TRANSPORTATION AND PLATFORMS PERSPECTIVE

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HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS
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INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY

CIVIL SPACE TECHNOLOGY INITIATIVE

DISCIPLINE RESEARCH
Aerothermodynamics
Space Energy Conversion
Propulsion
Materials & Structures
Information and Controls
Human Support
Space Communications

UNIVERSITY PROGRAMS

SPACE FLIGHT R&T

SYSTEMS ANALYSIS

SPACE SCIENCE TECHNOLOGY
Science Sensing
Observatory Systems
Science Information
In-Situ Science
Technology Flight Expts.

PLANETARY SURFACE TECHNOLOGY
Surface Systems
Human Support
Technology Flight Expts.

TRANSPORTATION TECHNOLOGY
ETO Transportation
Space Transportation
Technology Flight Expts.

SPACE PLATFORMS TECHNOLOGY
Earth-Observing Platforms
Space Stations
Deep-Space Platforms
Technology Flight Expts.

OPERATIONS TECHNOLOGY
Automation & Robotics
Infrastructure Operations
Info. & Communications
Technology Flight Expts.
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
INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

RESEARCH & TECHNOLOGY STRATEGY

• 5-YEAR FORECAST INCLUDES

'93 THRU '97:
- COMPLETION OF INITIAL SSF
- LIMITED SOME SHUTTLE IMPROVEMENTS
- NEW STARTS
- 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
- FINAL SHUTTLE ENHANCEMENTS
- NEW STARTS
- MULTIPLE 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:
- OPTIONS FOR NEW
- SSF-MARS EVOLUTION
- MULTIPLE OPTIONS FOR NEW
- BEGINNING OF AMS/SPS DEVELOPMENT
- STARTS TO BE
- MULTIPLE SPACE SCIENCE STARTS
- LAUNCHED IN
- DSN EVOLUTION (OPTICAL COMM)
- 2009 THRU 2020
- INITIAL MARS HLTV DEVELOPMENT
- EVOLVING LUNAR SYSTEMS
- MARS SEI ARCHITECTURE CHOSEN
- LARGE GEO COMMSATS
- NEW COMMERCIAL ELVS

SPACE RESEARCH & TECHNOLOGY PROGRAM

<table>
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<tr>
<th>Category</th>
<th>1992 Experiments</th>
<th>1993 Experiments</th>
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<tr>
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<td>OPERATIONS</td>
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FY 1992: $309.3M
FY 1993: $332.0M
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

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
- Systems & Components for Electric Actuators
- On-Vehicle Adaptive Guidance & Control
- 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
TRANSPORTATION TECHNOLOGY MISSION MODEL

TRANSPORTATION MILESTONES

SHUTTLE ENHANCEMENT


SHUTTLE ENHANCEMENT

- OEX Flight Data
  - Analysis Complete

- Vacuum Plasma Spray Treat Chamber Demo in TTS

NEXT GENERATION MANNED TRANSPORTS

- SSTO Assessment Complete
- Identify Preferred Propulsion Concepts
- Complete Aero-Aerodynamic Config Analysis
- Select Candidate Concept

HEAVY LIFT CAPABILITY

- Integrated AIN, CASE, APS Demo
- Cryogenic Fluid Film Bearing Tech.
- Complete CFD Tools for Turbine Design
- Verify System for ProFlight Checkout and FullPower Shutdown

LOW-COST COMMERCIAL TRANSPORT

- Cooperative Industry/Government Program Defined
- Booster Engine Concept Verification
- Advanced VH-M Demonstrated

SPACE TRANSFER VEHICLE/LANDERS

- Broadband Cryo Engine Testbed
- Select Nuclear Thermal & Electric Concepts
- Ultra-Reliable Avionics Architecture Defined
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

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
SPACE TECHNOLOGY PLANNING CYCLE

Winter
- Integrated NASA Space Technology Plan - Baseline
- SSTAC Review of Integrated NASA Space Technology Plan
- OMB Budget Action & Submission to Congress
- R&T Base & Focused R&T Program Revisions
- OMB Budget Action & Submission to Congress

Fall
- SSTAC ARTS Detailed Review
- R&T Base & Focused R&T Program Plans
- Technology Opportunities
- OMB Budget Submission
- OMB Budget Submission
- Administrator Budget Decisions
- Final Integrated Annual Plan and Budget To Code A

Spring
- SSTAC Preliminary Review of Planning
- Program Office Tech. Needs Coordination
- Integrated NASA Space Technology Annual Plan - Revised
- Spring Preview Technology Budget To Code A
- Spring Preview Technology Budget To Code A
- Final Integrated Annual Plan and Budget To Code A

Summer
- Integrated NASA Space Technology Plan
- OMB Budget Action & Submission to Congress
- R&T Base & Focused R&T Program Revisions
- OMB Budget Action & Submission to Congress
- OMB Budget Submission
- OMB Budget Submission
- Administrator Budget Decisions
- Final Integrated Annual Plan and Budget To Code A

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

TECHNOLOGY READINESS LEVELS

LEVEL 1
- BASIC PRINCIPLES OBSERVED AND REPORTED

LEVEL 2
- TECHNOLOGY CONCEPT AND/OR APPLICATION FORMULATED

LEVEL 3
- ANALYTICAL & EXPERIMENTAL CRITICAL FUNCTION AND/OR CHARACTERISTIC PROOF-OF-CONCEPT

LEVEL 4
- COMPONENT AND/OR BREADBOARD VALIDATION IN LABORATORY ENVIRONMENT

LEVEL 5
- COMPONENT AND/OR BREADBOARD VALIDATION IN RELEVANT ENVIRONMENT

LEVEL 6
- SYSTEM/SUBSYSTEM MODEL OR PROTOTYPE DEMONSTRATION IN A RELEVANT ENVIRONMENT (Ground or Space)

LEVEL 7
- SYSTEM PROTOTYPE DEMONSTRATION IN A SPACE ENVIRONMENT

LEVEL 8
- ACTUAL SYSTEM COMPLETED AND "FLIGHT QUALIFIED" THROUGH TEST AND DEMONSTRATION (Ground or Flight)

LEVEL 9
- ACTUAL SYSTEM "FLIGHT PROVEN" THROUGH SUCCESSFUL MISSION OPERATIONS

MARCH 17, 1981
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