

NASA Space Research & Technology Overview (ITP)

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p-23

Presentation to:

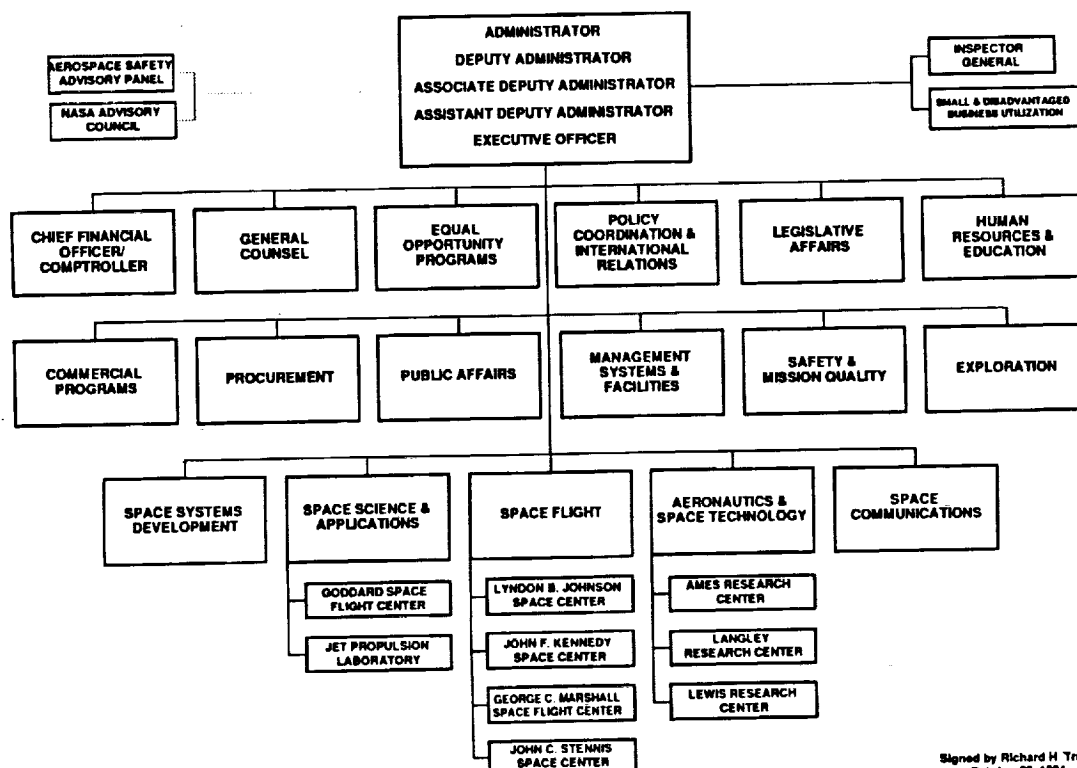
Civil Space Technology Development
Technology Transfer Workshop

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

March 17, 1992

OAST

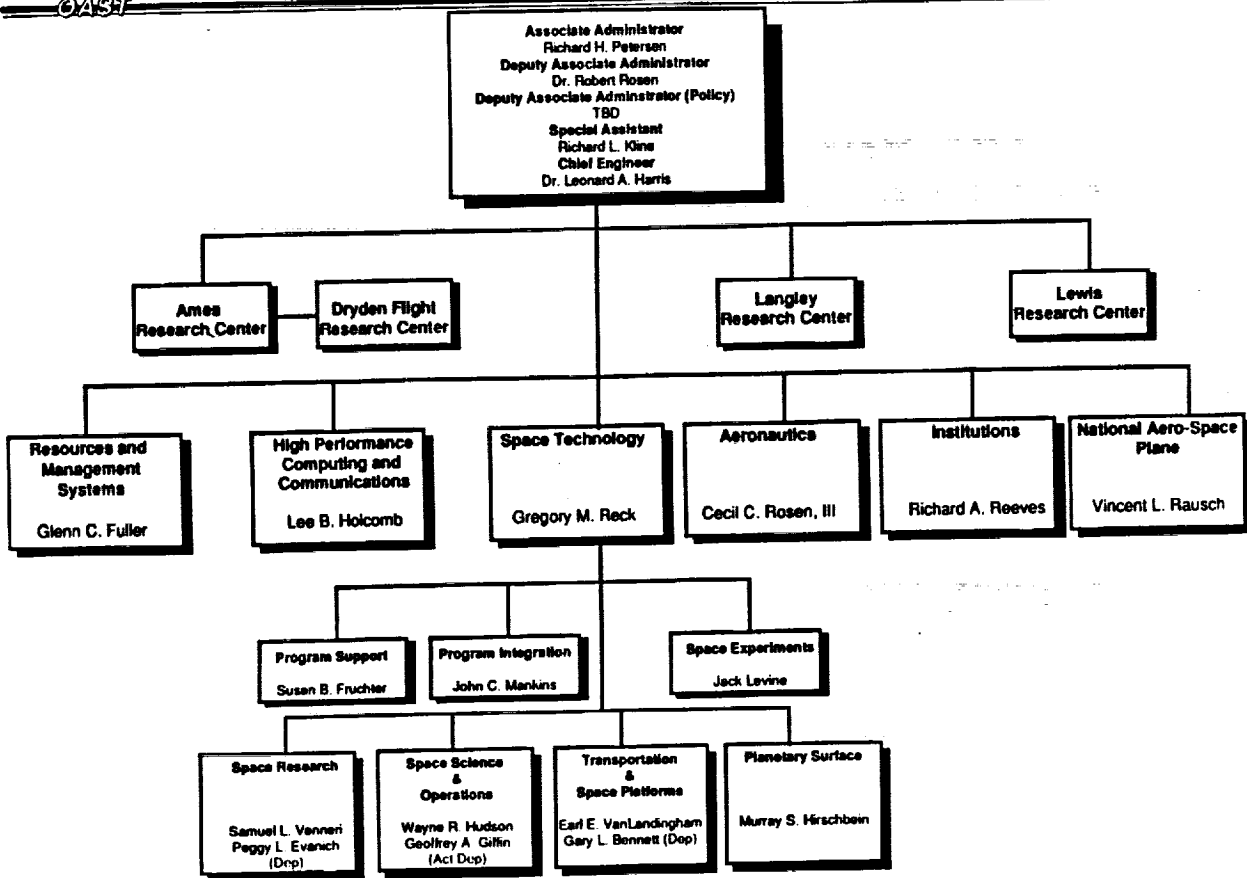
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



Signed by Richard H Truly
October 20, 1991

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)

SPACE R&T MISSION STATEMENT

OAST

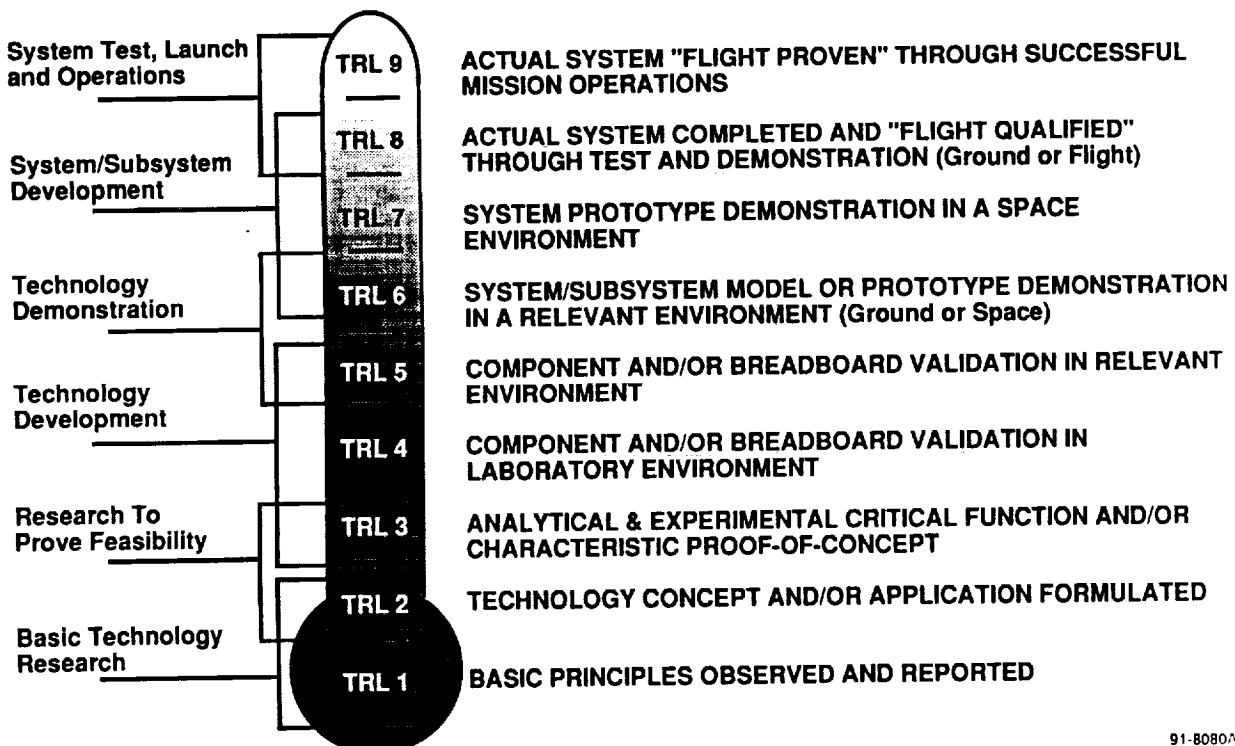
OAST SHALL PROVIDE TECHNOLOGY FOR FUTURE CIVIL SPACE MISSIONS AND PROVIDE A BASE OF RESEARCH AND TECHNOLOGY CAPABILITIES TO SERVE ALL NATIONAL SPACE GOALS

- **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

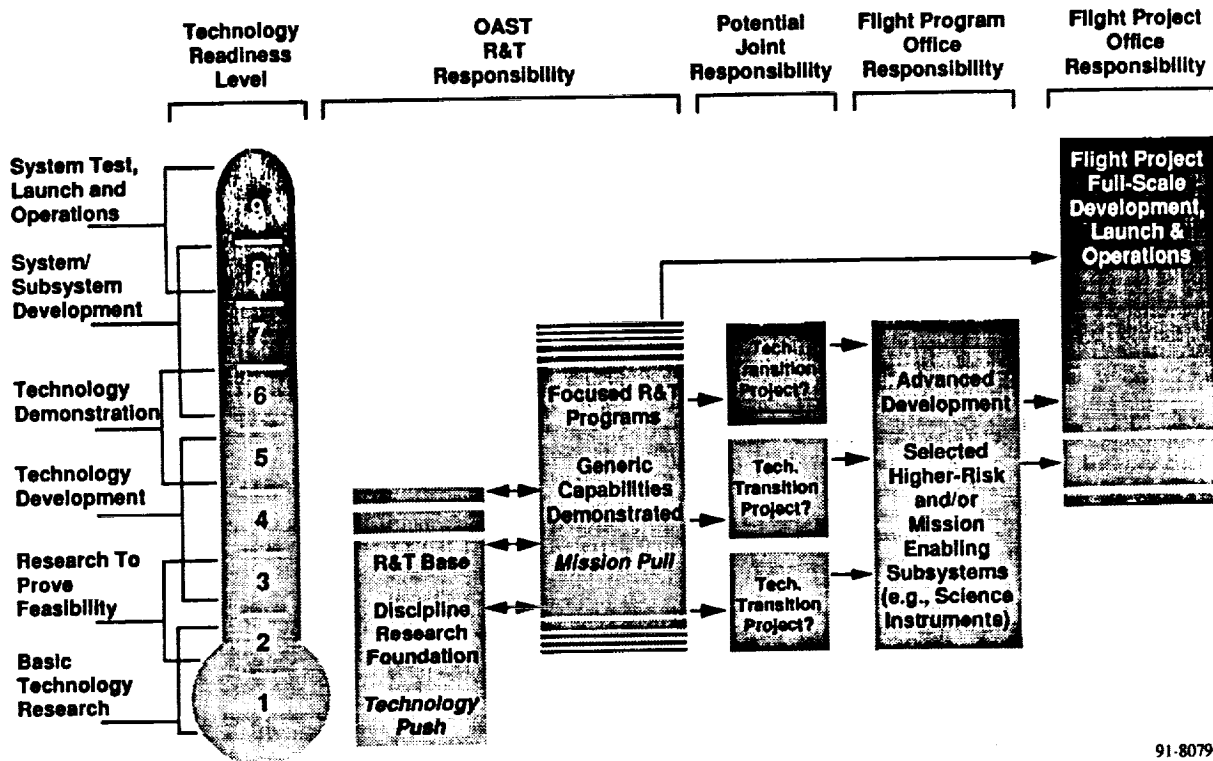
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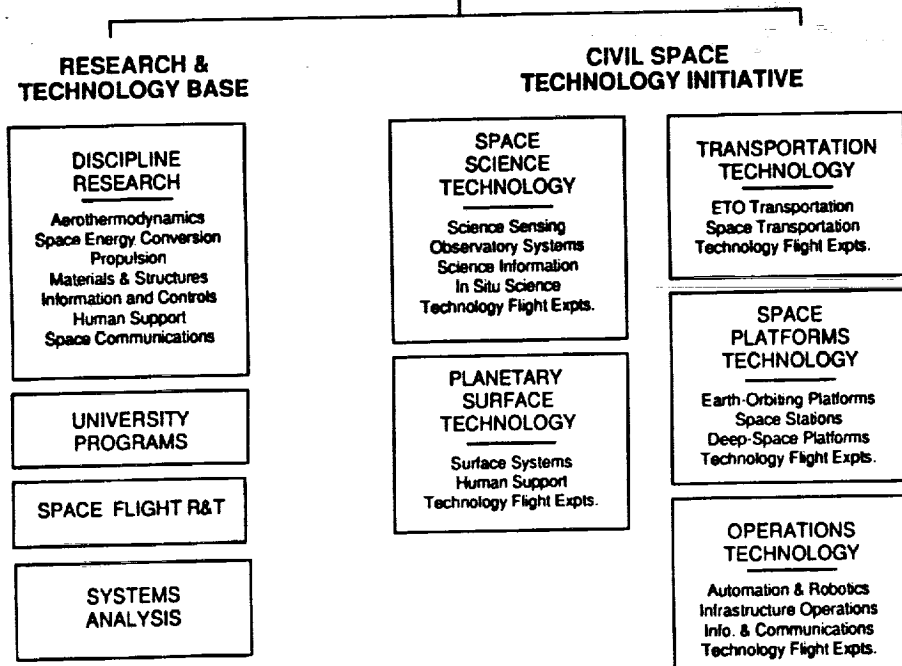
INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM TECHNOLOGY MATURATION STRATEGY

OAST



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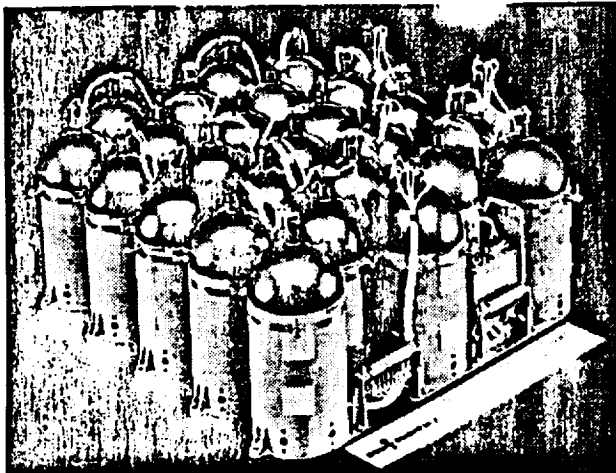
INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM SPACE RESEARCH & TECHNOLOGY



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

91-8064

Office of Aeronautics and Space Technology

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



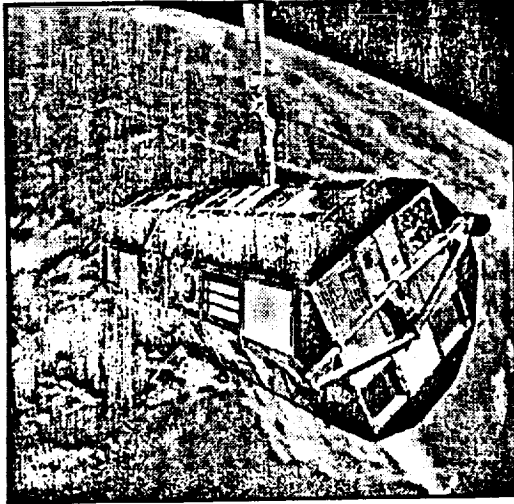
- **UNIVERSITY SPACE ENGINEERING RESEARCH CENTERS**
 - FOSTER CREATIVE AND INNOVATIVE CONCEPTS OF FUTURE SPACE SYSTEMS
 - EXPAND THE NATION'S ENGINEERING TALENT BASE FOR RESEARCH AND DEVELOPMENT
- **UNIVERSITY INVESTIGATORS RESEARCH**
 - SPONSOR INDIVIDUAL RESEARCH ON HIGHLY INNOVATIVE SPACE TECHNOLOGY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

91-8061

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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

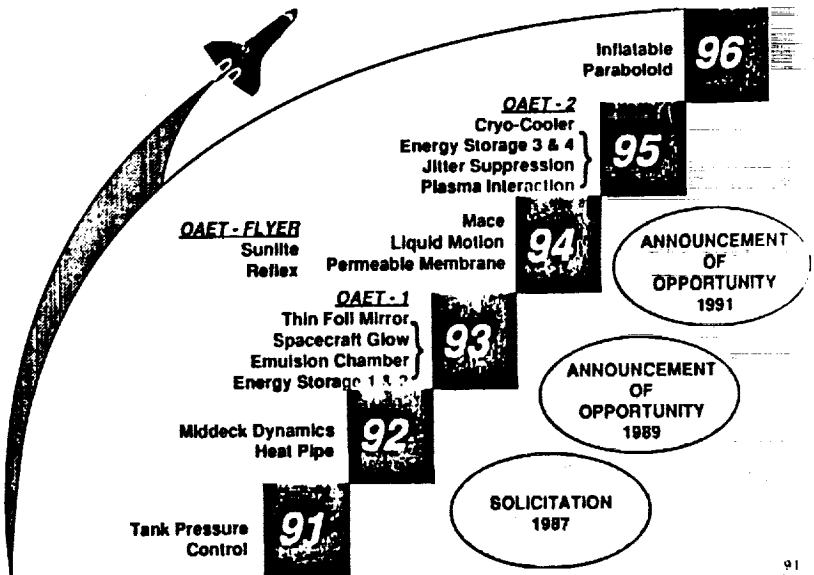
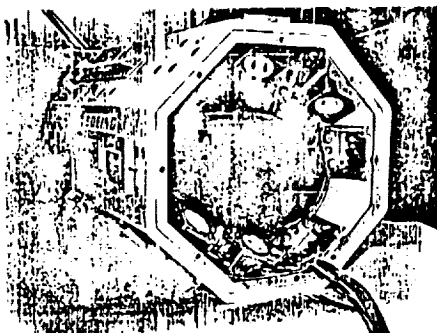
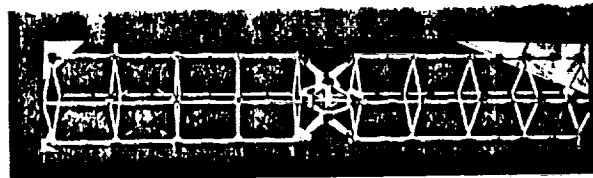
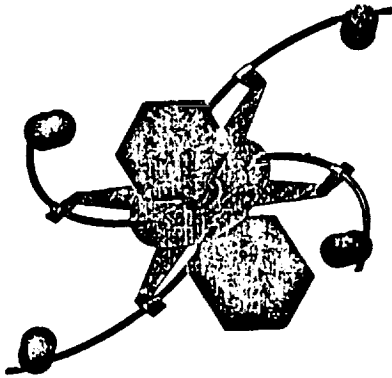
- **FLIGHT OPPORTUNITIES VIA**

- SPACE SHUTTLE
- EXPENDABLE LAUNCH VEHICLES
- SPACE STATION FREEDOM

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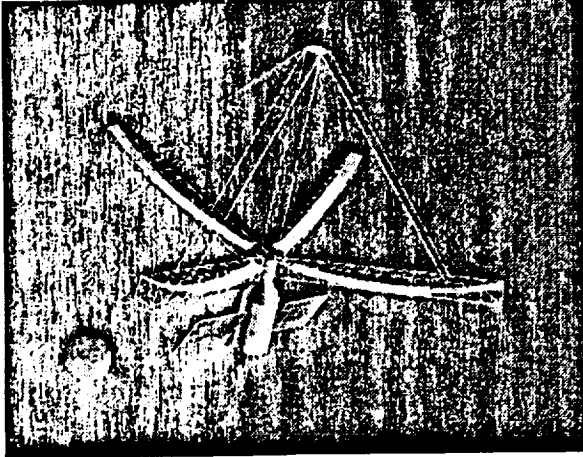
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IN-SPACE TECHNOLOGY EXPERIMENTS



SYSTEMS ANALYSIS

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



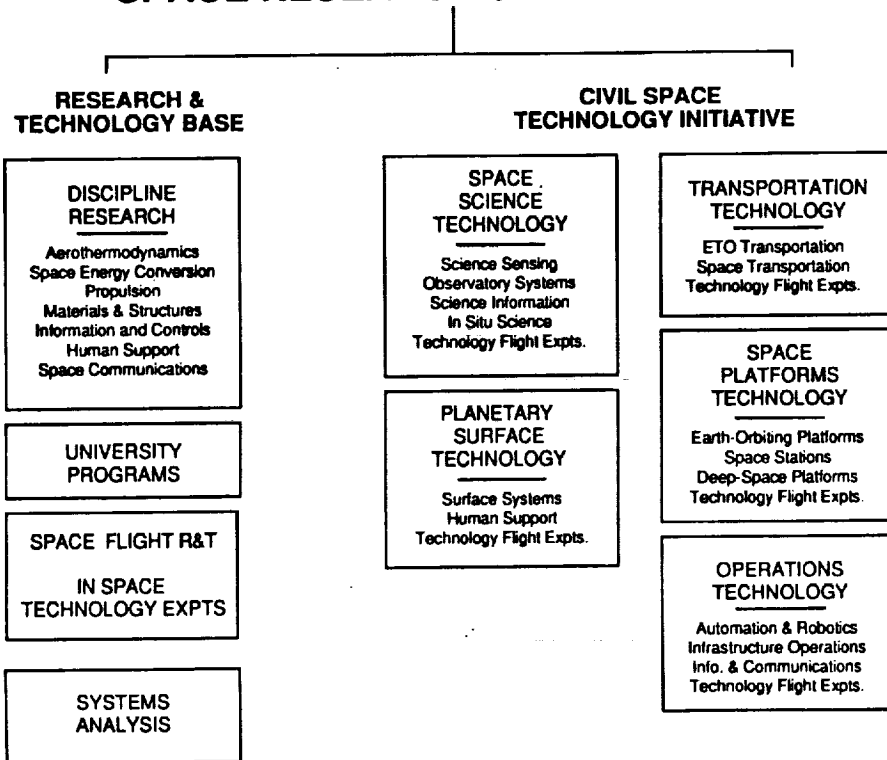
- **FOCUSED PROGRAMS**
 - IDENTIFY CRITICAL TECHNOLOGY ISSUES OF FUTURE MISSION CONCEPTS
 - TRANSPORTATION
 - SPACE SCIENCE
 - SPACE PLATFORMS
 - SPACE EXPLORATION
 - OPERATIONS
- **BREAKTHROUGH**
 - IDENTIFY BENEFITS OF HIGHLY INNOVATIVE SPACE TECHNOLOGY IDEAS AND SPACE APPLICATIONS OF NEW TECHNOLOGY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

Office of Aeronautics and Space Technology

91-8055

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY



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

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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:

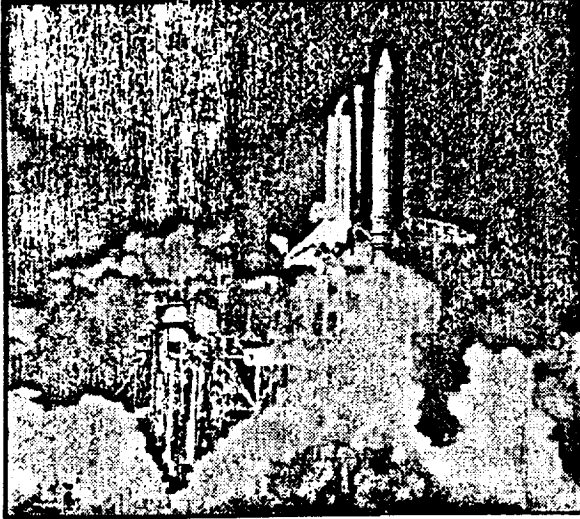
- ADVANCED SURFACE SYSTEM OPERATIONS ON THE MOON AND MARS
- TECHNOLOGIES FOR HUMAN SUPPORT DURING VERY LONG DURATION PILOTED MISSIONS IN DEEP-SPACE AND ON PLANETARY SURFACES

91-8050A
rev 8/23/91

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TRANSPORTATION TECHNOLOGY

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



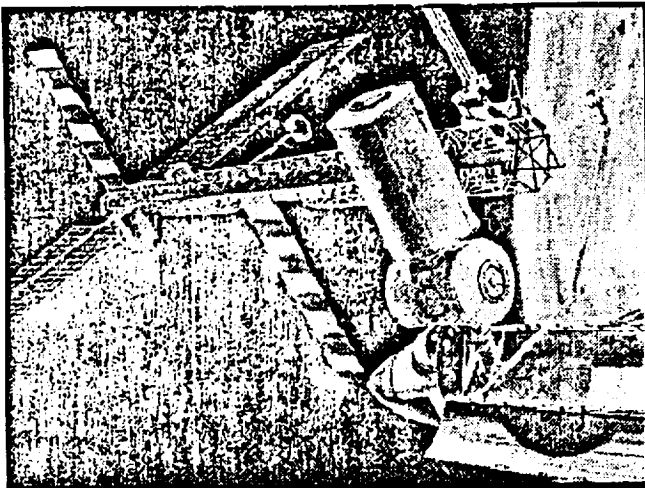
- ENHANCE SAFETY, RELIABILITY, AND SERVICEABILITY OF CURRENT SPACE SHUTTLE
- PROVIDE TECHNOLOGY OPTIONS FOR NEW MANNED SYSTEMS THAT COMPLEMENT THE SHUTTLE AND ENABLE NEXT GENERATION VEHICLES WITH RAPID TURNAROUND AND LOW OPERATIONAL COSTS
- SUPPORT DEVELOPMENT OF ROBUST, LOW-COST HEAVY LIFT LAUNCH VEHICLES
- DEVELOP AND TRANSFER LOW-COST TECHNOLOGY TO SUPPORT COMMERCIAL 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

91-8048

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.



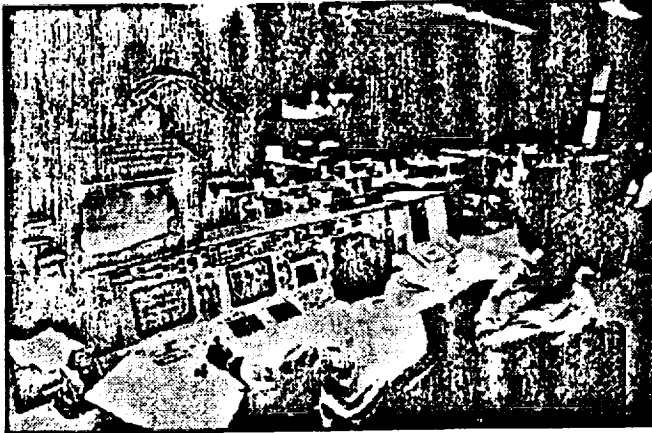
- DEVELOP TECHNOLOGIES THAT WILL DECREASE LAUNCH WEIGHT AND INCREASE THE EFFICIENCY OF SPACE PLATFORM FUNCTIONAL CAPABILITIES
- DEVELOP TECHNOLOGIES THAT WILL INCREASE HUMAN PRODUCTIVITY AND SAFETY OF MANNED MISSIONS
- DEVELOP TECHNOLOGIES THAT WILL INCREASE MAINTAINABILITY AND REDUCE LOGISTICS RESUPPLY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

91-8052

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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

91-8055

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INTEGRATED TECHNOLOGY PLAN PROCESS

OAS

- **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

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DEC 10 1991

Attn of: OP

TO: R/Associate Administrator for
Aeronautics and Space Technology

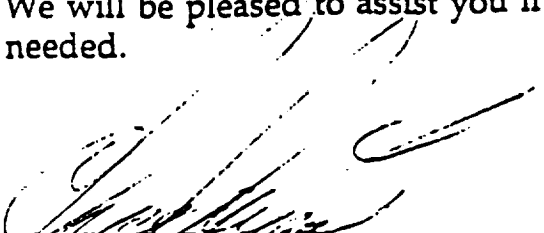
FROM: O/Associate Administrator for Space Communications

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

OSF Technology Requirements Evaluation

Technology Areas	
Program Unique Technologies	
1	Vehicle Health Management
2	Advanced Turbomachinery Components and Models
3	Combustion Devices
4	Advanced Heat Rejection Devices
5	Water Recovery and Management
6	High Efficiency Space Power Systems
7	Advanced Extravehicular Mobility Unit Technologies
8	Electromechanical Control Systems/Electrical Actuation
9	Crew Training Systems
10	Characterization of Al-Li Alloys
11	Cryogenic Supply, Storage, and Handling
12	Thermal Protection Systems for High Temperature Applications
13	Robotic Technologies
14	Orbital Debris Protection
15	Guidance, Navigation and Control
16	Advanced Avionics Architectures
Industry Driven Technologies	
	Signal Transmission and Reception
	Advanced Avionics Software
	Video Technologies
	Environmentally Safe Cleaning Solvents, Refrigerants and Foams
	Non-Destructive Evaluation

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

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM
EXTERNAL TECHNOLOGY PERSPECTIVES SUMMARY

~~OAST~~

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 & Microbotic 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)

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

● 5-YEAR FORECAST INCLUDES

'93 THRU '97: COMPLETION OF INITIAL SSF
LIMITED SOME SHUTTLE IMPROVEMENTS
NEW STARTS INITIAL EOS & EOSDIS
SELECTED SPACE SCIENCE STARTS
NLS DEVELOPMENT
INITIAL SEI ARCHITECTURE SELECTION
EVOLVING GEO COMMERCIAL COMMSATS
MINOR UPGRADES OF COMMERCIAL ELVS

FLIGHT PROGRAMS FORECAST

● 10-YEAR FORECAST INCLUDES

'98 THRU '03: SSF EVOLUTION/INFRASTRUCTURE
MULTIPLE FINAL SHUTTLE ENHANCEMENTS
NEW STARTS ADVANCED LEO EOS PLATFORMS/FULL EOSDIS
TO BE LAUNCHED MULTIPLE SPACE SCIENCE STARTS
IN 2003 THRU 2010 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 SSF-MARS EVOLUTION
MULTIPLE BEGINNING OF AMLS/PLS DEVELOPMENT
OPTIONS FOR NEW MULTIPLE SPACE SCIENCE STARTS
STARTS TO BE DSN EVOLUTION (OPTICAL COMM)
LAUNCHED IN INITIAL MARS HLLV DEVELOPMENT
2009 THRU 2020 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

Near Term	Detectors: IR Si & Ge arrays, multiplexers, CCD, optical, Xc, 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 Trans mission UV Filters (SZ)
	Submm & Microwave Tech: -- SIS 1.2 THz Heterodyne Rec. -- Active SAR Integrated Circuits -- Passive submm 600 GHz diodes (SN, SZ, SB)	Vibrative 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 (SB)	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 mass & 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)	Min/microsystems -- Instrumentation, rovers descent imager, camera, RTG ascent vehicle/lander, 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 internet (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 Structures Arrays/Deployables (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 Monitoring & Life Support (SB)	Regenerative - Microwave & Optical/Laser Detection (SB)	Auto Rendezvous/Asso Sample Transfer, Auto Landing (SL)	Non-Destructive Monitoring Capability (SB)	Non-Destructive Cosmic Dust Collection (SB)	
	Interplanetary Ranging & Positioning Precision Sensing Pointing & Control (SS, SZ, SL)	Large Filled Apertures -- lightweight & stable optics -- Cryo optical ver., fab., test. -- Deformable mirrors -- 13.25m 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)	
	30-1600W 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

D/R/2/0/11

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

OAST

Technologies Needing Near-Term Completion (for First Lunar Outpost)	<ul style="list-style-type: none"> ● Lunar EVA Systems <ul style="list-style-type: none"> — Durable, lightweight, high mobility suit and gloves — Lightweight, serviceable PLSS ● Surface Power (Non-Nuclear) <ul style="list-style-type: none"> — High Efficiency thermal to electric conversion — Heat Rejection — Long-Life Energy Storage ● Autonomous Terminal Landing <ul style="list-style-type: none"> — Sensors — Software/Algorithms — Hazard Avoidance 	<ul style="list-style-type: none"> ● Life Support <ul style="list-style-type: none"> — Contamination & Particulate Control — Trash & Waste Management — Loop Closure ● Cryogenic Fluid Systems <ul style="list-style-type: none"> — Cryogen Storage — Cryogen (Zero G) Transfer — Quick Disconnect Couplings — Zero-Gravity Cryo Gauging ● In Situ Resource Utilization (Tech Demo Capability) <ul style="list-style-type: none"> — Oxygen Process Chemistry — Mining — Construction Material Test 	<p><i>Note: No Prioritization is implied within a Given Category</i></p>
Technologies Needing Completion in the Mid- to Far- Term (for Mars and Permanently Manned Lunar Missions)	<ul style="list-style-type: none"> ● Nuclear Thermal Propulsion <ul style="list-style-type: none"> — Fuel Development — Turbopumps — Test Facilities — Reactor Development ● Surface Nuclear Power <ul style="list-style-type: none"> — Power Conversion — Radiators Radiation Protection <ul style="list-style-type: none"> — Lightweight shielding — Solar Particle Event Prediction — Transport Code Validation Mars EVA Systems <ul style="list-style-type: none"> — Durable, lightweight, high mobility suit and gloves — Lightweight, serviceable PLSS 	<ul style="list-style-type: none"> ● Surface Habitats & Construction <ul style="list-style-type: none"> — Radiation Shielding — Dust Control Long-Duration Life Support Systems/Thermal Control In Situ Resource Utilization <ul style="list-style-type: none"> — Liquefaction — Materials Compatibility — Electrolysis technologies 	<p>Aerobraking</p> <ul style="list-style-type: none"> — Thermal Protection Systems — CFD Codes — High Temp Structural Materials — Adaptive GN&C <p>Planetary Rovers</p> <ul style="list-style-type: none"> — Motors/Lubricants (long-term) — Dust Control — Power <p>Telerobotics</p> <ul style="list-style-type: none"> — Sensors — Vision — End Effectors
	CATEGORY 1	CATEGORY 2	

● Near-Term Investment Recommended by OEXP

FEBRUARY 5 1991
JCM 7941

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

LBF 40318
JCM 6803

**INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM
R&T Base Discipline Programs Content**

OAST

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

NOVEMBER 13, 1991
JCM 6800x

**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

Space Science Technology	Submillimeter Sensing	Direct Detectors Sensor Electronics Microprocecion CSI	Active μwave Sensing Laser Sensing	Sample Acq., Analysis & Preservation	Passive Microwave Sensing	---	Optoelectmcs Sensing & Processing	Probes and Penetrators	---
	Cooler and Cryogenics	---	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	---	Artificial 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 Flight Expt	Aeroassist/ Aerobraking	Transfer Vehicle Avionics	ETO Vehicle Avionics	ETO Vehicle Structures & Materials	Autonomous Rendezvous & Docking	COHE	Auxiliary Propulsion
	Cryogenic Fluid Systems	Advanced Cryo. Engines	Low-Cost ETO Transport	Nuclear Electric Propulsion	---	---	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	Ft. Telerobotic Servicer/DTF-1 Navigation & Guidance	CommSat Communicat'ns Flight Expts	---	Ground Test and Processing	---
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>← HIGHEST PRIORITY</p> <p>000</p> </div> <div style="text-align: center;"> <p>← 2nd-HIGHEST PRIORITY</p> <p>00</p> </div> <div style="text-align: center;"> <p>← 3rd-HIGHEST PRIORITY</p> <p>0</p> </div> </div>									

LBF40343 FINA

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM
FY 1992 Program ITP: CSTI Element Categorization

OAST

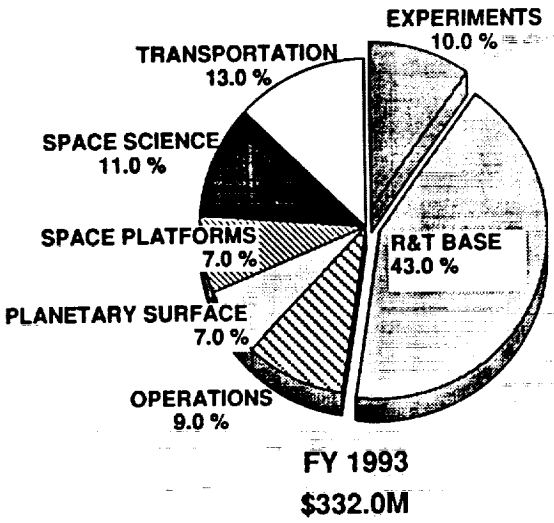
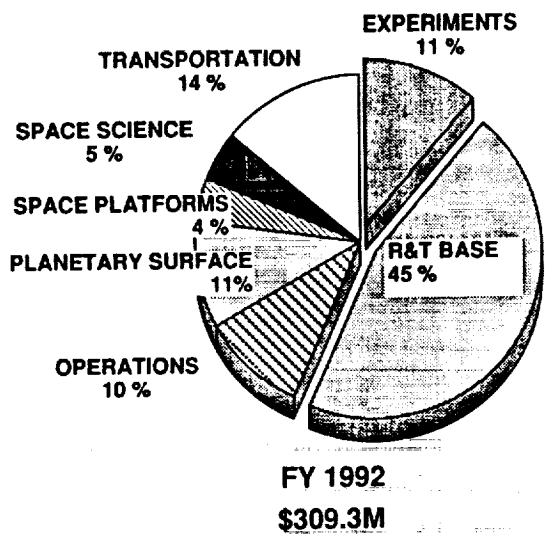
Space Science Technology	Submillimeter Sensing	Direct Detectors	Laser Sensing	---	---	---	---	---	---
	Cooler and Cryogenics	Microprecision CSI	---	---	---	---	---	---	---
Planetary Surface Technology	Radiation Protection	Regenerative Life Support (Phys-Chem.)	Space Nuclear Power (SP-100)	High Capacity 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	---	---	---	---	---	---

← HIGHEST PRIORITY 000
← 2nd-HIGHEST PRIORITY 00
← 3rd-HIGHEST PRIORITY 0

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SPACE RESEARCH & TECHNOLOGY PROGRAM

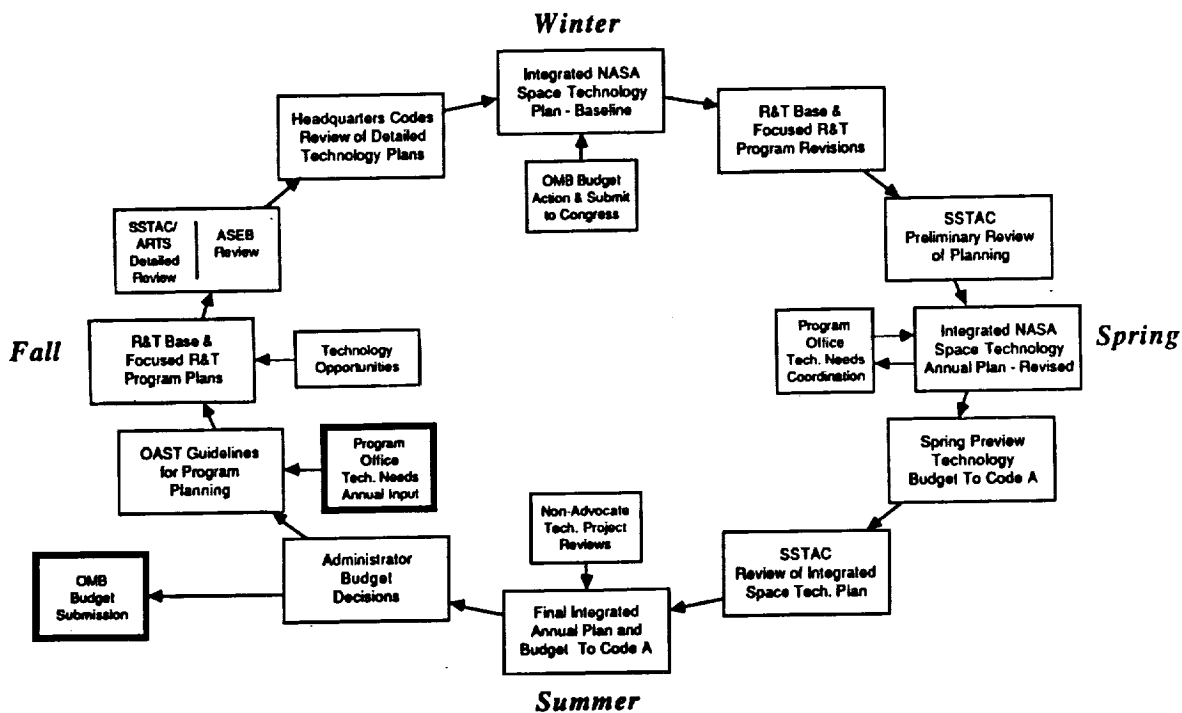
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LBF 40423c

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**

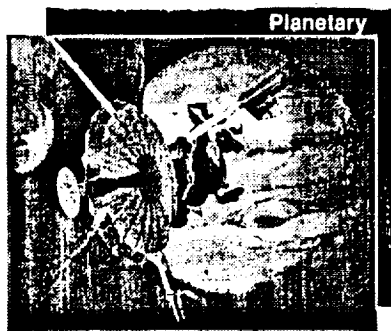
- CONTINUE TO IMPROVE THE INTEGRATED TECHNOLOGY PLAN
- DEVELOP NATIONAL TEAMS
- DEVELOP NATIONAL TESTBEDS
- REVITALIZE SPACE R&T FACILITIES
- INCREASE THE USE OF TECHNOLOGY FLIGHT DEMONSTRATIONS
- IMPROVE TECHNOLOGY TRANSFER

LBF40492

TECHNOLOGY CONTRIBUTIONS TO SCIENCE SPACECRAFT

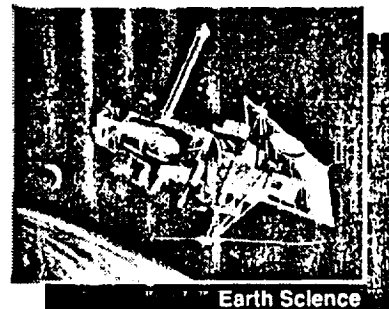


- Hubble - VLSI Data Processing
- Astro - Startracker
- Hubble - Battery Technology
- Hubble - Image Restoration



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

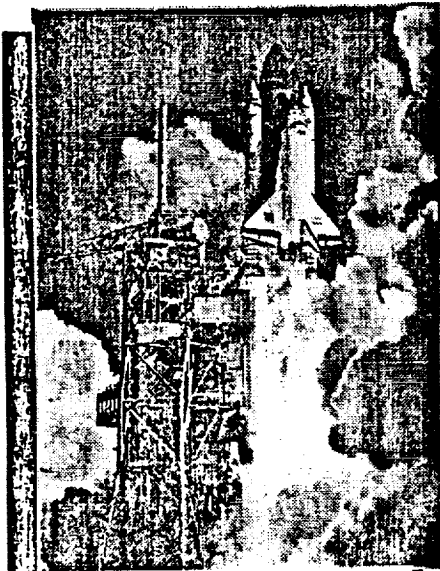
- UARS - 205 GHz Limb Sounder Technology
- Shuttle Imaging Radar - SAR Technologies
- TOPEX - Millimeter Accuracy Laser Ranging



Office of Aeronautics and Space Technology

92-8013

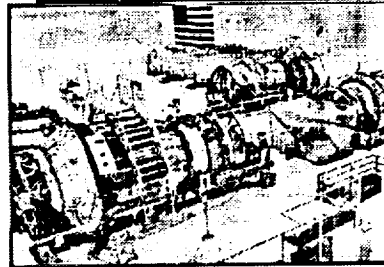
TECHNOLOGY CONTRIBUTIONS TO TRANSPORTATION



Space Shuttle

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

Expendable Launch Vehicles

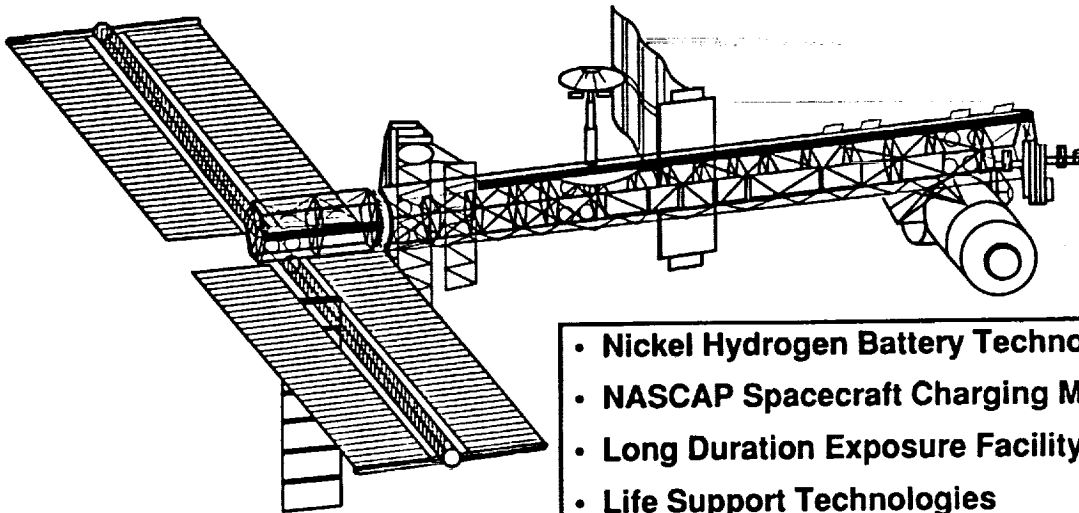


- Advanced Primary Battery

Office of Aeronautics and Space Technology

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

91-8047

Office of Aeronautics and Space Technology

SPACE SCIENCE MILESTONES

Activities	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
INSTRUMENT	Develop HgZnTe Linear Array Detector	HgZnTe 1x16 Array Demo	CO2 LAWS Breadboard Demo			2 Micron Laser Local Oscillator		(10-20 Micron) IR Array for EOS		2 Micron Solid State Breadboard	
	Develop Ti:Sa Laser for Lidar		600GHz SLS Receiver Demo				LWIR Array for SIRTf (20 Microns)	800 GHz Sensor Optimized, 1000GHz Initial		High Resolution CCD Array	
DATA & INFORMATION						Prototype Recognition Tech. for Image & Spatial Data Features		Prototype System for Data Screening & Classification		Integrated Testbed Demo	
					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				5KM 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 Capability to 130K			30K Stirling Cooler Demo			X-Ray Gratings, Variable Line Spacing			Submicron, 100K, 2M Parabolic Panel	
			Demo 100K Telescope Panel Coating	Breadboard Model 30K Stirling Cooler				Complete MOI Testbed Validation		Fabrication & Performance CHAR 2-5K	

Office of Aeronautics and Space Technology

- ▲ Indicates Funded
- △ Indicates NonFunded

