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
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 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
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

Office of Aeronautics and Space Technology

AA-5
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

Office of Aeronautics and Space Technology

IN-SPACE TECHNOLOGY EXPERIMENTS

- DAET-FLYER
- Sunlite Reflex
- Inflatable Paraboloid

- DAET-1
- Thin Film Mirror
- Spacecraft Glow
- Emulsion Chamber
- Energy Storage

- DAET-2
- Cryo-Cooler
- Energy Storage 3 & 4
- Jitter Suppression
- Plasma Interactions

- Mace
- Liquid Motion
- Permeable Membrane

- Tank Pressure Control

ANNOUNCEMENT OF OPPORTUNITY 1991
SOLICITATION 1987
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

- 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-Oriented 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

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

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
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

INTEGRATED TECHNOLOGY PLAN
PROCESSES

- 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
### Technology Areas

<table>
<thead>
<tr>
<th>Program Unique Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vehicle Health Management</td>
</tr>
<tr>
<td>2. Advanced Turbomachinery Components and Models</td>
</tr>
<tr>
<td>3. Combustion Devices</td>
</tr>
<tr>
<td>4. Advanced Heat Rejection Devices</td>
</tr>
<tr>
<td>5. Water Recovery and Management</td>
</tr>
<tr>
<td>6. High Efficiency Space Power Systems</td>
</tr>
<tr>
<td>7. Advanced Extravehicular Mobility Unit Technologies</td>
</tr>
<tr>
<td>8. Electromechanical Control Systems/Electrical Actuation</td>
</tr>
<tr>
<td>9. Crew Training Systems</td>
</tr>
<tr>
<td>10. Characterization of AHU Alloys</td>
</tr>
<tr>
<td>11. Cryogenic Supply, Storage, and Handling</td>
</tr>
<tr>
<td>12. Thermal Protection Systems for High Temperature Applications</td>
</tr>
<tr>
<td>13. Robotic Technologies</td>
</tr>
<tr>
<td>14. Orbital Debris Protection</td>
</tr>
<tr>
<td>15. Guidance, Navigation and Control</td>
</tr>
<tr>
<td>16. Advanced Avionics Architectures</td>
</tr>
</tbody>
</table>

### Industry Driven Technologies

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

---

### 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

SEPTEMBER 9, 1991
JCM 6430
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 & Micro robotic 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
### OSSA TECHNOLOGY NEEDS

Grouped According to Urgency & Commonality

<table>
<thead>
<tr>
<th>Near Term</th>
<th>Far Term</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cryogenic Systems</strong></td>
<td>Large Livered Apertures</td>
</tr>
<tr>
<td>High Frame Rate, High Resolution</td>
<td>2.3 - 4.5, 100K</td>
</tr>
<tr>
<td>High Frame Rate, High Resolution</td>
<td>2.3 - 4.5, 100K</td>
</tr>
<tr>
<td>Nuclear Reactor</td>
<td>2.3 - 4.5, 100K</td>
</tr>
<tr>
<td><strong>Fluid Diagnostics</strong></td>
<td><strong>Real-Time Solar Array/Cells</strong></td>
</tr>
<tr>
<td><strong>Real-Time Radiometric Monitoring</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
<tr>
<td><strong>Electrode/Thermal</strong></td>
<td><strong>Electrode/Thermal</strong></td>
</tr>
</tbody>
</table>

### PRIORITY

- **Highest Priority**
- **2nd Highest Priority**
- **3rd Highest Priority**

**Notes:**
- SB: Life Sciences
- SE: Earth Sciences and Applications
- SL: Space Weather
- ST: Microgravity Science and Applications
- SS: Space Physics
- SC: Astrophysics

**REVISED:**
November 15, 1991

**LBF40305**
(UOM-7682)

AA-14
SPACE RESEARCH AND TECHNOLOGY PROGRAM
SEI TECHNOLOGY NEEDS (for FY 1994 planning)

TECHNOLOGIES NEEDING NEAR-TERM COMPLETION (for First Lunar Outpost)

- Lunar EVA Systems
  - Durable, lightweight, high mobility suit and gloves
  - Lightweight, serviceable PLSS
- Life Support
  - Contamination & Particulate Control
  - Trash & Waste Management
  - Loop Closures
- Surface Power (Non-Nuclear)
  - High Efficiency thermal to electric conversion
  - Heat Rejection
  - Long-life Energy Storage
- Cryogenic Fluid Systems
  - Oxygen Storage
  - Cryogen (Zero D) Transfer
  - Quick Disconnect Interfaces
  - Zero-Gravity Cryo Geaging
- Autonomous Terrestrial Landing
  - Sensors
  - Software/Algorithms
  - Hazard Avoidance
- In Situ Resource Utilization
  - Tech Demo Capability
  - Oxygen Process Chemistry
  - Mining
  - Construction Material Test

TECHNOLOGIES NEEDING COMPLETION IN THE MID- TO FAR-TERM (for Mars and Permanently Manned Lunar Missions)

- Nuclear Thermal Propulsion
  - Fuel Development
  - Turbopumps
  - Test Facilities
  - Reactor Development
- Surface Nuclear Power
  - Power Conversion
  - Reactors
  - Radiation Protection
  - Gradient shielding
  - Solar Particle Event Prediction
  - Transport Code Validation
- Mars EVA Systems
  - Durable, lightweight, high mobility suit and gloves
  - Lightweight, serviceable PLSS

Note: No Prioritization is implied within a given category

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

FEBRUARY 5, 1994
JCM PMU
INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

R&T Base Discipline Programs Content

<table>
<thead>
<tr>
<th>DAST</th>
<th>BASE CAPABILITIES</th>
<th>ADVANCED TECHNOLOGIES</th>
<th>&quot;BREAKTHROUGH&quot; TECHNOLOGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerothermodynamics</td>
<td>Hypersonic Flowfield</td>
<td>Hypersonic Vehicle Synth.</td>
<td>Fl. Environ. Configuration</td>
</tr>
</tbody>
</table>
|                       | and Heat Transfer | Fundamental Design Tools | Instrument
| Data Bases | | | |
| Space Communications | Travelling Waves | Ka-Band TWT | Digital Switching Components |
|                     | Tubes (TWTs) | | Laser Comm. |
|                     | MMICs | Solid State | Ground Terminals |
|                     | | | |
|                        | Dynamics | (Galactic, In-P) | Thermoelectric Conv. Systems |
|                        | Electrocatalyst | Concentrators | Solar Dynamics |
|                        | Design/Analysis | and Arrays | Power Mgmt. |
|                        | | Conv. Systems | |
| Human Support | Extravehicular | EVA Gloves | EMU Components |
|                  | Activity Suit | | Life Support Models |
|                   | Human Modeling | PLSS Components | Interactive Life Support |
|                  | (Cogn./Phys.) | | Sensors/Control |
| Information and Controls | Electro-optic | Advanced | Computational Controls |
|                        | Marks/Sensors | At Research | Software |
|                        | | | Develop. Tools |
| Materials and Structures | Materials | Space Durable | High Precision Struct. |
|                        | Synthesis | Effects (L/M) | Durable Polymers |
|                        | Propulsion | Tribology | |
|                        | Sensors/Concepts | | |
| Propulsion | Combustion | Internal Pump | Ion Thrusters |
| Models/Design. | | Flow CFD | Water |
| | | | H2O |
| Engine Analysis | Cryo Fluid | Hydrogen Rockets | Engine Grow |
| | | | Hydrogen Fluoride |
| Expert Systems | Modeling | MHD Thrusters | Engine Lining |
| | | | Health Mgmt. |

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 Science Technology</th>
<th>Space Platforms Technology</th>
<th>Operations Technology</th>
</tr>
</thead>
</table>
| Submillimeter Sensing | Platform Structures & Dynamics | Data Systems
| Direct Decoders | Power and Life Support | Ground Data 
| Active wave sensing | Thermal Highs | Artificial Intelligence
| Passive Sensing | Materials & Environ. Effects | Data
| Laser Sensing | Propulsion | Systems 
| TCS and Microposition Systems | Platform | Analytical Intelligence
| Telescopes and Optical Systems | Zero-G | 
| High Capacity Power | Zero-G | 
| Planetary Vehicles | 
| Surface Solar Power and Thermal Utilization | 
| Interplanetary Activity | 
| Nuclear Electric Propulsion | Autonomous CONE | Autonomous TV Structures and Cryo Tanks
| Nuclear Heat Transfer | Autonomous Landing | 
| Aerostat Flight Exit | Autonomous Spacecrafts | Autonomous Spacecrafts
| Low-Cost ETO | Earth-Orbiting | On-Board Propulsion
| Cryo Engines | Mission & Support | Spacecraft Controls
| 

<table>
<thead>
<tr>
<th>HIGHEST PRIORITY</th>
<th>2nd HIGHEST PRIORITY</th>
<th>3rd HIGHEST PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>900</td>
<td>0</td>
</tr>
</tbody>
</table>

LBF40265
(JCM-6684a)

AA-17
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</th>
<th>Laser</th>
<th>Submillimeter Sensing</th>
<th>Radiometric Imaging</th>
<th>Micropropulsion CBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planetary Surface Technology</td>
<td>Regenerative Life Support (Phys-Chem)</td>
<td>Space Nuclear Power (SP-100)</td>
<td>High Power Laser</td>
<td>Extravehicular Activity Systems</td>
<td></td>
</tr>
<tr>
<td>Transportation Technology</td>
<td>ETO Population</td>
<td>Nuclear Electric Power</td>
<td>Nuclear Electric Power Population</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Platforms Technology</td>
<td>Advanced Cryogenic Engines</td>
<td>Platform</td>
<td>Platform Power &amp; Thermal Mgmt.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operations Technology</td>
<td>Space Data Systems</td>
<td>Artificial Intelligence</td>
<td>TeleRobotics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HIGHEST PRIORITY

FY 1992 $309.3M

EXPERIMENTS 11%

SPACE SCIENCE 5%
SPACE PLATFORMS 4%
PLANETARY SURFACE 11%
OPERATIONS 10%

FY 1993 $332.0M

EXPERIMENTS 10.0%

SPACE SCIENCE 11.0%
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

AA-20
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
92-8013

AA-21
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

Expendable Launch Vehicles

- 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

AA-22
### 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

---

#### SPACE SCIENCE MILESTONES

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INSTRUMENT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HgCdTe Linear Array Detector</td>
<td>HgCdTe 1x16 Array Demo</td>
<td>CO2 LIAS Breadboard Demo</td>
<td>2 Micron Laser Local Oscillator</td>
<td>(10-20 Micron) IR Array for EOS</td>
<td>2 Micron Solid State Breadboard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop Ti:Sa Laser for Lidar</td>
<td>605GHz SLS Receiver Demo</td>
<td>850GHz Sensor with SIRTF (20 Microns)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### DATA & INFORMATION

- Document Scope of High Rate Instruments, Data Structures and Science Algorithms
- First Generation Visualization Tools Incorporated into Workstation
- Interactively Visualizing with Animated Science Data Models

#### IN SITU MEASUREMENT

- Remote Sampling Image
- SKM Science Instrument Emplacement & Deployment
- Automated Rock Coring, Multipurpose Sample Acquisition End Effector
- Integrated SAAP Testbed Validated in Natural Environment

#### OBSERVATION

- Characterize 100K Temp. Materials Test Panel Capacity to 130K
- 30K Stirling Cooler Demo
- X-Ray Gratings, Variable Line Spacing
- Submicron, 100K, 2M Parabolic Panel

Office of Aeronautics and Space Technology

A Indicates Funded
△ Indicates NonFunded

Office of Aeronautics and Space Technology

AA-23