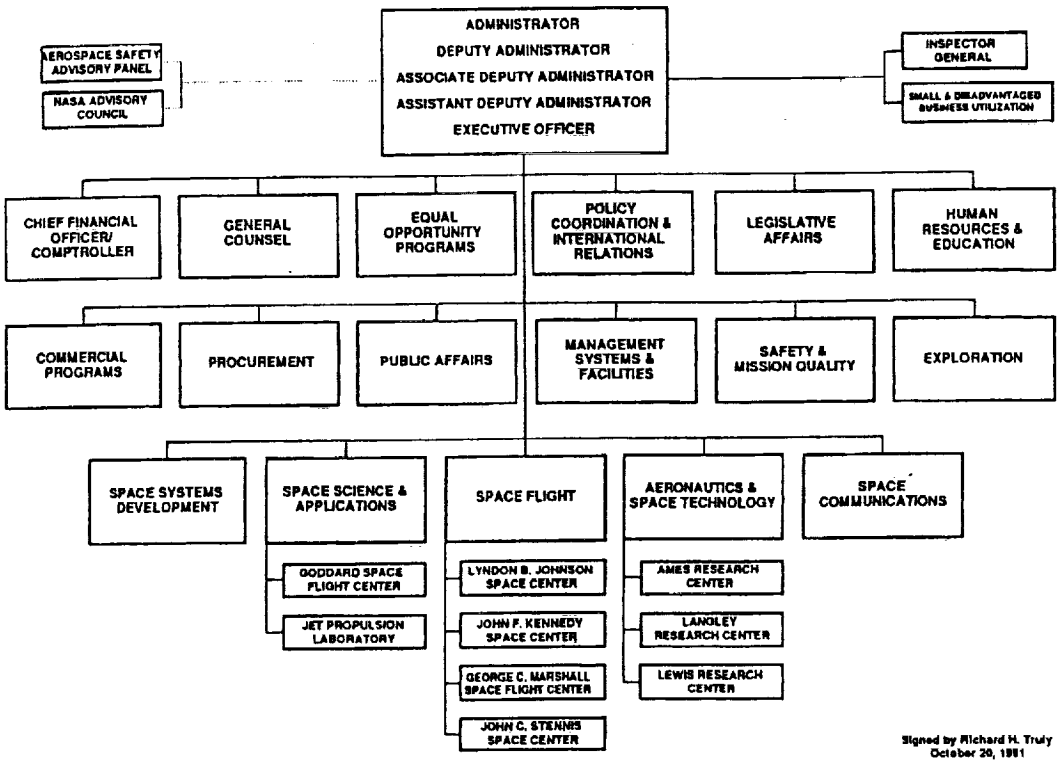
N93-18636

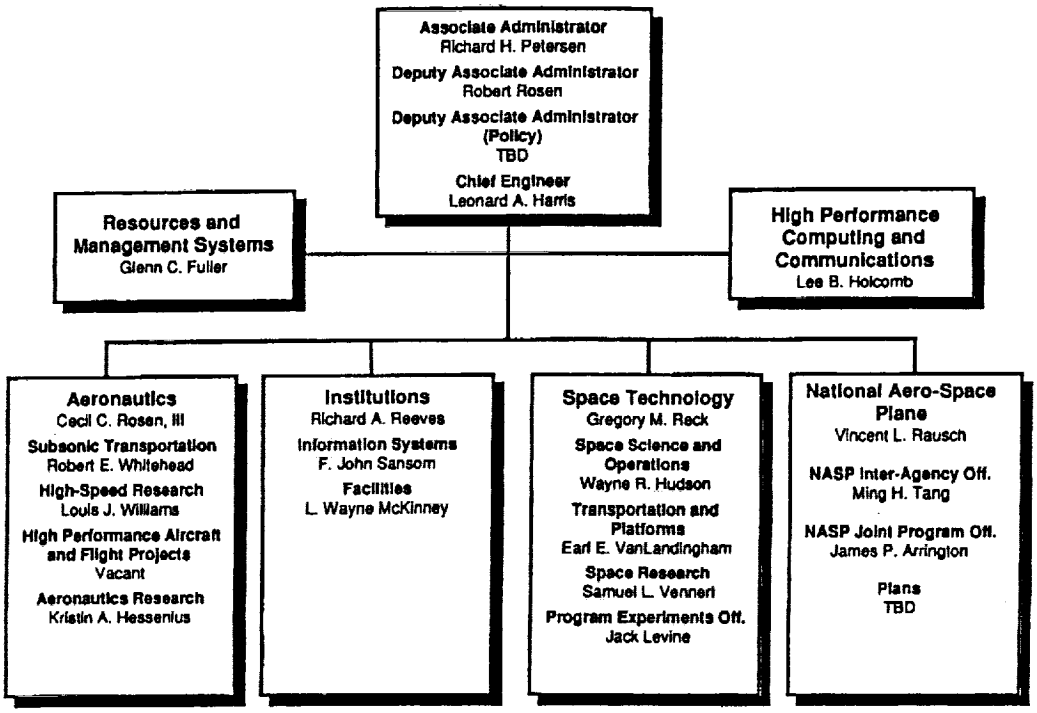
TRANSPORTATION AND PLATFORMS PERSPECTIVE

Gary L. Bennett
National Aeronautics and Space Administration
Washington, DC

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

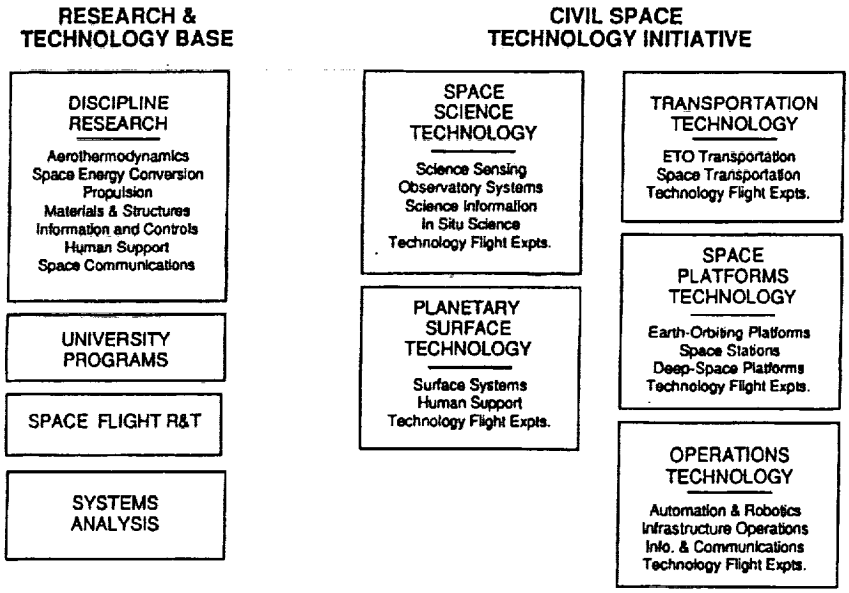


OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY



INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY



LBF40319

SPACE R&T MISSION STATEMENT

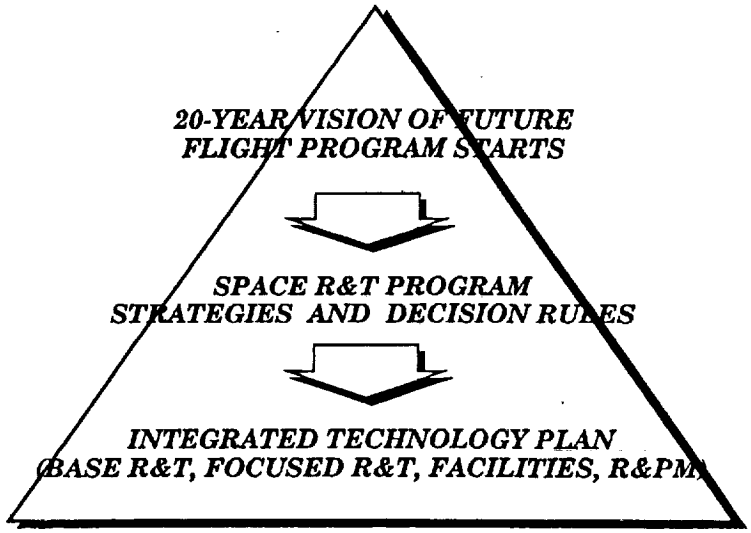
OAST SHALL PROVIDE TECHNOLOGY FOR FUTURE CIVIL SPACE MISSIONS AND PROVIDE A BASE OF RESEARCH AND TECHNOLOGY CAPABILITIES TO SERVE ALL NATIONAL SPACE GOALS

- *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

LBF4194B

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE R&T PROGRAM DEVELOPMENT



MAY 4, 1991
JCM-7586

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

RESEARCH & TECHNOLOGY STRATEGY

FLIGHT PROGRAMS FORECAST

- **5-YEAR FORECAST INCLUDES**

'93 THRU '97: LIMITED NEW STARTS

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

- **10-YEAR FORECAST INCLUDES**

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

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

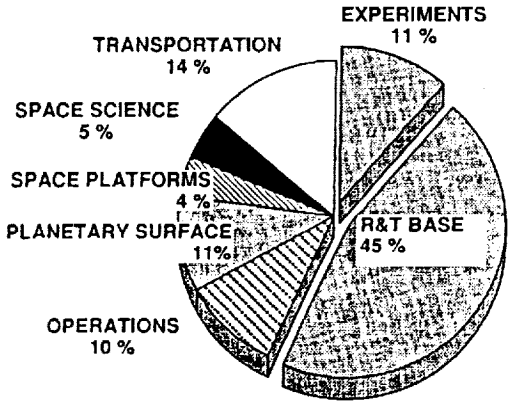
- **20-YEAR FORECAST INCLUDES**

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

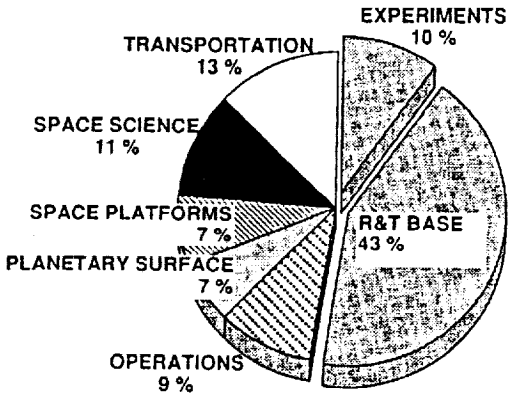
SSF-MARS EVOLUTION
BEGINNING OF AMLS/PLS DEVELOPMENT
MULTIPLE SPACE SCIENCE STARTS
DSN EVOLUTION (OPTICAL COMM)
INITIAL MARS HLLV DEVELOPMENT
EVOLVING LUNAR SYSTEMS
MARS SEI ARCHITECTURE CHOSEN
LARGE GEO COMMSATS
NEW COMMERCIAL ELVS

LBF40305
(JCM-7602)

SPACE RESEARCH & TECHNOLOGY PROGRAM



FY 1992
$309.3M



FY 1993
$332.0M

LBF 40423c

OSSA TECHNOLOGY NEEDS
Grouped According to Urgency & Commonality

REVISED
NOVEMBER 15, 1991

	HIGHEST PRIORITY		2nd-HIGHEST PRIORITY			3rd HIGHEST PRIORITY			
Near Term	Detectors: IR Si & Ge arrays, multiplexers, CCD, optical, Xe, non-cryo IR, high purity Ge, sensor readout electronics & tunnel sensors (SE, SL, SZ, SS)	Cryogenic Systems -- Optics, coolers, shielding, electronics (SZ, SE, SL, SS)	High Frame Rate, High Resolution Video (SN, SL)	2.5 - 4m, 100K Lightweight, PSR (SZ)	Fluid Diagnostics (SN)	Real-Time Radiation Monitoring (SB)	Solar Arrays/Cells (SL, SZ, SE)	Telerobotics (SN)	High Transmission UV Filters (SZ)
	Submm & Microwave Tech: -- SIS 1.2 THz Heterodyne Rec. -- Active SAR integrated circuits -- Passive submm 600 GHz diodes (SZ,SE)	Vibration Isolation Technology (SN, SZ, SB)	Telescience, Telepresence, & AI (SN, SL, SB)	Automated Biomedical Analysis (SB)	Rad Hard Parts & Detectors (SZ, SL)	Solid/Liquid Interface Characterization (SN)	Laser Light Scattering (SN)	High Temperature Materials For Furnaces (SN)	K-band Transponders (SZ)
	Efficient, Quiet Refrigerator/Freezer (SB)	Extreme Upper Atmosphere Instrument Platforms (SS)	Batteries -- Long life time -- High energy density (SL, SZ)	Real-Time Environmental Control & Monitoring (SB)	Space Qualified maser & ion Clocks (SZ)	Field Portable Gas Chromatographs (SB)	Advanced Furnace Technology (SN)	3-D packaging for 1 MB Solid State Chips (SZ)	Rapid Subject/ Sample Delivery & Return Capability (SB)
	Lasers: Long-life, Stable & Tunable (SE, SZ, SL, SB)	Mini/microsystems -- Instrumentation, rovers descent Imager, camera, RTG ascent vehicle/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 Decontaminatio Methods (SB)
	Data -- High Volume, High Density, High Data Rate,On-board Storage & Compression (SE, SL, SN, SZ)	Interferometer-specific Tech: -- picometer metrology -- active delay lines -- control-structures interact (SZ, SL, SB)	Microphonics Technology, FET development (SZ)	Auto S/C Monitoring & Fault Recovery (SL)	Improved EVA Suit/PLSS (EMU) (SB)	Thermal Control System (SZ)	Special Purpose Bioreactor Simulator Syst. (SB)	Animal & Plant Reproduction Aids (SB)	
	Controlled Structures/ Large Antenna Structure Arrays/Deployable (SE, SZ, SS, SB)	Parallel Software Environment for Model & Data Assimilation, Visualization Computational Techniques (SE, SL, SZ)	X-ray Optics Tech: -- imaging system -- low cost optics -- Bragg concentrators -- coated apertures (SZ)	SETI Technologies -- Microwave & Optical/Laser Detection (SB)	Regenerative Life Support (SB)	Auto Rendezvous Auto Sample Transfer, Auto Landing (SL)	Non-Destructive Monitoring Capability (SB)	Non-Destructive Cosmic Dust Collection (SB)	
Far Term	Interspacecraft Ranging & Positioning Precision Sensing Pointing & Control (SS, SZ, SL)	Large Filled Apertures -- lightweight & stable optics -- Cryo optical ver., fab., test. -- Deformable mirrors -- 15-25m PSR (SL, SZ, SE)	Sample Acquisition, Analysis and Preservation (SB, SL)	32 Ghz TWT Optical Communication (SL, SS)	High Resolution Spectrometer (SB)	Spacecraft Thermal Protection (SL)	Partial-g/ µg Medical Care Delivery Systems (SB)	Dust Protection/ Jupiter's Rings (SL)	
	50-100Kw Ion Propulsion (NEP) (SL)		Radiation Shielding for Crews (SB)	SIS 3 Thz Heterodyne Receiver (SZ)	Human Artificial Gravity Systems (SB)	CELSS Support Technologies (SB)			
Tally:	SB: 5 SE: 8 SL: 9	SN: 2 SS: 5 SZ: 11	SB: 10 SE: 1 SL: 7	SN: 4 SS: 2 SZ: 8		SB: 10 SE: 0 SL: 5	SN: 5 SS: 0 SZ: 6		

NASA

NUCLEAR ELECTRIC PERFORMANCE CHARACTERISTICS

- Mission Performance Factors
  - Specific Impulse (Isp): Determines propellant mass
  - Power Level (P_e): Affects trip time
  - System Specific Mass (α): Determines trip time limits
  - Thruster Efficiency (η): Affects trip time, vehicle mass

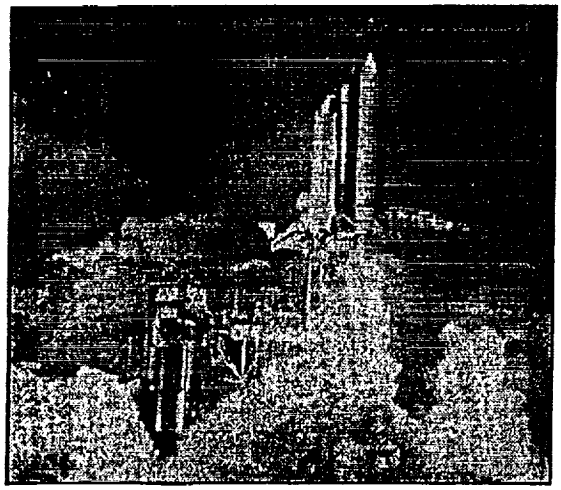
Parameter	Desired Range	Mission Impact
Isp	High (>5000s)	Low initial mass, Resupply mass
P_e	High (MWe)	Reduced trip time
α	Low (<10 kg/kWe)	Reduced Mass, trip time
η	High (>50%)	Improved mass, trip time

Office of Exploration

2/Congressional/Committee on Space/Program Review 2/7/92 Ver 1/2-7-92

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

TRANSPORTATION TECHNOLOGY

SHUTTLE ENHANCEMENT

- SSME Improvements
- Durable Thermal Protection Systems
- Improved Health Monitoring
- Light Structural Alloys
- Lidar-Based Adaptive Guidance & Control

NEXT GENERATION MANNED TRANSPORTS

- Configuration Assessment
- High Frequency, High Voltage Power Management/Distribution Systems
- LOX/LH2 Propellant for OMS/RCS
- Maintenance-free TPS
- Advanced Reusable Propulsion
- GPS-Based Autonomous GN&C
- Composites & Advanced Lightweight Metals
- Vehicle-Level Health Management For Autonomous Operations

HEAVY-LIFT CAPABILITY

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

LOW-COST COMMERCIAL

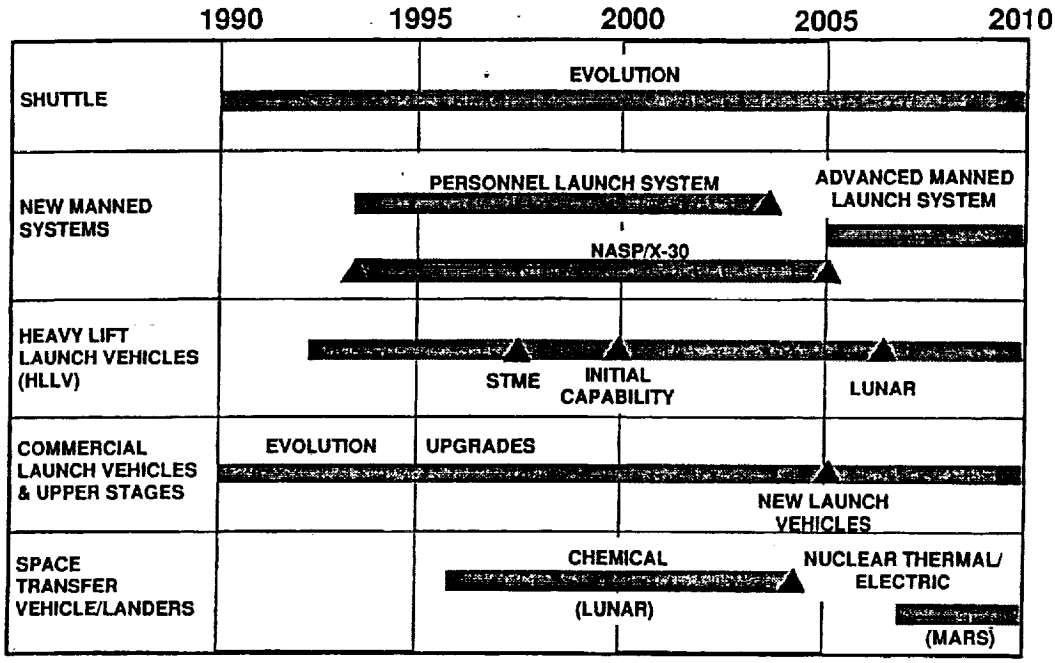
- Alternate Booster Concepts
- Advanced Cryogenic Upper Stage Engines
- Low-Cost Fab./Automated Processes/NDE
- Continuous Forging Processes for Cryogenic Tanks
- Fault-Tolerant, Redundant Avionics

IN-SPACE TRANSPORT

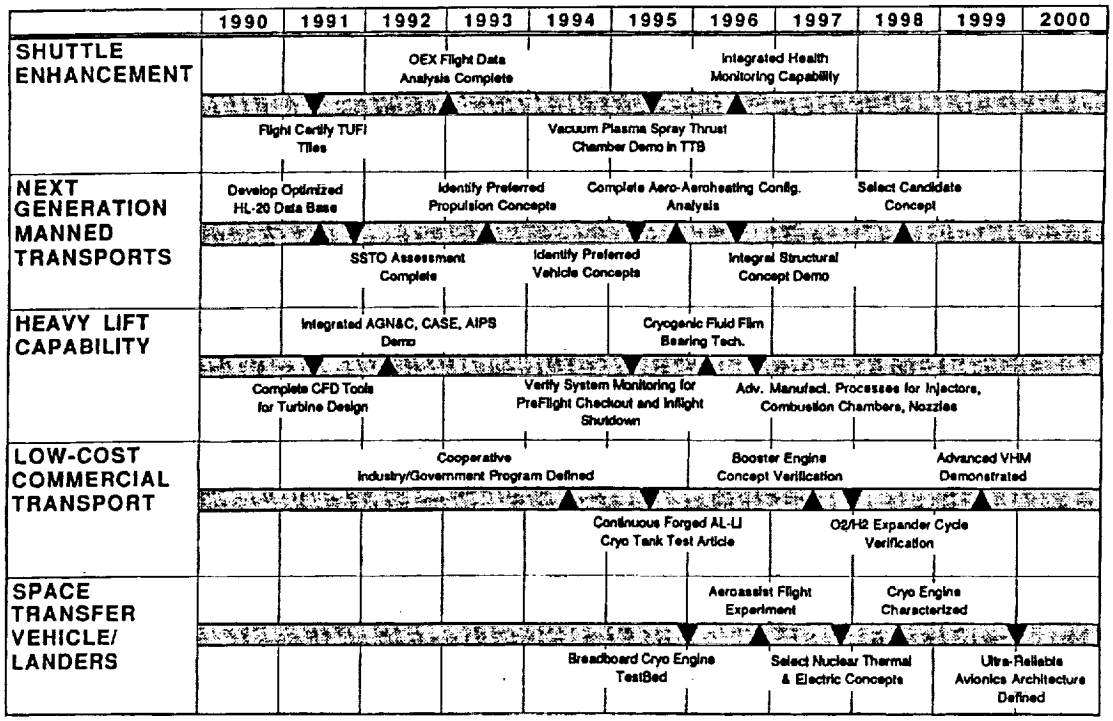
- High-Power Nuclear Thermal & Electric Propulsion
- High Performance, Multiple Use Cryogenic Chemical Engine
- Highly Reliable, Autonomous Avionics
- Low Mass, Space Durable Materials
- Long-Term, Low-Loss Management of Cryogenic Hydrogen
- Autonomous Rendezvous, Docking & Landing
- Aeroassist Technologies

91-8066

TRANSPORTATION TECHNOLOGY MISSION MODEL

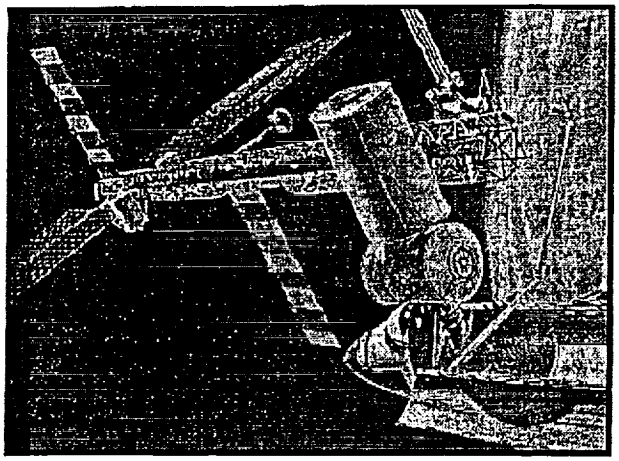


TRANSPORTATION MILESTONES



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

SPACE PLATFORMS TECHNOLOGY

EARTH ORBITING PLATFORMS

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

SPACE STATIONS

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

SPACE BASED LABORATORY AND TESTBED

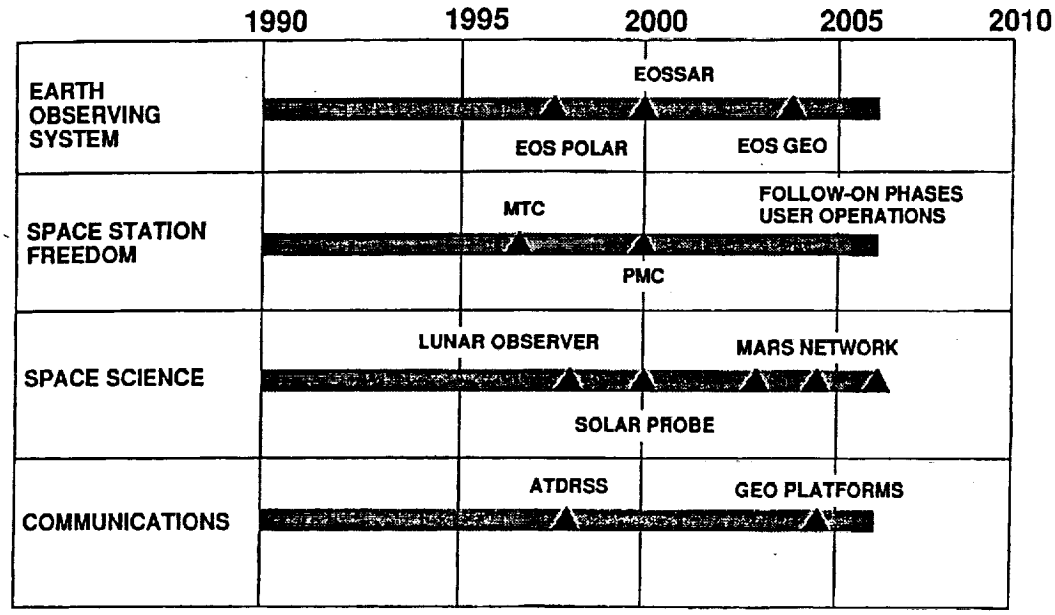
- Exploit Microgravity and Crew Interactive Capability to Advance and Validate Selected Technologies

DEEP SPACE MISSIONS

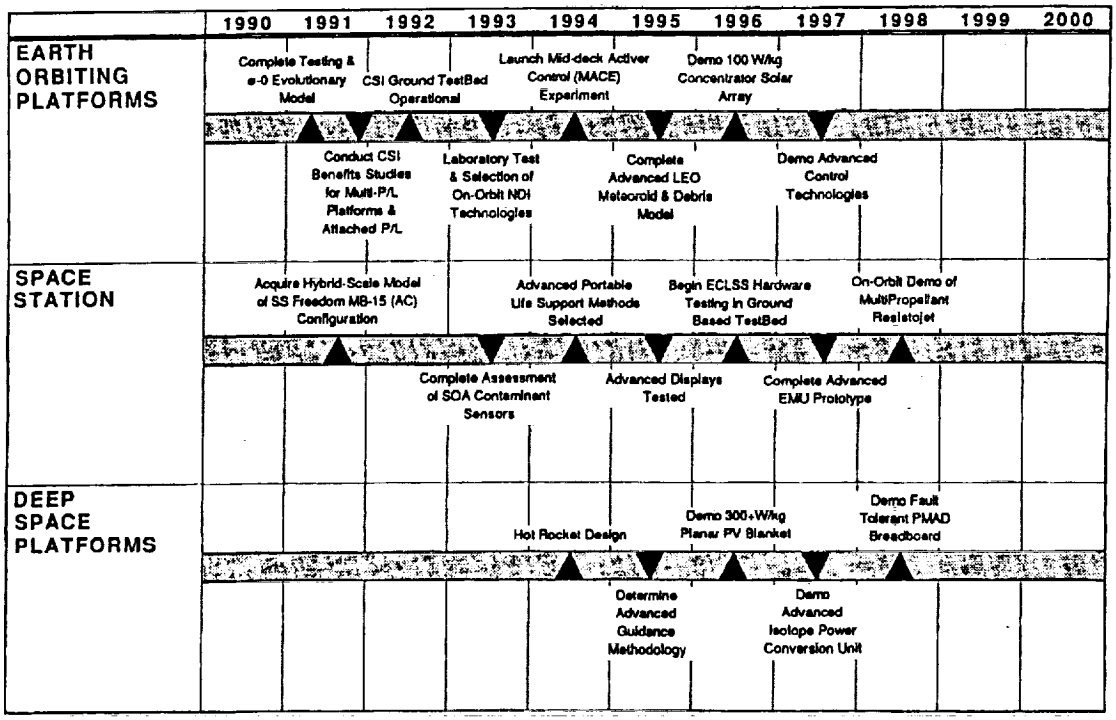
- Power and Thermal Management
- Propulsion
- Guidance, Navigation and Control

91-8053

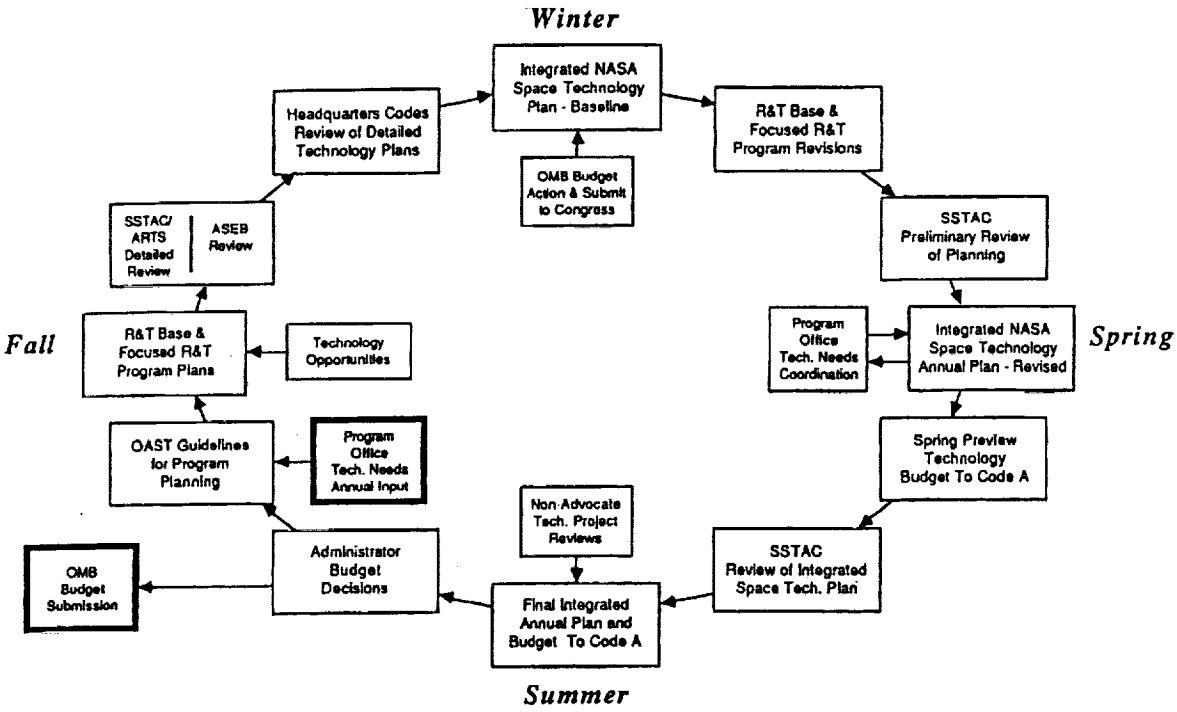
SPACE PLATFORMS TECHNOLOGY MISSION MODEL



SPACE PLATFORMS MILESTONES



SPACE TECHNOLOGY PLANNING CYCLE



March 25, 1991
JCM-7207b

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

TECHNOLOGY READINESS LEVELS

Basic Technology Research	LEVEL 1	BASIC PRINCIPLES OBSERVED AND REPORTED
	LEVEL 2	TECHNOLOGY CONCEPT AND/OR APPLICATION FORMULATED
Research To Prove Feasibility	LEVEL 3	ANALYTICAL & EXPERIMENTAL CRITICAL FUNCTION AND/OR CHARACTERISTIC PROOF-OF-CONCEPT
Technology Development	LEVEL 4	COMPONENT AND/OR BREADBOARD VALIDATION IN LABORATORY ENVIRONMENT
	LEVEL 5	COMPONENT AND/OR BREADBOARD VALIDATION IN RELEVANT ENVIRONMENT
Technology Demonstration	LEVEL 6	SYSTEM/SUBSYSTEM MODEL OR PROTOTYPE DEMONSTRATION IN A RELEVANT ENVIRONMENT (Ground or Space)
System/Subsystem Development	LEVEL 7	SYSTEM PROTOTYPE DEMONSTRATION IN A SPACE ENVIRONMENT
	LEVEL 8	ACTUAL SYSTEM COMPLETED AND "FLIGHT QUALIFIED" THROUGH TEST AND DEMONSTRATION (Ground or Flight)
System Test, Launch and Operations	LEVEL 9	ACTUAL SYSTEM "FLIGHT PROVEN" THROUGH SUCCESSFUL MISSION OPERATIONS

MARCH 17, 1991
JCM-7410

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

TECHNOLOGY MATURATION STRATEGY