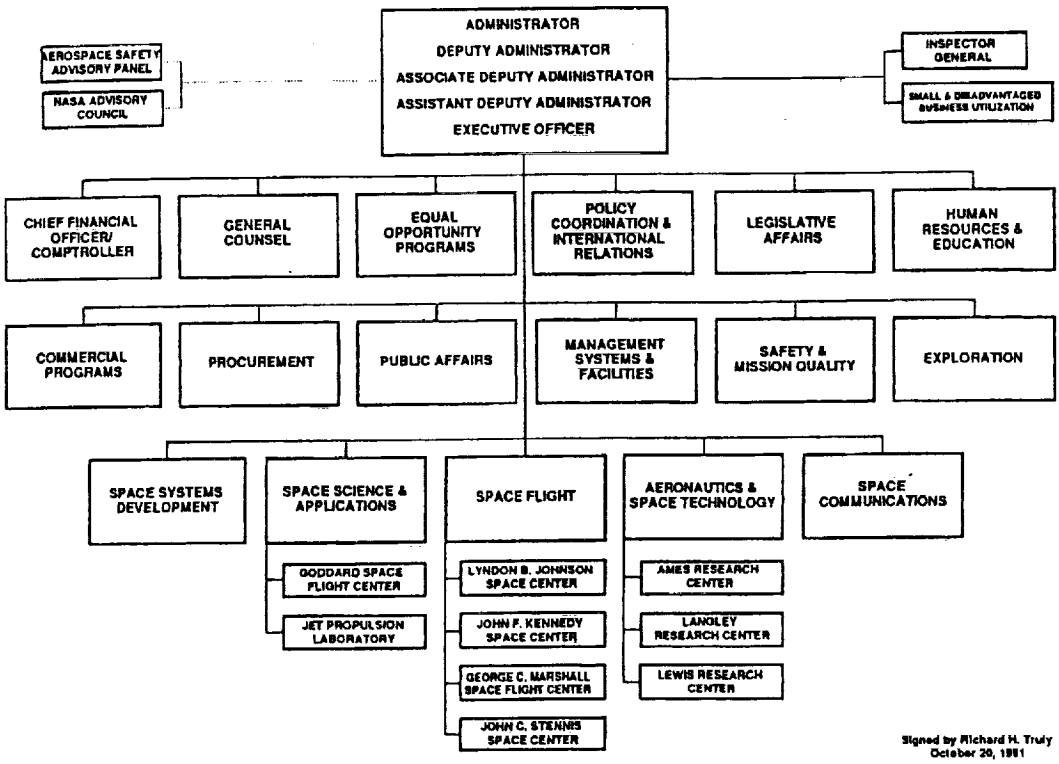
N93-18636

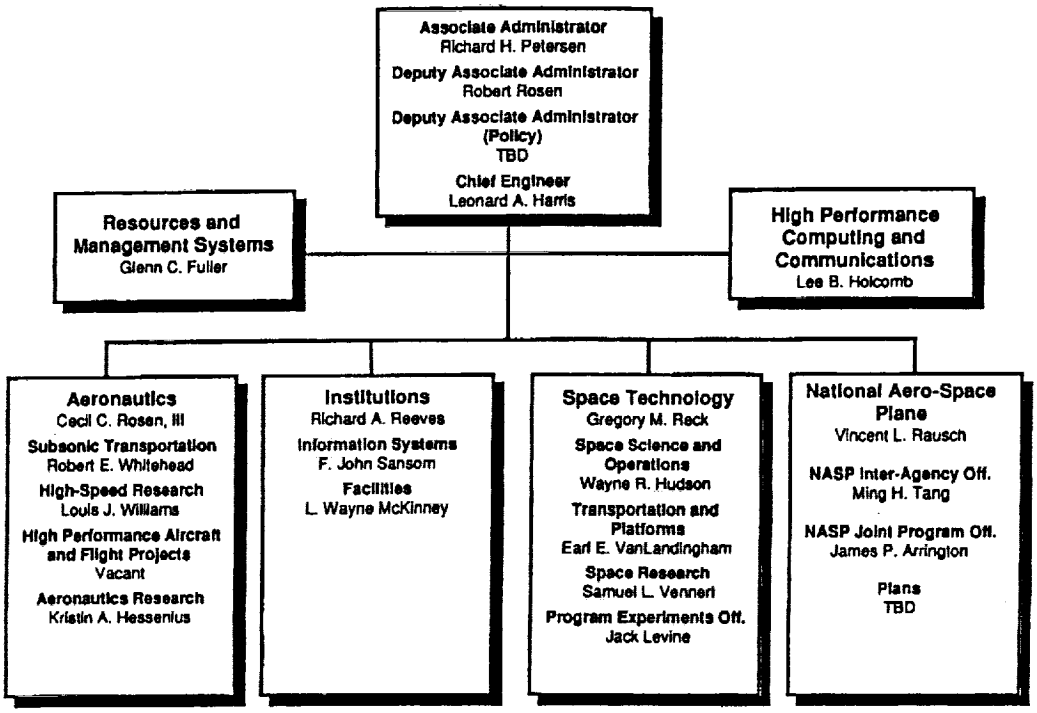
# TRANSPORTATION AND PLATFORMS PERSPECTIVE

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

## NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

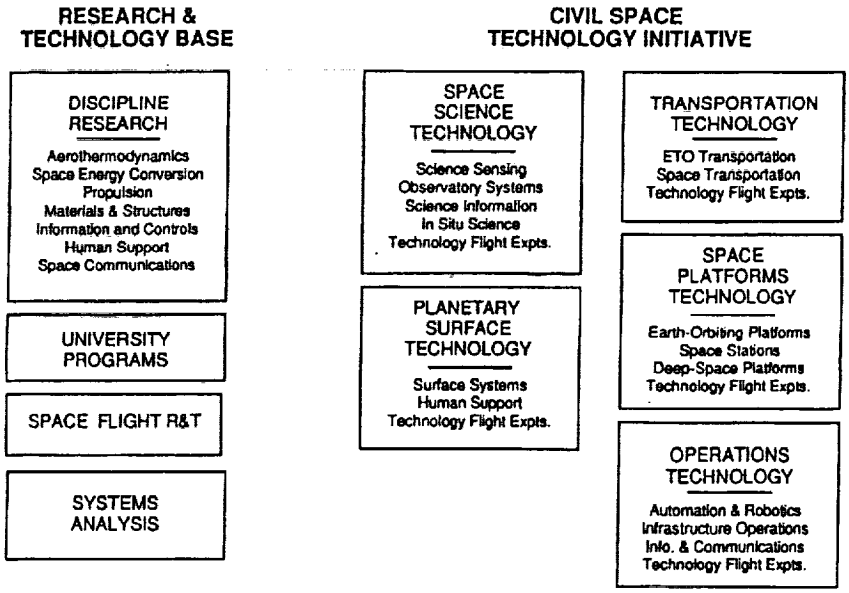


# OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY




INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

## SPACE RESEARCH & TECHNOLOGY




LBF40319

# SPACE R&T MISSION STATEMENT

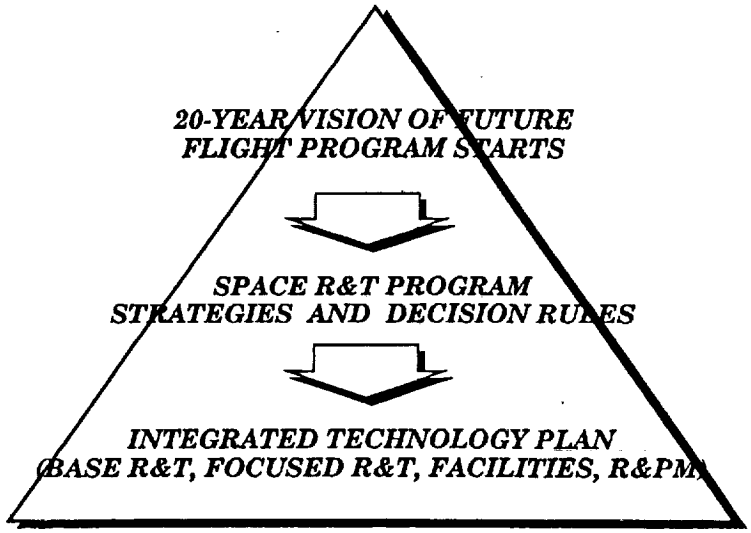
*OAST SHALL PROVIDE TECHNOLOGY FOR FUTURE CIVIL SPACE MISSIONS AND PROVIDE A BASE OF RESEARCH AND TECHNOLOGY CAPABILITIES TO SERVE ALL NATIONAL SPACE GOALS*

- *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

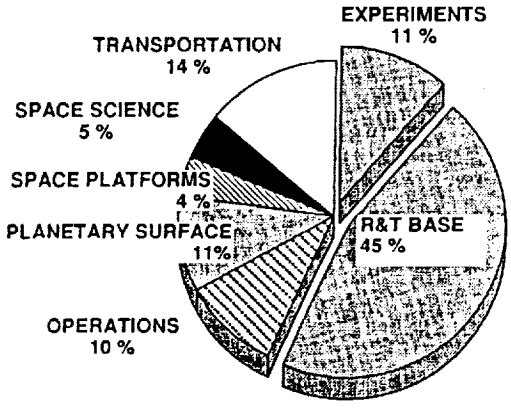
- **20-YEAR FORECAST INCLUDES**

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

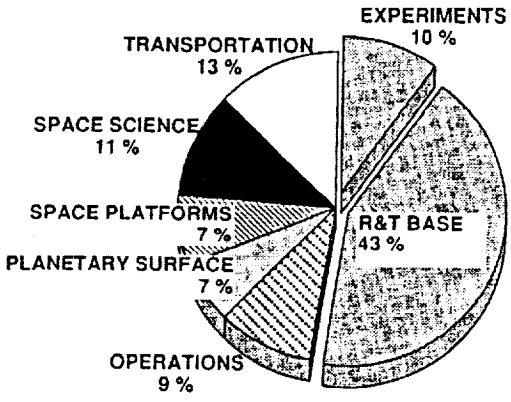
SSF-MARS EVOLUTION
BEGINNING OF AMLS/PLS DEVELOPMENT
MULTIPLE SPACE SCIENCE STARTS
DSN EVOLUTION (OPTICAL COMM)
INITIAL MARS HLLV DEVELOPMENT
EVOLVING LUNAR SYSTEMS
MARS SEI ARCHITECTURE CHOSEN
LARGE GEO COMMSATS
NEW COMMERCIAL ELVS

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 ($\alpha$): Determines trip time limits
  - Thruster Efficiency ($\eta$): Affects trip time, vehicle mass

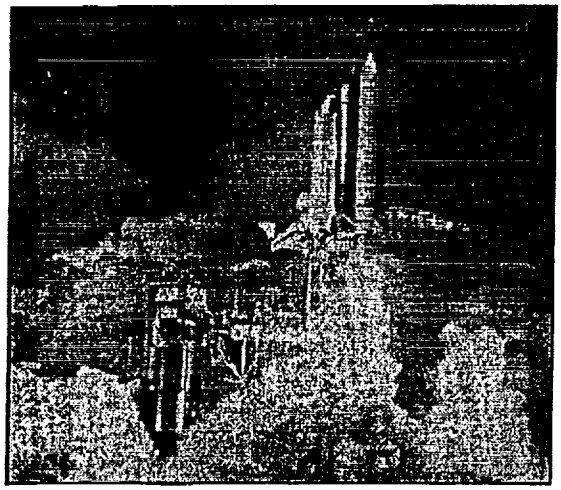
| Parameter | Desired Range | Mission Impact |
|---|---|---|
| Isp | High (>5000s) | Low initial mass, Resupply mass |
| $P_e$ | High (MWe) | Reduced trip time |
| $\alpha$ | Low (<10 kg/kWe) | Reduced Mass, trip time |
| $\eta$ | High (>50%) | Improved mass, trip time |

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

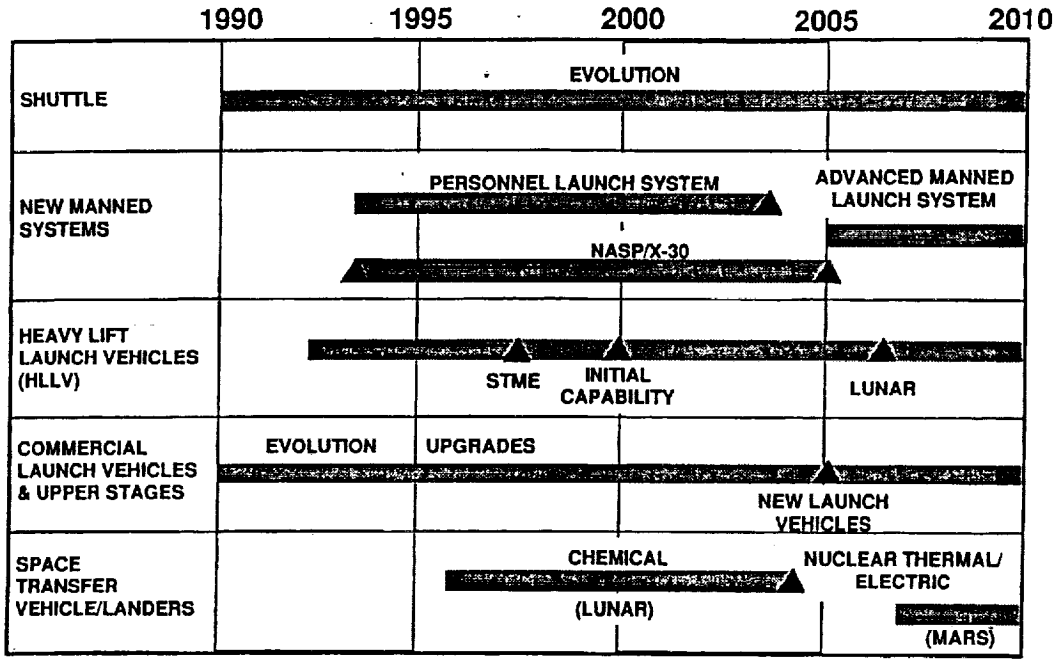
- Alternate Booster Concepts
- Advanced Cryogenic Upper Stage Engines
- Low-Cost Fab./Automated Processes/NDE
- Continuous Forging Processes for Cryogenic Tanks
- Fault-Tolerant, Redundant Avionics

### IN-SPACE TRANSPORT

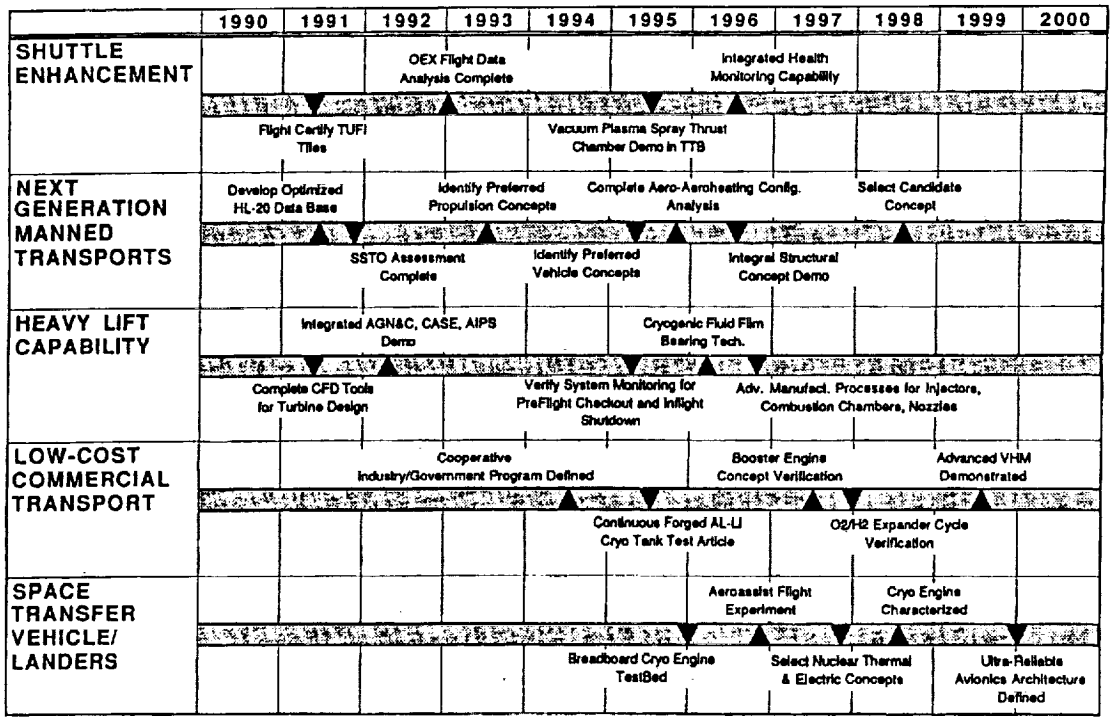
- High-Power Nuclear Thermal & Electric Propulsion
- High Performance, Multiple Use Cryogenic Chemical Engine
- Highly Reliable, Autonomous Avionics
- Low Mass, Space Durable Materials
- Long-Term, Low-Loss Management of Cryogenic Hydrogen
- Autonomous Rendezvous, Docking & Landing
- Aeroassist Technologies

91-8066

# TRANSPORTATION TECHNOLOGY MISSION MODEL

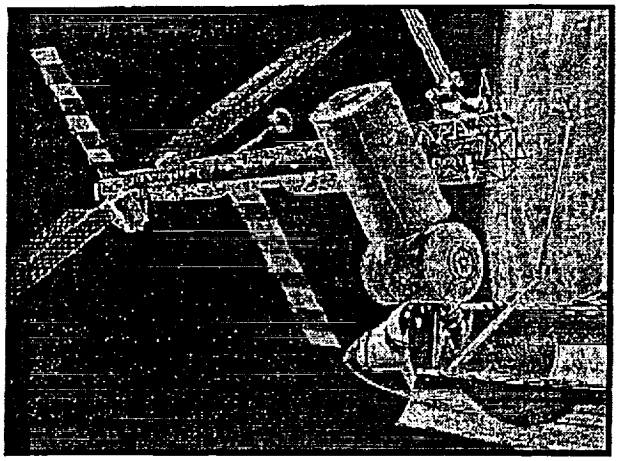



# TRANSPORTATION MILESTONES



# 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

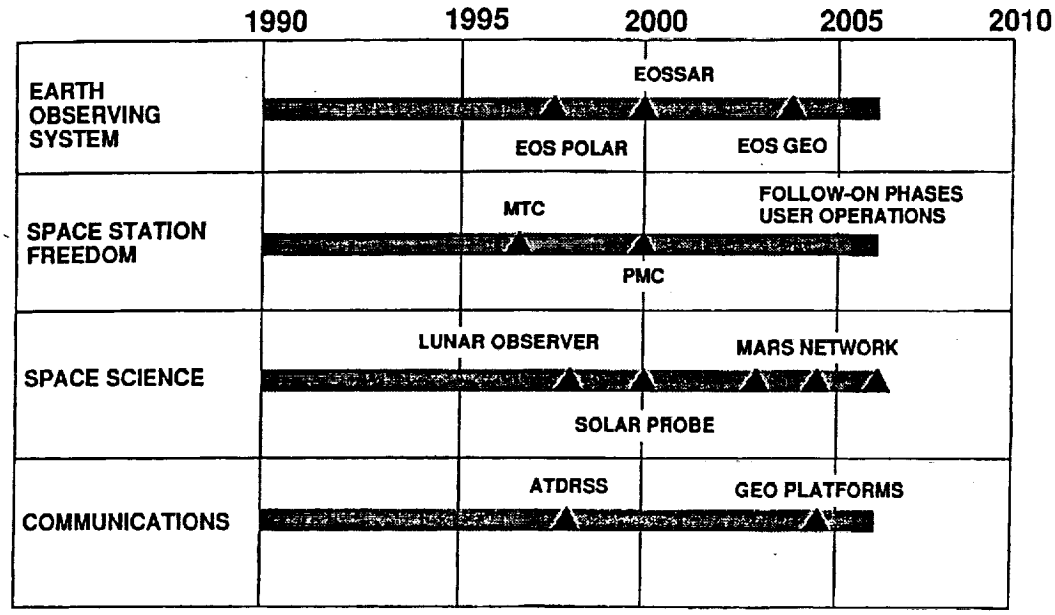
- Exploit Microgravity and Crew Interactive Capability to Advance and Validate Selected Technologies

## DEEP SPACE MISSIONS

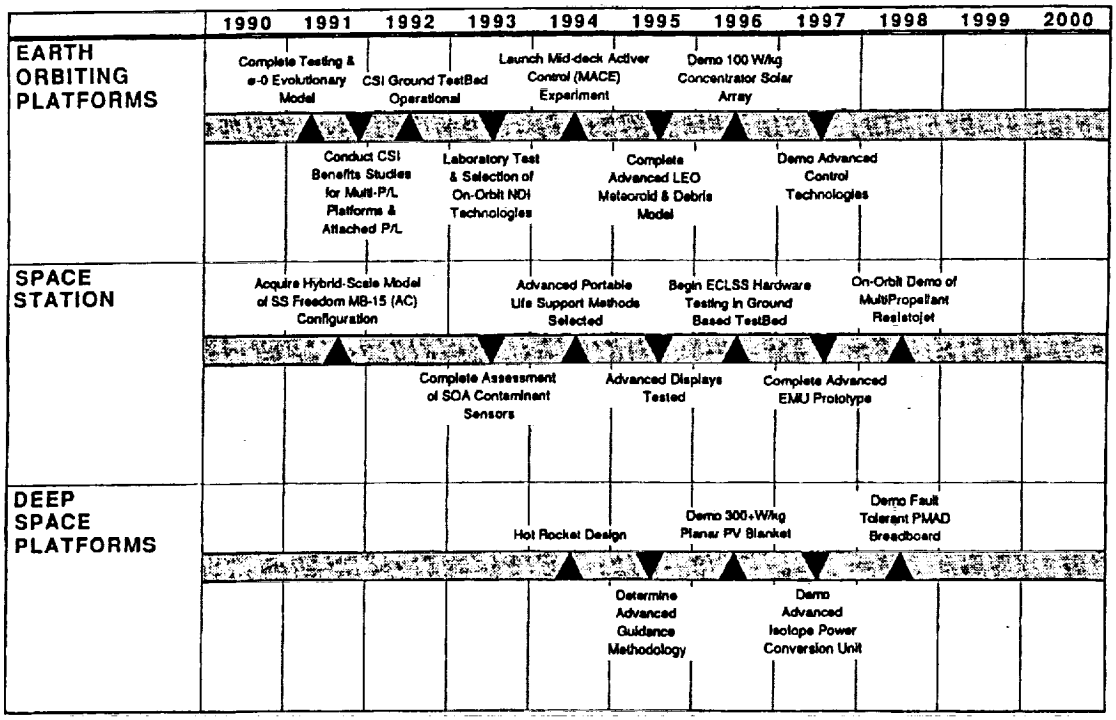
- Power and Thermal Management
- Propulsion
- Guidance, Navigation and Control

91-8053

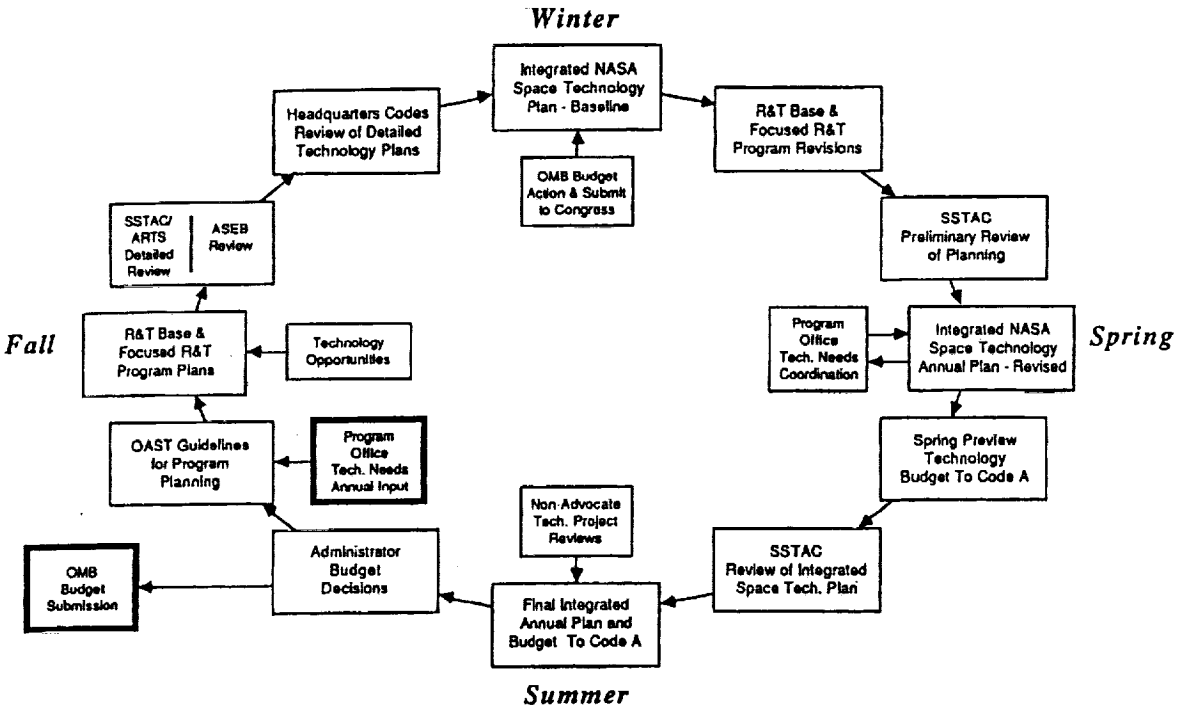
# SPACE PLATFORMS TECHNOLOGY MISSION MODEL




# 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