRAMS

SPACE FLIGHT R&T

SYSTEMS ANALYSIS

SPACE SCIENCE TECHNOLOGY

Science Sensing
Observatory Systems
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.

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
## INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

### R&T Base Discipline Programs Content

<table>
<thead>
<tr>
<th>BASE CAPABILITIES</th>
<th>ADVANCED TECHNOLOGIES</th>
<th>&quot;BREAKTHROUGH&quot; TECHNOLOGIES</th>
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<tbody>
<tr>
<td><strong>Space Communications</strong></td>
<td>Traveling Wave Tubes (TWs)</td>
<td>Digital Switching Processes</td>
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<tr>
<td><strong>Space Energy Conversion</strong></td>
<td>Solar Cells (S-III, In-Pi)</td>
<td>Solar Thermal Electric Converters</td>
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<tr>
<td><strong>Human Support</strong></td>
<td>Extravehicular Activity Builts</td>
<td>Life Support Models</td>
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<tr>
<td><strong>Information and Controls</strong></td>
<td>Electromagnetic Design/Analysis</td>
<td>Interactive EVA Displays</td>
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<tr>
<td><strong>Materials and Structures</strong></td>
<td>Space Durables</td>
<td>High Precision/Structural Materials</td>
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<tr>
<td><strong>Propulsion</strong></td>
<td>Internal Combustion</td>
<td>Inertial Thrusters</td>
</tr>
</tbody>
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### 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**
IN-SPACE TECHNOLOGY EXPERIMENTS

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
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

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
INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY

RESEARCH & TECHNOLOGY BASE

CIVIL SPACE TECHNOLOGY INITIATIVE

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

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

TRANSPORTATION TECHNOLOGY
- ETO Transportation
- Space Transportation
- Technology Flight Expts.

UNIVERSITY PROGRAMS

PLANETARY SURFACE TECHNOLOGY
- Surface Systems
- Human Support
- Technology Flight Expts.

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

SPACE FLIGHT R&T

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

IN SPACE TECHNOLOGY EXPTS

SYSTEMS ANALYSIS

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
### SCIENCE TECHNOLOGY

#### INSTRUMENT
- IR Detectors
- Active Microwave
- Optoelectronics
- Submillimeter Detectors
- High Energy Detectors
- Passive Microwave
- Laser Sensors
- Sensor Readouts
- Cryocoolers
- Micro Precision CSI
- Precision Pointing
- Telescope Systems
- Sensor Optics
- Passive Microwave
- Submillimeter Detectors
- High Energy Detectors
- Cryocoolers
- Micro Precision CSI
- Precision Pointing
- Telescope Systems
- Sensor Optics

#### IN-SITU MEASUREMENT
- Sample Acquisition, Analysis, and Preservation
- Probes and Penetrators
- Data Archives
- Information Visualization

#### DATA & INFORMATION
- Data Archives
- Information Visualization

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### SPACE SCIENCE MILESTONES

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<td>2 Micron Laser Local Oscillator</td>
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<td>800 GHz Sensor Optimized, 1000GHz Initial</td>
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<td>Document Scope of High Rate Instruments, Data Structures and Science Algorithms</td>
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<td>First Generation Visualization Tools Incorporated into Workstation</td>
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<td>Automated Rock Coring, Multipurpose Sample Acquisition End Effector</td>
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<td>30K Stirling Cooler Demo</td>
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<td>X-Ray Gratings, Variable Line Spacing</td>
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<td>Submicron 100K, 2µm Parabolic Panel</td>
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△ Indicates Funded
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Office of Aeronautics and Space Technology

BB-10
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

Office of Aeronautics and Space Technology

PLANETARY SURFACE TECHNOLOGY

SURFACE SYSTEMS

- Space Nuclear Power
- In Situ Resource Utilization
- Planetary Rover
- High Capacity Power

- Surface Power and Thermal Management
- Surface Habitats & Construction
- Laser-Electric Power Beaming

HUMAN SUPPORT

- Regenerative Life Support
- Radiation Protection
- Extravehicular Activity Systems

- Exploration Human Factors
- Artificial Gravity
- Remote Medical Care Systems

Office of Aeronautics and Space Technology
### PLANETARY SURFACE MILESTONES

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<tbody>
<tr>
<td>SURFACE OPERATIONS</td>
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<td>Demonstrated ColdEnd (525K) Operation of Stirling System</td>
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<td>Select RFC Component Technologies</td>
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<td>Decision on Laser Power Beaming R&amp;T</td>
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<td>Complete Testbed Evaluation for Early Unpress. Lunar Piloted/Teleoperated Rover, Early RFC Demo</td>
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<td>Complete Lunar EVA R&amp;T; Guidelines for Lunar Habits</td>
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<td>Complete EVA Suit Tech. for Early Lunar Mission Option; Radiation Code with ≤25% Uncertainty</td>
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<td>Comp. Integrated Lunar Outpost Testbed Man-Rated Demo w/Adv. RLSS</td>
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### 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 ELVs 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**

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TRANSPORTATION TECHNOLOGY

### SHUTTLE ENHANCEMENT
- SSME Improvements
- Improved Health Monitoring
- Durable Thermal Protection Systems
- Light Structural Alloys
- LIDAR-Based Adaptive Guidance & Control

### NEXT-GENERATION MANNED TRANSPORTS
- Configuration Assessment
- High Frequency, High Voltage Power Management/Distribution Systems
- LOX/LH2 Propellant for OMS/RCS
- Maintenance-free TPS
- Advanced Reusable Propulsion
- GPS-Based Autonomous GNAC
- Composites & Advanced Lightweight Metals
- Vehicle-Level Health Management for Autonomous Operations

### HEAVY-LIFT CAPABILITY
- Advanced Fabrication (Forming & Joining)
- STSE Improvements
- On-Vehicle Adaptive Guidance & Control
- Systems & Components for Electric Actuators
- Health Monitoring for Safe Operations
- AL-LI Cryo Tanks

### LOW-COST COMMERCIAL
- Alternate Booster Concepts
- Advanced Cryogenic Upper Stage Engines
- Low-Cost Fab/Automated Processes/NDE
- Continuous Forging Processes for Cryogenic Tanks
- Fault-Tolerant, Redundant Avionics

### IN-SPACE TRANSPORT
- High-Power Nuclear Thermal & Electric Propulsion
- High Performance, Multiple Use Cryogenic Chemical Engine
- Highly Reliable, Autonomous Avionics
- Low Mass, Space Durable Materials
- Long-Term, Low-Loss Management of Cryogenic Hydrogen
- Autonomous Rendezvous, Docking & Landing
- Aeroassist Technologies

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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

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SPACE PLATFORMS TECHNOLOGY

EARTH ORBITING PLATFORMS
- Structural Dynamics
- Power Systems
- On-Orbit Non-Destructive Evaluation Techniques
- Thermal Management
- Space Environmental Effects
- Advanced Information Systems

SPACE STATIONS
- Regenerative Life Support
- Extravehicular Mobility
- Integrated Propulsion and Fluid Systems Architecture
- Telerobotics
- Artificial Intelligence

SPACE BASED LABORATORY AND TESTBED
- Exploit Microgravity and Crew Interactive Capability to Advance and Validate Selected Technologies

DEEP SPACE MISSIONS
- Power and Thermal Management
- Propulsion
- Guidance, Navigation and Control

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BB-14
## SPACE PLATFORMS MILESTONES

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<tr>
<td>EARTH ORBITING PLATFORMS</td>
<td>Complete Testing &amp; e-0 Evolutionary CSI Ground TestBed Model</td>
<td>Laboratory Test &amp; Selection of On-Orbit NDI Technologies</td>
<td>Complete Advanced LEO Meteoroid &amp; Debris Model</td>
<td>Demo Advanced Control Technologies</td>
<td>Large Scale Flight Experiment</td>
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<td>Award Contract for SD Ground Test System</td>
<td>Complete Assessment of SOA Contaminant Sensors</td>
<td>Advanced Portable Life Support Methods Selected</td>
<td>Complete Testing of Lightweight NiH2 Battery</td>
<td>Complete Adv. EMU Prototype</td>
<td>On-Orbit Demo of Multi-Propellant Rocketjet</td>
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<td>DEEP SPACE PLATFORMS</td>
<td>Complete Assessment of Spacecraft Adv. Power Systems</td>
<td>Determine Advanced Guidance Methodology</td>
<td>Demo Advanced Isope Power Conversion Unit</td>
<td>Demo Hybrid Smart Power Synch. Rectifier</td>
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### 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
## OPERATIONS TECHNOLOGY

### AUTOMATION & ROBOTICS
- Mission Control Support
- Planning & Scheduling
- Ground Servicing & Support Roles
- In-Space Teleoperation & Telerobotics

### INFRASTRUCTURE OPERATIONS
- In-Space Assembly & Construction
- Space Processing & Servicing
- Training & Human Factors
- Ground Test & Processing
- Flight Control & Space Operations

### INFORMATION & COMMUNICATIONS
- Space Data Systems
- Ground Data Systems
- Commercial Satellite Communications
- Photonics Systems
- High Rate Communications

### FLIGHT EXPERIMENTS
- Commercial Satellite Communications
- Optical Communications

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<td>Automated Assembly Planar Structure</td>
<td>Complete Non-Planar Tensile Assembly</td>
<td>Complete Automatic STS Scheduling System</td>
<td>Demonstrate One-Operator SMM Repair</td>
<td>Complete Development of AI Analysis Tools for Planetary Science</td>
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<td>Improved RMS Performance Demo</td>
<td>Demonstrate Phil-e-Box In-Flight Test</td>
<td>Insert AI Tools in all MCC Stations</td>
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<td>Demonstrate Automated Space Welding</td>
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<td>Demonstrate Realtime Data Analysis for Command Sequence Validation</td>
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<td>Demonstrate Automated Construction of Large EOS-likePlatform Structure</td>
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<td>Demonstrate Testbed with SOCR Controller</td>
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<td>Non-Volatile RAM Tests 60 GHz TWI Power Conditioner</td>
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<td>Flight Demo of SOCR Drive</td>
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△ Indicates Funded
▼ Indicates Non-Funded

**Office of Aeronautics and Space Technology**

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INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

Strategic Plan ITP: CSTI Element Categorization

<table>
<thead>
<tr>
<th>Element</th>
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FY 1992 Program ITP: CSTI Element Categorization

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**SCIENCE**

- HgZnTe 1x270 Array
- SiGeBIB Detector Arrays
- SIS Mixer Elements
- 2-Micron Laser for Lidar
- Microdynamic Component Tester
- AOTF-Based Imaging Spectrometer

**OPERATIONS**

- Automated Assembly of Space Structures
- Advanced Teleoperation
- Autonomous Mobile Exploration Robot
- MINI-Rover Technology
- Astronaut Science Advisor
- AUTOCASS IV

**SPACE PLATFORMS**

- Controls-Structures Interaction
- Hybrid-Scale Model of SSF Configuration
- Simulated EVA Assembly of Truss Structure and Panels

**RESEARCH & TECHNOLOGY BASE**

- Personnel Launch System Benchmark Study
- Optimized PLS HL-20 Database
- PLS Approach & Landing Simulation Study
- Ceramic Matrix Composites
- Wind Tunnel Air Flow Density Measurements
- MAGELLAN Aerobrake Maneuver Gas Flow Predictions
- Advanced Concentrator Photovoltaic System
- Advanced Photovoltaic Solar Array
- Hot Rocket Technology
- High Power Electric Propulsion
- FOIL Bearing Technology
- Brush Seal Technology
- Molecular Computational Fluid Dynamics
- Multilayer Insulation Technology
- Toughened Uni-Piece Fibrous Insulation Material
- Adaptive Unstructured Meshes
- Radiation Resistance of Novel TiNi-Containing Polyimide

**PLANETARY SURFACE**

- STIRLING Cold End Motoring Test
- Regenerative Life Support

**TRANSPORTATION**

- New CFD Tools for Turbine Blade Design
- New Technology Main Combustion Chamber
- High-Aspect-Ratio Cooling Channel Designs
- Low Cost Thrust Chamber Critical Test
- Ceramic Composite Engine Parts
- Ceramic Balls for Long-Life Ball Bearings

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**TECHNOLOGY CONTRIBUTIONS TO SCIENCE SPACECRAFT**

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

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

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

Office of Aeronautics and Space Technology
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

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
NASA INSTALLATIONS

AMES RESEARCH CENTER
Moffett Field, CA

DRYDEN FLIGHT RESEARCH FACILITY
Edwards AFB, CA

JET PROPULSION LABORATORY
Pasadena, CA

JOHNSON SPACE CENTER
Houston, TX

WHITE SANDS TEST FACILITY
Las Cruces, NM

STENNIS SPACE CENTER
Mississippi

LEWIS RESEARCH CENTER
Cleveland, OH

GODDARD SPACE FLIGHT CENTER
Greenbelt, MD

WALLOPS FLIGHT FACILITY
Wallops Island, VA

NASA HEADQUARTERS
Washington, D.C.

LANGLEY RESEARCH CENTER
Hampton, VA

KENNEDY SPACE CENTER
Florida

MARSHALL SPACE FLIGHT CENTER
Huntsville, AL

MICHOUD ASSEMBLY FACILITY
New Orleans, LA

RESEARCH CENTERS

AMES
- Human Support
- Artificial Intelligence
- Aerothermodynamics
- Thermal Protection Systems
- Computer Science

LANGLEY
- Large Space Systems
- Aerothermodynamics, Materials, Structures & Dynamics
- Remote Sensing
- Advanced Vehicle System Concept Studies
- Robotic Systems
- Space Data Systems
- Guidance, Navigation & Control

LEWIS
- Electric Propulsion
- Thermal Management
- Chemical Propulsion
- CryoFluid Systems
- Communications Systems
- Nuclear Propulsion
- Space Power Systems

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SPACE SCIENCE CENTERS

JET PROPULSION LABORATORY

- Autonomous Systems & Robotics
- Guidance, Navigation & Control
- Sensors
- Space Data & Information Systems
- Optical Systems
- Advanced Propulsion

GODDARD

- Sensors
- Space Data Systems
- Laser Communications
- Telerobotics

Office of Aeronautics and Space Technology

SPACE FLIGHT CENTERS

KENNEDY

- Telerobotics
- Artificial Intelligence

STENNIS

- Chemical Propulsion
- Vehicle Health Monitoring

MARSHALL

- Chemical Propulsion
- Structures, Materials & Dynamics
- CryoFluid Systems
- Space Power Systems
- Controls & Avionics

JOHNSON

- Human Support
- Thermal Management
- Controls & Avionics
- Mission Operations
- InSitu Resource Utilization/Surface Systems

Office of Aeronautics and Space Technology