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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ADMINISTRATOR
DEPUTY ADMINISTRATOR
ASSOCIATE DEPUTY ADMINISTRATOR
ASSISTANT DEPUTY ADMINISTRATOR
EXECUTIVE OFFICER

INSPECTOR
GENERAL

CHIEF FINANCIAL OFFICER
COMPTROLLER

GENERAL COUNSEL

EQUAL OPPORTUNITY PROGRAMS

POLICY COORDINATION & INTERNATIONAL RELATIONS

LEGISLATIVE AFFAIRS

HUMAN RESOURCES & EDUCATION

COMMERCIAL PROGRAMS

PROCUREMENT

PUBLIC AFFAIRS

MANAGEMENT SYSTEMS & FACILITIES

SAFETY & MISSION QUALITY

EXPLORATION

SPACE SYSTEMS DEVELOPMENT

SPACE SCIENCE & APPLICATIONS

SPACE FLIGHT

AERONAUTICS & SPACE TECHNOLOGY

SPACE COMMUNICATIONS

GOODRICH SPACE FLIGHT CENTER

JET PROPULSION LABORATORY

LYNDON B. JOHNSON SPACE CENTER

JOHN F. KENNEDY SPACE CENTER

GEORGE C. MARSHALL SPACE FLIGHT CENTER

JOHN C. STENNIS SPACE CENTER

AMES RESEARCH CENTER

LIGO RESEARCH CENTER

LEWIS RESEARCH CENTER

Signed by Richard H. Truly
October 30, 1994
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY
FY 1992 BUDGET

($,M)

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* SPACE EXCLUDES MISSION STUDIES ($5.0M)
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

TECHNOLOGY READINESS LEVELS

- TRL 1: BASIC PRINCIPLES OBSERVED AND REPORTED
- TRL 2: TECHNOLOGY CONCEPT AND/OR APPLICATION FORMULATED
- TRL 3: ANALYTICAL & EXPERIMENTAL CRITICAL FUNCTION AND/OR CHARACTERISTIC PROOF-OF-CONCEPT
- TRL 4: COMPONENT AND/OR BREADBOARD VALIDATION IN LABORATORY ENVIRONMENT
- TRL 5: COMPONENT AND/OR BREADBOARD VALIDATION IN RELEVANT ENVIRONMENT (Ground or Space)
- TRL 6: SYSTEM/SUBSYSTEM MODEL OR PROTOTYPE DEMONSTRATION IN A RELEVANT ENVIRONMENT (Ground or Space)
- TRL 7: SYSTEM PROTOTYPE DEMONSTRATION IN A SPACE ENVIRONMENT
- TRL 8: ACTUAL SYSTEM COMPLETED AND "FLIGHT QUALIFIED" THROUGH TEST AND DEMONSTRATION (Ground or Flight)
- TRL 9: ACTUAL SYSTEM "FLIGHT PROVEN" THROUGH SUCCESSFUL MISSION OPERATIONS

System Test, Launch and Operations
System/Subsystem Development
Technology Demonstration
Technology Development
Research To Prove Feasibility
Basic Technology Research
INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

TECHNOLOGY MATURATION STRATEGY

Technology Readiness Level

OAST R&T Responsibility

Potential Joint Responsibility

Flight Program Office Responsibility

Flight Project Office Responsibility

System Test, Launch and Operations

System/Subsystem Development

Technology Demonstration

Technology Development

Research To Prove Feasibility

Basic Technology Research

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
- 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.
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

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
SPAC 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

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IN-SPACE TECHNOLOGY EXPERIMENTS
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

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.
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

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
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

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
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 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

INTEGRATED TECHNOLOGY PLAN
PROCESS

• 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
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

AA-11
## INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

### EXTERNAL TECHNOLOGY NEEDS SOURCES

- 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**

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### OSF Technology Requirements Evaluation

#### Technology Areas

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<td>2. Advanced Turbomachinery Components and Models</td>
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<td>3. Combustion Devices</td>
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<td>4. Advanced Heat Rejection Devices</td>
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<td>5. Water Recovery and Management</td>
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<td>6. High Efficiency Space Power Systems</td>
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<td>7. Advanced Extravehicular Mobility Unit Technologies</td>
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<td>8. Electromechanical Control Systems/Electrical Actuation</td>
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<td>9. Crew Training Systems</td>
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<tr>
<td>10. Characterization of AH1 Alloys</td>
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<td>11. Cryogenic Supply, Storage, and Handling</td>
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<td>12. Thermal Protection Systems for High Temperature Applications</td>
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<td>13. Robotic Technologies</td>
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<td>14. Orbital Debris Protection</td>
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<td>15. Guidance, Navigation and Control</td>
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<td>16. Advanced Avionics Architectures</td>
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#### Industry Driven Technologies

- Signal Transmission and Reception
- Advanced Avionics Software
- Video Technologies
- Environmentally Safe Cleaning Solvents, Refrigerants and Foams
- Non-Destructive Evaluation

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**Figure 3-1**
INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

EXTERNAL TECHNOLOGY PERSPECTIVES SUMMARY

SPACE SCIENCE
- Precision Space Structures and Pointing Accuracy

PLANETARY SURFACE
- Regenerative 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
- Regenerative 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)

USER PRIORITIZED TECHNOLOGY NEEDS - UPDATE

- 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
INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM
RESEARCH & TECHNOLOGY STRATEGY

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

- 10-YEAR FORECAST INCLUDES
  '96 THRU '03:
  FINAL SHUTTLE ENHANCEMENTS
  MULTIPLE NEW STARTS
  MULTIPLE SPACE SCIENCE STARTS
  NLS OPERATIONS/EVOLUTION
  EVOLVING LAUNCH/OPERATIONS FACILITIES
  INITIAL SEKULINAR OUTPOST START
  DSN EVOLUTION (KA-BAND COMMUNICATIONS)
  NEW GEO COMMERCIAL COMMISSATS
  NEW COMMERCIAL ELVS

- 20-YEAR FORECAST INCLUDES
  '04 THRU '11:
  OPTIONS FOR NEW STARTS TO BE LAUNCHED IN 2003 THRU 2010

OSSA TECHNOLOGY NEEDS
Grouped According to Urgency & Commonality

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FLIGHT PROGRAMS FORECAST

REVISED NOVEMBER 15, 1991

AA-14
**INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM**

**DECISION RULES: R&T BASE**

### 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**
### INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

**R&T Base Discipline Programs Content**

<table>
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<th>BASE CAPABILITIES</th>
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<td>KeiBand TWs Digital Switching Processors Ground Terminals</td>
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<td>Hydrogen Arcjet Resistors Engines Hydrogen Ionen-Thruster Propulsion</td>
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<tr>
<td></td>
<td>Expert System Modeling</td>
<td>MPD Thrusters Engine Liners Health Mgt.</td>
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</tbody>
</table>

### INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

**DECISION RULES: FOCUSED PROGRAMS**

**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**
# INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

## INVESTMENT PRIORITIZATION CRITERIA

### 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**

---

## INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

### Strategic Plan ITP: CSTI Element Categorization

<table>
<thead>
<tr>
<th>Space</th>
<th>Science Technology</th>
<th>Engineering Leverage</th>
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<tbody>
<tr>
<td></td>
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### Space Science Technology

<table>
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<tr>
<th>Subsystem</th>
<th>Direct</th>
<th>Active</th>
<th>Sample Art.</th>
<th>Passive</th>
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<td>and</td>
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<td>Microrep</td>
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<td>Data Arching</td>
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<td>Sensing</td>
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### Planetary Surface Technology

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<thead>
<tr>
<th>Radiation</th>
<th>Propulsion</th>
<th>Aerosol/Thermal</th>
<th>Aerostat</th>
<th>Propulsion</th>
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<tbody>
<tr>
<td>Protection</td>
<td>Life Support</td>
<td>Power (SP-100)</td>
<td>Systems</td>
<td>Power (SP-100)</td>
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<td>Extravehicular</td>
<td>Activity Systems</td>
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### Transportation Technology

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<th>Avionics</th>
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### Space Platforms Technology

<table>
<thead>
<tr>
<th>Platform</th>
<th>Structures &amp; Dynamics</th>
<th>Zero-G</th>
<th>Zero-G</th>
<th>Advanced</th>
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<td>Power and Life Support</td>
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<td>High</td>
<td>Service/Orbit</td>
<td>Flight Control</td>
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<td>Liftoff</td>
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<td>Data</td>
<td>Operations</td>
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<td>Service/Orbit</td>
<td>Thermal</td>
<td>Flight</td>
<td>Systems</td>
<td>Systems</td>
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<tr>
<td></td>
<td>Flight Support</td>
<td>Thermal</td>
<td>Data</td>
<td>Systems</td>
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<td>Flight</td>
<td>Systems</td>
<td>Systems</td>
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<tr>
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<td>Service/Orbit</td>
<td>Thermal</td>
<td>Flight</td>
<td>Systems</td>
<td>Systems</td>
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### Operations Technology

<table>
<thead>
<tr>
<th>Space Data</th>
<th>High-Rate Comm.</th>
<th>Artificial Intelligence</th>
<th>Ground Data</th>
<th>Optical Comm. and Operations</th>
<th>Space Data</th>
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<td></td>
<td>Ft. Telerobotics</td>
<td>Service/Orbit</td>
<td>Construction</td>
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<td>Service/Orbit</td>
<td>Flight Control and Operations</td>
<td>Support</td>
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<td>Service/Orbit</td>
<td>Flight Control and Operations</td>
<td>Service/Orbit</td>
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<td>Flight Control and Operations</td>
<td>Service/Orbit</td>
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<td>Service/Orbit</td>
<td>Flight Control and Operations</td>
<td>Service/Orbit</td>
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</tbody>
</table>

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### Integrated Technology Plan for the Civil Space Program

**OAST**

**3rd HIGHEST PRIORITY**

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**HIGHEST PRIORITY**

---

**2nd HIGHEST PRIORITY**

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**LBF40285**

(JCM-6684a)
### INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

**FY 1992 Program ITP: CSTI Element Categorization**

<table>
<thead>
<tr>
<th>Space Science Technology</th>
<th>Direct Sensing</th>
<th>Laser Sensing</th>
<th>Submillimeter Sensing</th>
<th>Microparticle CIB</th>
<th>Laser Sensing</th>
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<tr>
<td>Planetary Surface Technology</td>
<td>Radiation Protection</td>
<td>Regenerative Life Support (Phys-Chem)</td>
<td>Space Nuclear Power (SP-100)</td>
<td>High Capacity Power</td>
<td>Extravehicular Activity Systems</td>
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<tr>
<td>Transportation Technology</td>
<td>ETO Propulsion</td>
<td>Advanced Cryogenic Engines</td>
<td>Nuclear Thermal Propagation</td>
<td>Nuclear Electric Propulsion</td>
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</tr>
<tr>
<td>Space Platforms Technology</td>
<td>Platform</td>
<td>Power &amp; Thermal Mgt.</td>
<td>Artificial Intelligence</td>
<td>TeleRobotics</td>
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</table>

**SPACE RESEARCH & TECHNOLOGY PROGRAM**

**2092**

- **Transportation** 14%
- **Space Science** 5%
- **Space Platforms** 4%
- **Planetary Surface** 11%
- **Operations** 10%

**Experiments** 11%

**FY 1992**

- **R&T Base** 45%
- **Space Science** 11.0%
- **Space Platforms** 7.0%
- **Planetary Surface** 7.0%
- **Operations** 9.0%

**FY 1993**

- **R&T Base** 43.0%
- **Space Science** 13.0%
- **Space Platforms** 7.0%
- **Planetary Surface** 7.0%
- **Operations** 9.0%
WHY SHOULD SPACE TECHNOLOGY BE A NATIONAL PRIORITY?

- 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.
BENEFITS FOR THE NATION

- 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

- 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

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

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
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

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

92-8024